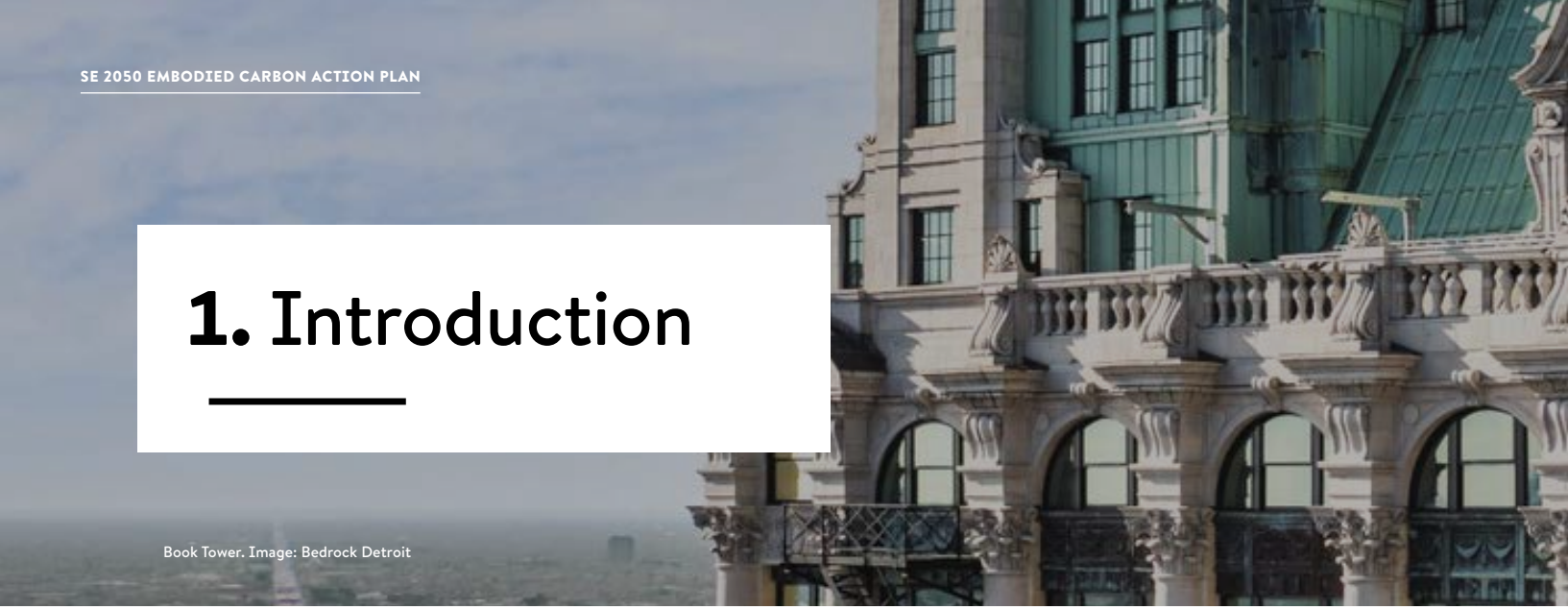
BURO HAPPOLD

SE 2050 Embodied Carbon Action Plan

2024

Contents

Quinnipiac University,
Recreation and Wellness Center
Image: Anton Grassl



Book Tower. Image: Bedrock Detroit

1. Introduction

At Buro Happold, we believe collective action is the best way to address the climate and biodiversity crisis. It is our responsibility to design and create environments that are sustainable and fair. Every engineer, consultant and advisor must put the environment at the heart of their work. If we make major reductions in greenhouse gas emissions, we can limit global warming to 1.5 degrees. This will mean environmental justice for all.

With this in mind, Buro Happold is proud to commit to the SE 2050 program with the explicit goal of achieving net zero carbon by 2050.

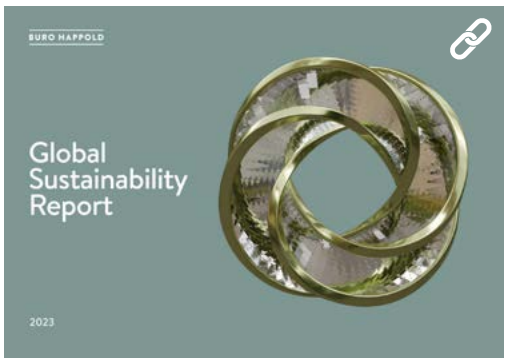
Buro Happold signs Structural Engineers 2050 Commitment Program

