

# Our transition to a zero carbon future

SE 2050 Embodied Carbon Action Plan for 2024 (4th year)



# SE 2050

## Embodied Carbon Action Plan



A climate emergency is upon us. As structural materials represent about 12% of global greenhouse gas emissions, our structural engineers recognize their role in achieving net zero embodied carbon structures by 2050.

Arup is committed to shaping a better world, creating shared value for our clients and communities, and safeguarding our planet. Every part of our firm has a role to play in making sustainable development central to our business. Sustainable development is fundamentally about creating a balance between the needs of a growing world population and the finite resources and health of our planet—our life support system.

Arup embodies ‘total value’ with a holistic design approach, integrating a wide breadth of advisory services and skills in sustainability and resilience, digital, buildings and building envelope design, infrastructure, and masterplanning. We have the opportunity to use our design and advisory services to produce safer, more inclusive, resilient and sustainable cities and infrastructure.

In October 2017, Arup made a commitment to contribute meaningfully to the UN Sustainable Development Goals. This commitment was furthered through Arup’s [announcement](#) at COP27 to use whole life carbon data to target meaningful reductions in operational and embodied carbon.

As designers, engineers and advisors, our skills and vision are increasingly in demand from clients and partners wanting to transition to a more sustainable future.

It is up to each of us, working individually and collectively, to drive change. We must all promote sustainable development as a central basis of our projects, as distinct from a supplementary feature. Everyone has a role to play inspiring and supporting our clients and colleagues alike by offering innovative ideas, and challenging the status quo. We are proud to have been part of the development of the SE 2050 Initiative since 2014 and to be among the inaugural signatories to the Structural Engineering Institute’s SE 2050 Commitment.

The mission of the SE 2050 Commitment is to support the SE 2050 Challenge and transform the practice of structural engineering in a way that is holistic, firm-wide, project based, and data-driven. By prioritizing reduction of embodied carbon, through the use of less and/or less impactful structural materials, Arup is working to achieve net zero embodied carbon structural systems by 2050.

Our commitment requires the publication of our strategy in the areas of education, reporting, reduction, and advocacy. Our Embodied Carbon Action Plan for North America leverages our strong internal skills networks and aligns with our global commitment to contribute meaningfully to the UN Sustainable Development Goals.



### Strategic focus areas

Arup is working to achieve net zero embodied carbon structures by 2050.

**Our partners**

A collection of logos for various partners. In the top left is the SEI logo (Structural Engineering Institute) with the ASCE logo below it. To its right is the SE2050 logo with the tagline 'COMMITTING TO NET ZERO'. Below these are the IStructE logo, the CLF logo (Carbon Leadership Forum), the architecture 2030 logo, the EBNet logo (Ecological Building Network) with the tagline 'the art and science of building well', the ELLEN MACARTHUR FOUNDATION logo with the tagline 'Rethink the future', and the USGBC logo (U.S. Green Building Council).

Our aim is to make embodied carbon reporting a normal part of the design and delivery of every project.

## Reporting

In 2022, Arup committed to undertaking whole lifecycle carbon assessments for its buildings projects – new and retrofit. It has been estimated that less than 1% of buildings projects are currently evaluated in a way that quantifies the scale and source of carbon emissions generated during their lifespans – a step that is essential if the most effective decarbonization actions are to be identified.

Adopting whole lifecycle carbon assessment is the crucial next step that will allow the global buildings sector to progress toward 50% carbon emissions reduction by 2030. Find more details [here](#).

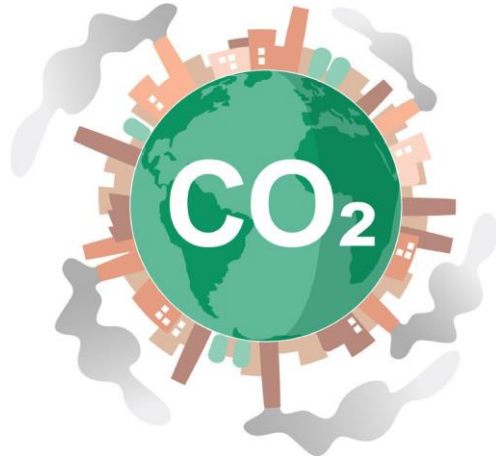
Arup commits to calculating embodied carbon per the SE 2050 Program Requirements and submit to the SE 2050 Database. The requirements align with Arup’s own internal initiative to perform LCAs on all our projects with Arup’s new software platform, [Zero](#). Regionally appropriate tools and workflows will be used by project teams to complete life cycle assessment (LCA) studies. The results will be submitted to SE 2050 to gain insights into the embodied carbon of structural designs.