The SE2050 commitment aligns with our firm wide goals which are outlined in our annual Sustainability Report:

- Achieve net zero operational greenhouse gas (GHG) emissions by 2045.
- Design all new build projects to be net zero carbon in operation by 2030.
- Reduce embodied carbon intensity of all new buildings, major retrofits and infrastructure projects by 50% by 2030

At Buro Happold, we pride ourselves in our problem-solving acumen through our multidisciplinary expertise. With a challenge as complex and far reaching as climate change, we must leverage the collective knowledge and experience of all parties. Buro Happold is committed to leveraging the skills of our various disciplines (Structures, MEP, facades, sustainability) in order to tackle this issue to the fullest extent.

Only together can we begin to set forth a future that is sustainable, equitable, and just.



We believe our biggest responsibility is to shift from sustainability goal setting and planning, into action and implementation... Our vision is that everywhere we live, work, move and socialise will respect and contribute to a more equitable world, enabling our clients and partners to develop built environments that are better for people, places and planet.

— Oliver Plunkett, CEO

> All structural engineers shall understand, reduce and ultimately eliminate embodied carbon in their projects by 2050.
>
> SE 2050 Challenge mission statement

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October 6, 2021

Laura Champion
Director
Structural Engineering Institute

Dear Laura,

Buro Happold North America is hereby signing on to the SE 2050 Commitment Program. We support the vision that all structural engineers shall understand, reduce, and ultimately eliminate embodied carbon in their projects by 2050.

Buro Happold is committed to regularly reporting and holding ourselves accountable to our people and the wider industry. We are on a route map to net zero carbon through the following targets:

1. Reduce our own operational carbon emissions by 21% by 2025 and aim to be net zero carbon from April 2021 by offsetting residual emissions.
2. Design all new build projects to be net zero carbon in operation by 2030.
3. Reduce embodied carbon intensity of all new buildings, major retrofits and infrastructure projects by 50% by 2030.

We therefore commit Buro Happold North America to take the following steps which are part of the SE2050 Commitment Program:

- Within six months and annually henceforth, we commit to reporting an Embodied Carbon Action Plan (ECAP) and permit the ECAP document on form be made public on the SE 2050 website.
- Within one year and annually henceforth, we commit to submit data to the SE 2050 project database in a collaborative effort to understand embodied carbon in structural engineering projects and to set attainable targets for future projects.

We look forward to joining this coalition and industry effort to achieve the goals of the SE 2050 Program.

On behalf of Buro Happold Consulting Engineers P.C.

S. Curtis

Stephen Curtis
Principal
Buro Happold
stephen.curtis@burohappold.com

SE 2050 COMMITMENT PROGRAM

Buro Happold's SE 2050 commitment letter

Our 12 North America offices are connected through a network of local champions who led our efforts on embodied carbon and host regular Sustainability in Structures Task Group meetings and participate in global Sustainability Community Regional Leads meetings.

Stephen Curtis
Principal

Fraser Reid
Associate Principal,
SE 2050 Embodied Carbon Champion

Luke Lombardi
Senior Sustainability Consultant,
CLF Member, SE 2050 Education Lead

Luke Bastian
Graduate Struct. Engineer
SE 2050 Committee

Matthew Jackson-Jones
Senior Structural Engineer,
SE 2050 Reporting Lead

Stacey Brown
Associate Struct. Engineer,
SE 2050 Reduction Lead

Andrew Rastetter
Associate Structural Engineer,
SE2050 Advocacy Lead

Additional Task Group Contributors

Lupe Gomez, Structural Engineer
Terenia Hankewycz, Graduate Structural Engineer
Alanna Muldowney, Graduate Structural Engineer

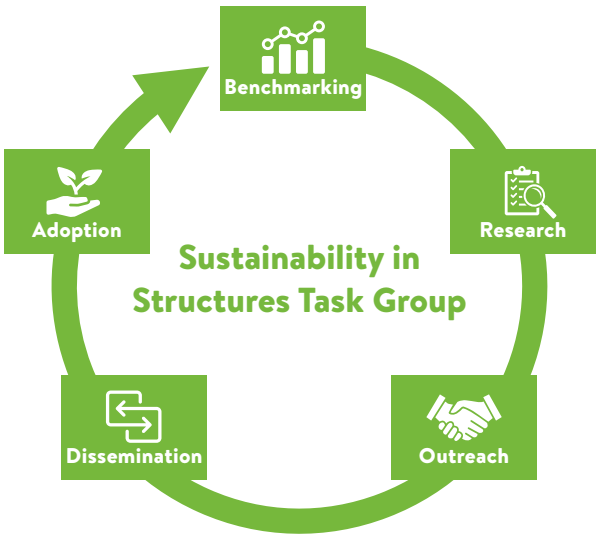
Our 12 North American Offices

New York, Boston, Seattle, Washington D.C, Los Angeles, Atlanta, Durham, Chicago, San Diego, Pittsburgh, Detroit, and San Francisco

The current focuses of the Sustainability Task Group is:

- **Benchmarking** – establishing embodied carbon metrics for current and completed projects
- **Research** – undertaking studies to determine where embodied carbon sensitivities lie in structural designs
- **Outreach** – connecting with industry partners to discuss trends and potential opportunities.
- **Dissemination** – sharing information and best practice guidance from national and global industry partners.
- **Adoption** – driving the uptake of embodied carbon measurement on new projects and reflecting on emerging trends.

Over the last couple of years we have seen an increase in the interest and awareness of embodied carbon within the industry. This has ranged from collaborators asking that we share our knowledge and experience to clients indicating EPD targets for materials.



Minnesota Zoo Treetop Trail. Image: Gaffer Photography

2. Education

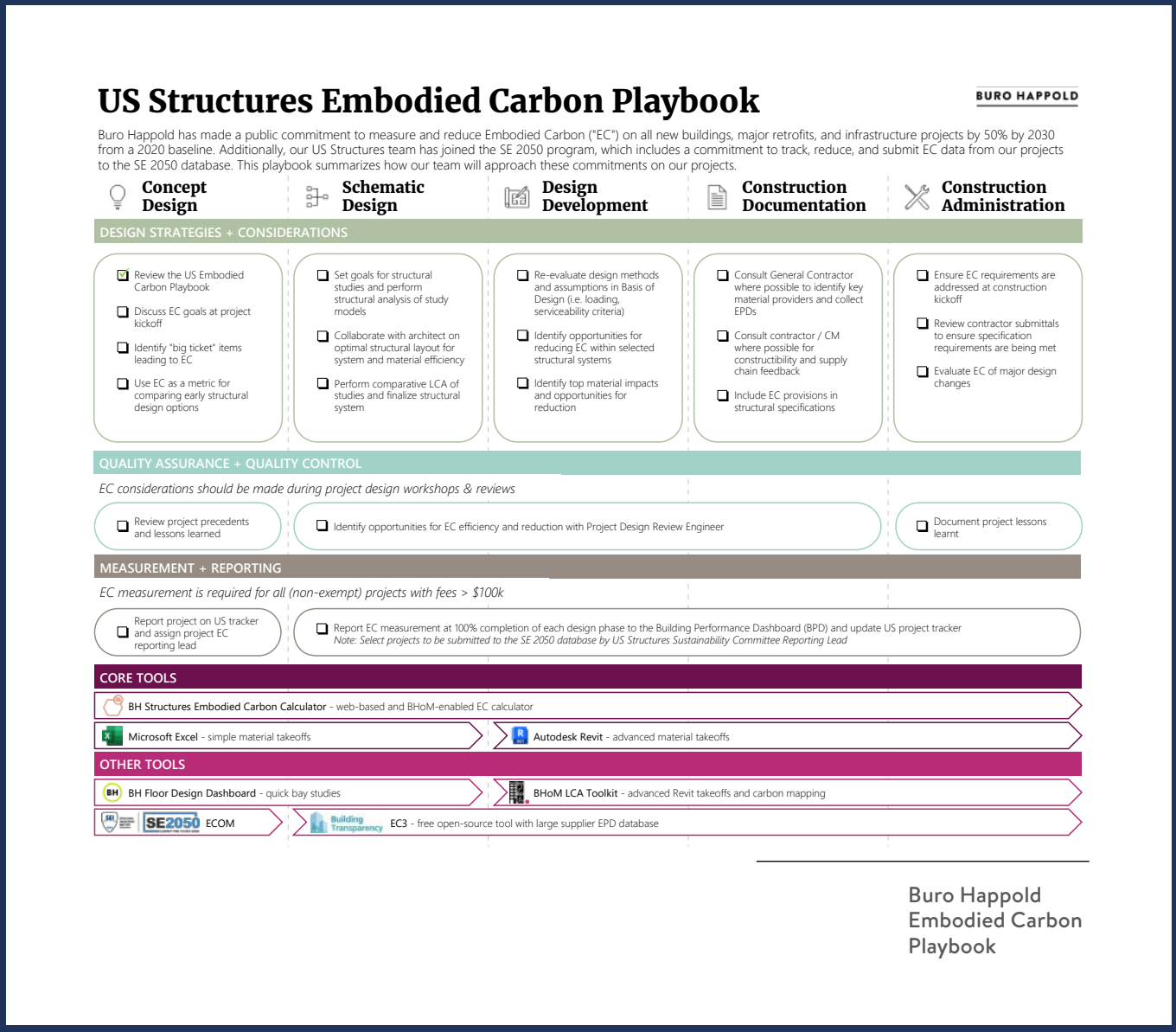
Education is a pivotal step in tackling climate change. Only with a common understanding of the impending climate crisis can we begin to take steps to reduce the environmental impacts of the built environment. Buro Happold's North America Region has taken significant steps to educate our team about the importance of sustainability and how as structural engineers we can influence the impact of our designs.