## Project delivery

Arup’s high-level process for integrating embodied carbon reduction and reporting into projects.



Arup's vision is to equip our structural engineers with the skills and insights necessary to implement the Embodied Carbon Action Plan in all offices and on all future projects.

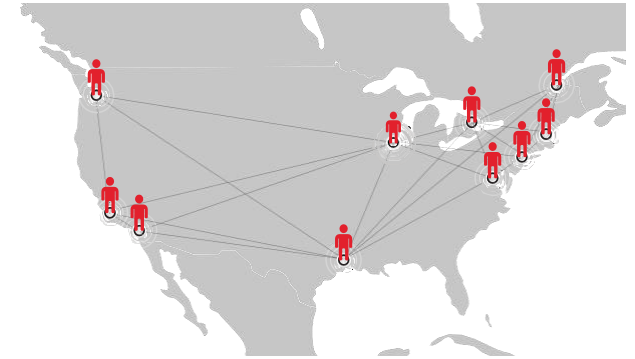


## Education

As a global firm, Arup's unique culture embraces knowledge sharing and collaboration in a way that enables us to easily tap into our collective capabilities across great distances. This is done primarily through our skills networks, of which the structural skills network (SSN) is one of the oldest and strongest. Within the SSN, there are regional sustainability hubs that keep the teams connected within and across regions.

The North America hub is comprised of structural sustainability champions from ten of our offices who act as internal and external representatives for embodied carbon resources and educational programs.

This group is currently led by our regional champions, [Ann Jiras](#), [Ashley Cooper](#), and [Genevieve Graham](#), who are the points of contact for SE 2050 and responsible for coordinating embodied carbon efforts at a regional level.



## Arup sustainability champions

Ten of our offices in North America are well connected through our structural skills network and local sustainability champions.

- Boston
- Chicago
- Houston
- New York
- Montreal
- Los Angeles
- San Francisco
- Seattle
- Toronto
- Washington D. C

Only by working together and ever widening our circle of partners can we achieve a healthy, carbon-neutral built environment.

### Reduction strategy

As Arup’s global strategy calls on us to transition to a zero-carbon economy and respect our planetary boundaries, we have developed resources to support structural engineers in reducing embodied carbon in their designs.

We seek to make embodied carbon reduction a key design criteria alongside elegance, fitness for purpose, speed of construction, and future flexibility. Our regional structural skills network (SSN) provides guidance on several strategies, which include:

- specifying low-carbon concrete
- sourcing sustainable mass timber
- incorporating salvaged steel
- designing for deconstruction
- pushing material efficiency beyond standard practice

Many of these are aligned with the SE 2050 electives. Each office will choose from these strategies and other SE 2050 electives to employ at least one elective on chosen projects. Embodied carbon savings will be calculated to show the effects of improved design and specifications and used to spread awareness both internally and externally.

### Advocacy

Arup has been sharing knowledge and data on embodied carbon with the buildings industry for over a decade. Our SSN sustainability representatives are active participants in external organizations such as the SEI Sustainability Committee, Carbon Leadership Forum, SEAONC Sustainable Design Committee, and the SE 2050 leadership group. [CLF shoutouts]

By acknowledging the greater role and responsibility of structural engineers in reducing carbon emissions, we have expanded our technical services to offer: [letter of support?]