In the last year, Buro Happold's North America structural teams have continued to expand our educational material and events

- The **Sustainability in Structures Task Group** formed from Structural Engineers Forum with objectives in the SE 2050 framework to engage more people.
- An **Embodied Carbon Playbook** has been developed by the reduction task group to offer guidance at various stages of a project.
- **Onboarding meetings** adapted to include the Embodied Carbon Playbook and Structures Forum content to demonstrate the LCA process and opportunities on our projects to new hires.
- Development of a work bidding **Embodied Carbon Cheat Sheet** for company leadership to incorporate into project proposals and educate clients.
- Addition of an **"Intro to EC3" presentation** and recording as an educational resource to support others in the EC series.

Michael S. Van Leesten Memorial Bridge. Providence, RI. Image: Kroo Photography

> The SE2050 initiative is targeting halving embodied carbon in our structures by 2030 and getting it to zero by 2050. It is a lofty goal, but actually it is aligned with the goals Buro Happold set out within our Global Sustainability Report. Many organisations across the engineering community share the same ambition, and it is great to see different strands of industries start to think about taking action: we need all strands to tackle their own challenges if we are to make a difference.
>
> Stephen Curtis, Principal, Buro Happold
> Embodied carbon and timber in the USA: in conversation with Buro Happold experts



US Structures Embodied Carbon Playbook

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Buro Happold has made a public commitment to measure and reduce Embodied Carbon ("EC") on all new buildings, major retrofits, and infrastructure projects by 50% by 2030 from a 2020 baseline. Additionally, our US Structures team has joined the SE 2050 program, which includes a commitment to track, reduce, and submit EC data from our projects to the SE 2050 database. This playbook summarizes how our team will approach these commitments on our projects.

Concept Design	Schematic Design	Design Development	Construction Documentation	Construction Administration

DESIGN STRATEGIES + CONSIDERATIONS

Concept Design	Schematic Design	Design Development	Construction Documentation	Construction Administration
☑ Review the US Embodied Carbon Playbook ☐ Discuss EC goals at project kickoff ☐ Identify "big ticket" items leading to EC ☐ Use EC as a metric for comparing early structural design options	☐ Set goals for structural studies and perform structural analysis of study models ☐ Collaborate with architect on optimal structural layout for system and material efficiency ☐ Perform comparative LCA of studies and finalize structural system	☐ Re-evaluate design methods and assumptions in Basis of Design (i.e. loading, serviceability criteria) ☐ Identify opportunities for reducing EC within selected structural systems ☐ Identify top material impacts and opportunities for reduction	☐ Consult General Contractor where possible to identify key material providers and collect EPDs ☐ Consult contractor / CM where possible for constructibility and supply chain feedback ☐ Include EC provisions in structural specifications	☐ Ensure EC requirements are addressed at construction kickoff ☐ Review contractor submittals to ensure specification requirements are being met ☐ Evaluate EC of major design changes

QUALITY ASSURANCE + QUALITY CONTROL

EC considerations should be made during project design workshops & reviews

☐ Review project precedents and lessons learned

☐ Identify opportunities for EC efficiency and reduction with Project Design Review Engineer

☐ Document project lessons learnt

MEASUREMENT + REPORTING

EC measurement is required for all (non-exempt) projects with fees > $100k

☐ Report project on US tracker and assign project EC reporting lead

☐ Report EC measurement at 100% completion of each design phase to the Building Performance Dashboard (BPD) and update US project tracker
Note: Select projects to be submitted to the SE 2050 database by US Structures Sustainability Committee Reporting Lead