- whole-building life-cycle assessments
- embodied carbon policy assistance
- third-party expert support on low-carbon concrete
- design for circularity
- other non-traditional design strategies

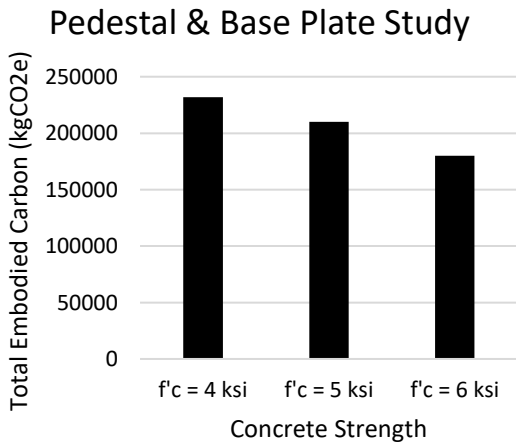
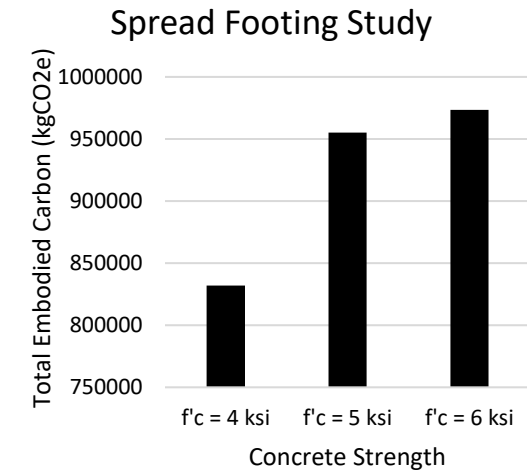
We realize that reaching net zero embodied carbon is an ambitious goal that will take significant collaborative effort. Arup will continue to seek out ways to engage with others in the buildings industry, inclusive of clients, policymakers, manufacturers, builders, academia, and our peers.

### Lessons Learned

Entering into Arup’s 4<sup>th</sup> year committed to the SE 2050 program, we have these lessons to share:

1. *We learned* that a successful use of carbon data is an iterative process, therefore efficiency in conducting carbon assessments is critical. At early stages, this can be achieved through simple spreadsheets or the use of the ECOM tool. However, at later stages, it becomes critical to have an assessment tool that integrates with the structural BIM model.
2. *We learned* collaboration is key. Knowledge sharing both internally and externally aids our understanding of the embodied carbon landscape and informs our ability to improve.
3. *We learned* that communication between disciplines can significantly impact the embodied carbon of the structure. For example, a simple question of verifying soil bearing capacity resulted in an increase in design capacity and reduction in concrete required for the foundation system.

SE 2050 requires us to Plan, Implement, and Share. These Arup projects illustrate what “implementation” looks like and show us the critical role structural design can have in achieving net zero carbon projects.



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## Confidential Project: Concrete Massing and GWP in Foundation Elements

### Idaho

*Summary: Parameterize embodied carbon in relation to structural design decisions to study the impact of the Engineer’s design decisions. The results are not always intuitive and reveal the need for nuance in establishing a project’s embodied carbon reduction strategies.*

Arup provided structural services to deliver a three-story wastewater treatment building. The 650,000 sq. ft. steel structure features composite floors, steel framing and a shallow foundation system. Site conditions comprised of native fill underlain by basalt rock layers interspersed with soil pockets. Large water tanks and heavy equipment loading resulted in high foundation loads and sizeable footings.

Arup engaged with the client to study options to reduce the embodied carbon of the foundation system. The study compared the impact of a range of concrete strengths (f'c = 4ksi, 5ksi and 6ksi) for the spread footings and for the below ground pedestals that support building columns. The baseline option is f'c = 5ksi.

Generally, higher strength concrete mixes have higher embodied carbon than lower strength mixes. However, the knock-on effects of concrete strength on the element design means that the relationship between concrete strength and embodied carbon is not always straightforward.

The study showed that for spread footings, the lowest concrete strength option (f'c = 4ksi) resulted in the lowest embodied carbon for that element. Compared to the baseline option, a 6% increase in concrete volume due to punching shear considerations still resulted in an 11% net decrease in embodied carbon due to the lower carbon content of the lower strength mixes.

The study showed that for pedestals, the highest concrete strength option (f'c = 6ksi) resulted in the lowest embodied carbon for that element. This is because the column base plate design was governed by concrete bearing so concrete strength affected the base plate sizing. Higher strength concrete resulted in a halving of the steel base plate tonnage. Compared to the baseline option, there was a 14% net decrease in embodied carbon when considering embodied carbon for combined base plates and pedestals.

The findings provided nuance to structural sustainability and how there isn’t a single, simple strategy to achieve it but that thoughtful and comprehensive studies illuminate the right strategy for each situation. In the case study shown here, Arup structural engineers used quantitative studies while considering holistic design impacts to inform decision making on the project that would optimize for reduced embodied carbon.

# Case studies (2024)



SE 2050 requires us to Plan, Implement, and Share. These Arup projects illustrate what “implementation” looks like and show us the critical role structural design can have in achieving net zero carbon projects.



## 80M

### Washington, DC

*Summary: 80M is a successful example of the prioritization of structural embodied carbon reduction strategies: optimizing the re-use of existing structures and using alternative low carbon structural systems when building new.*

The existing reinforced concrete office building was constructed in the early 2000s, predating the redevelopment of the surrounding neighborhood. The building owner, recognizing the available density on the site, engaged Hickok Cole Architects and Arup to develop multiple schemes for an addition which would minimize impacts to the existing building and allow it to remain fully operational. During the initial feasibility stage, a mass timber structural system was selected as the basis of design to minimize the loading on the existing structure while offering a unique office product in a competitive submarket.

Arup extensively analyzed the existing building to fully utilize the available capacity. Concrete cores were taken to justify higher concrete strengths and a lateral system for the overbuild was designed to concentrate overturning loads into the existing core of the building, avoiding impacts to tenant spaces below.

The mass timber structure was designed as a fully exposed post-and-beam system, utilizing the Type IV-C code provisions in the 2021 IBC. Arup developed custom 2-hour fire rated beam-to-beam and beam-to-column connections that were further detailed and tested by the timber contractor. 80M is the first completed 2-hour fire rated exposed mass timber structure in the U.S.

When compared to an equivalent ground up new concrete structure, the 80M project achieved an 85% embodied carbon reduction for cradle-to-grave emissions.

#### Client

Hickok Cole Architects

#### Project owner

Columbia Property Trust

#### Key collaborators

DAVIS

Construction

Katerra

#### Key facts

Mass timber overbuild, first completed 2-hour fire rated exposed mass timber structure in the U.S.

#### Key services provided

Structural, mechanical, electrical, plumbing, and fire protection engineering, fire and life safety consulting, acoustic consulting, sustainability consulting

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## Heartburst – Burning Man Art Installation

### Black Rock, Nevada

*Summary: Now in its permanent home in southern California, Heartburst represents a study into the carbon reduction potential of bamboo.*

Arup provided structural services to verify the design integrity of Heartburst, an art installation/pavilion showcased at the 2023 Burning Man Festival. The structure — approximately 30ft by 30ft in plan and 15ft tall — was comprised of a series of bamboo rod lattices with cable tiedowns.

Arup often seeks out atypical materials to provide clients with educated design solutions. Here, the client requested a specific material and Arup used its knowledge of materials science to successfully evaluate and improve its use.

By mass, bamboo is 50% carbon. Therefore, bamboo as a structural material sequesters the carbon that would otherwise decay in its origin forest. Even with processing and ocean freight shipping, Heartburst’s structure subtracted approximately 7.5 metric tons of CO2 from our atmosphere.

Our client chose bamboo for its beauty and its capacity for carbon sequestration. Therefore, our goal was to minimize the need for non-bamboo structural components as well as adhere to the architectural intent of the installation’s lattice structure.

Using project-specific testing data, Arup was able to confidently analyze the behavior of the bamboo structure. The analysis resulted in optimized splice locations and materials reductions. The Burning Man Festival occurred in August 2023. Images from the festival show the bamboo structure stood proud in the desert, unbothered by dust storms or human climbers. Since Burning Man, Heartburst has found a permanent installation location in southern California.

In sharing this story, Arup hopes to encourage more structural engineers to take on design and analysis using atypical materials that have environmental benefits.

#### Project owner

OFFICEUNTITLED

#### Key

#### collaborators

JTK Consult,

SEAD Build,

Universiti

Teknologi

Malaysia

#### Key facts

Art Installation at

Burning Man,

bamboo lattice

structure and

cable tiedowns

#### Key services

#### provided

Structural

engineering

consulting

Arup project contact:  
toshiyasu.yoza@arup.com

# Table of requirements: Education (2024)

Arup satisfaction of requirements	Requirements/Electives	Implementation
✓	Provide a narrative of how the Embodied Carbon Reduction Champion will engage embodied carbon reduction at each office.	Through our SSN, we regularly share tools and procedures to educate all structural engineers in the region. Our implementation plan for the Embodied Carbon Reduction Plan will be shared through our monthly calls and the structural sustainability champion in each office.
✓	Present at least (1) webinar focused on embodied carbon and make a recording available to employees. Include this resource in your orientation and onboarding program.	SSN members will present to their respective offices, at minimum, once per year on embodied carbon reduction tools, targets, or education. Presentations are recorded and saved for future viewing for new hires.
✓	Train all of your firm’s structural engineers on the core concepts and skills required to measure, reduce, and report embodied carbon.	Arup directs all structural engineers to internal training regarding embodied carbon.
✓	Incorporate embodied carbon education in your onboarding for all new employees.	Arup directs its new structural engineers to internal training regarding embodied carbon during the onboarding process.
✓	Initiate an embodied carbon interest group within your firm and outline their goals. This group may more broadly address sustainability, but they must include embodied carbon.	Arup currently has multiple groups: SESH (Global, Americas, UK), Arup Carbon Tool, Americas Region Decarbonization Group. These groups are available on Arup's Teams platform and continually keep members apprised of news and resources related to embodied carbon.
✓	Create an Embodied Carbon digital resource wiki and/or forum on your firm’s website for staff to create, share, and discuss Embodied Carbon educational resources.	Arup shares its embodied carbon resources through a central repository Teams channel called SESH (Structural Engineering Sustainability Hub).
✓	Engage with a CLF Regional Hub. This could include attending presentations or working sessions and reporting back to the firm or co-chairing a hub.	Arup engineers across the country engage with their local CLF Hub. In Washington D.C. and San Francisco, Arup engineers are part of the CLF Hub leadership. Additionally, Arup is a sponsor to CLF National.
	Provide narrative outlining plans for minimum (2) firm-wide presentations per year on the topic of embodied carbon.	
	Propose other actions promoting embodied carbon education and describe their value.	



# Table of requirements: Reporting (2024)

Arup satisfaction of requirements	Requirements/Electives	Implementation
✓	Submit a minimum of (2) projects per U.S. office with structural engineer services to the SE2050 Database. You are not required to submit more than (5) total projects across your firm, but we encourage you to submit as many as possible!	We commit the SE 2050 Program Requirements including the submission requirements of embodied carbon data.
✓	For multi-office firms, describe how each office is measuring and reporting embodied carbon. For single-office firms, describe how different project teams or managers are measuring and reporting embodied carbon.	For each project that we decide to report embodied carbon for, it is up to the project team which tool they wish to use. Within Arup we have access to Athena Impact Estimator, Tally, ECOM Tool, EC3, and an internal Arup Carbon tool called Zero Platform. When studying embodied carbon, we plan to only use tools that are regionally appropriate for the project calculation and aim to complete full LCA studies spanning modules A to C. We are beginning to develop tools to better utilize our Revit models to extract material quantities and link quantities and LCA results to the Zero Platform, a project information database. Our plan is for this to be fully compatible with the SE 2050 database.
✓	Compare the embodied carbon from multiple projects across your firm. Analyze and document what data and pieces of information are most important and communicate the findings to your firm.	Arup plans to assess the embodied carbon of its airport structural designs across North America and include findings in the 2025 ECAP submission.
✓	Propose other actions that promote the reporting of embodied carbon data and describe their value.	Arup had launched a global initiative titled <a href="#">Zero</a> , which collects LCA data across all projects. This effort stands as an additional action Arup is actively taking to enhance the reporting and assessing of embodied carbon data.

# Table of requirements: Reduction (2024)

Arup satisfaction of requirements	Requirements/Electives	Implementation
✓	Update your specifications to incorporate embodied carbon as a performance metric during the project concept phase. Explain what you did and what the results changed (if anything).	Arup has incorporated performance-based design specifications for concrete suppliers to uphold, incorporating GWP targets as part of the requirements.
✓	Develop and implement a workflow that makes it easier to make early design decisions based on embodied carbon.	For structural projects, we have implemented a checklist that encompasses 'best practices' for structural sustainability. At major project milestones, project teams review this list and gauge which items they can pursue for their project. This process assists teams in engaging with early stage thinking for embodied carbon reduction and paves the pathway for carbon assessments and reduction strategies.
✓	Submit a Circular Economy Narrative describing how a project supports the circular economy. This can be done by incorporating re-use or design for deconstruction into at least one project.	See 80M Case Study for an example of Arup supporting and providing a narrative on circular economy by incorporating re-use of existing concrete structure for the updated design.
	Communicate the embodied carbon impacts of different options to clients with create and effective data visualization. You are welcome to include these visualizations in your Elective Documentation, though it is not required.	
✓	Compare different design options with embodied carbon as a performance metric during the project concept phase. Explain what you did and what the results changed (if anything).	See case study section for an example of Arup studying design options using embodied carbon as a performance metric.
✓	Participate in a LEED, ILFI Zero Carbon, or similar project design charrette and speak to potential design considerations impacting embodied carbon.	Arup regularly supports client in their LEED goals, which includes a design charrette in which a structural engineer participates.
✓	Collaborate with your concrete supplier to reduce embodied carbon in a mix design below an acceptable baseline (e.g. NRMCA regional baseline values). Discuss what you found and what it means in your market.	Arup has incorporated performance-based design specifications for concrete suppliers to uphold, incorporating GWP targets as part of the requirements. This regularly results in collaborative conversations with concrete suppliers.
	Have an Environmental Product Declarations (EPD) created for a project. Get a project or client to require the creation of an Environmental Product Declaration (EPD) that did not exist before.	
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# Table of requirements: Advocacy (2024)

Arup satisfaction of requirements	Requirements/Electives	Implementation
✓	Describe the value of SE 2050 to clients. How can your design teams collaborate to reduce embodied carbon? Please attach any associated marketing materials.	External kickoff meetings include slides on Arup's commitment to sustainable development. For structural, this includes a statement of our commitment to the SE 2050 Commitment Program.
✓	Publicly declare your firm as a member of the SE2050 Commitment however you see fit (e.g. on your website, LinkedIn, or other social media).	Upon joining SE 2050, Arup announced its commitment in 2020. This commitment continues to be visible on Arup's website. Our commitment to the SE 2050 Commitment Program is renewed via an annual regional call for our structural engineers.
✓	Give an external presentation on embodied carbon that demonstrates a project success or lessons learned. Get connected at a CLF regional hub near you and be sure to post the recording.	Arup presents at external conferences around the globe with embodied carbon being a frequent topic. See our Americas Chair, Fiona Cousins, Ted x Manhattan Beach talk ( <a href="#">hyperlinked</a> ) as an example.
	Mentor a firm new to the embodied carbon space. Describe how you identified their needs and what improvements were made.	
✓	Engage with structural material suppliers in your region to communicate the importance of Environmental Product Declarations (EPDs) and low carbon materials options.	Arup champions the need for EPDs on its projects. Our boiler-plate structural specs have EPD clauses and commentary to guide conversation with the client.
✓	Engage with local, state, and federal governments to communicate the importance of low embodied carbon procurement and construction policies, and provide expert testimony to this effect.	<p>Examples of Arup's industry and policy influence to encourage low carbon and carbon-sequestering materials of 2023:</p> <ul style="list-style-type: none"> <li>• Letter of Support to CalGreen Legislative update</li> <li>• Technical support to the DC Green Building Advisory regarding embodied carbon reduction</li> <li>• Advisement to NYC department of buildings task group for low carbon concrete</li> <li>• CLF Hub involvement and leadership across multiple cities</li> <li>• Letter of Support for the Low Embodied Carbon Motion for the city of LA</li> </ul>