CORE TOOLS

BH Structures Embodied Carbon Calculator - web-based and BHoM-enabled EC calculator

Microsoft Excel - simple material takeoffs

Autodesk Revit - advanced material takeoffs

OTHER TOOLS

BH Floor Design Dashboard - quick bay studies

BHoM LCA Toolkit - advanced Revit takeoffs and carbon mapping

SE2050 ECOM

Building Transparency **EC3** - free open-source tool with large supplier EPD database

Buro Happold Embodied Carbon Playbook

Book Tower. Image: Bedrock Detroit

3. Reporting

Buro Happold have set clear reporting targets to ensure that embodied carbon is measured across our project portfolio. As a minimum, all major projects must have an embodied carbon assessment carried out at each design stage in order to track reduction through the design and to benchmark against similar types of projects. The data reported from these reviews is collected in the Building Performance Dashboard, alongside other sustainability metrics such as operational carbon, to give a holistic overview of a design's performance.

Accountability

To ensure that these reviews are taking place and to hold the team accountable, a new project tracker has been developed and released in 2023. This gives an overview of all projects and tracks planned and completed embodied carbon reviews over the project lifecycle. What is monitored is the review process rather than the outcome. This ensures that there is a consistent and rigorous approach to reviews that is becoming part of the normal project workflow.

From the past year, Buro Happold have submitted five projects to the SE2050 database and is committed to submitting a further five over the next year. The projects presented give an overarching view of the work we carry out across all our US offices and encompasses the full range of project scales and types that we work on.

Tools

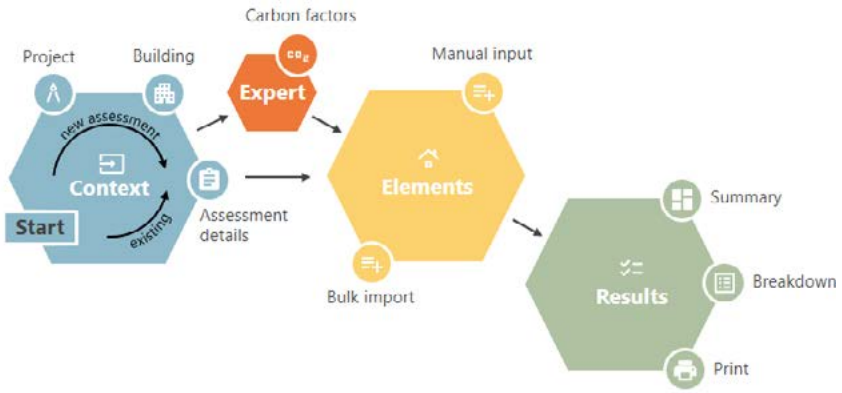
Buro Happold have developed several embodied carbon measurement tools for engineers to utilize and these will continue to be improved over the coming year.

The internal, structures Web-Based Embodied Carbon Calculator has been developed to give an accessible, easy-to-use option for all engineers. This has a manual data entry function for early-stage assessments as well as a bulk excel import function for handling larger datasets. US EPD values have been uploaded alongside values from around the world and the tool is used globally across all offices. The output from the tool ranks projects on an A-F scale allowing quick comparison to similar projects or between proposed systems. Collation of the output data into several useful charts breaking down the embodied carbon between building components or assessment stages allows designers to target reduction efforts where they have the greatest impact.

The award-winning open sourced and publicly accessible Building Habitats and Object Model (BHoM) LCA toolkit will continue to be developed over the coming years for linking directly to data from BIM software such as Revit or Rhino. The toolkit consists of a suite of tools for measuring the embodied carbon of any building material at any stage of design and compares it to benchmarked datasets. This is useful for early comparative studies as well as being listed as an approved tool by the International Living Futures Institute for the Living Building Challenge.

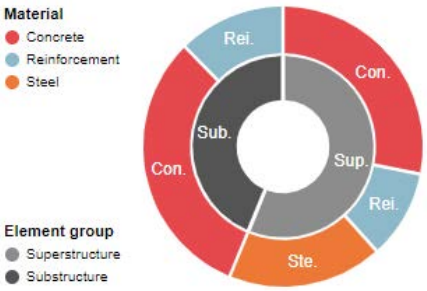
This is a demonstration of the power of the collective to build a machine and develop a taxonomy for the industry. It could have a profound impact on the way we do things."

Jury comment from the 2020 Innovation Awards for the BHoM Life Cycle Assessment Toolkit

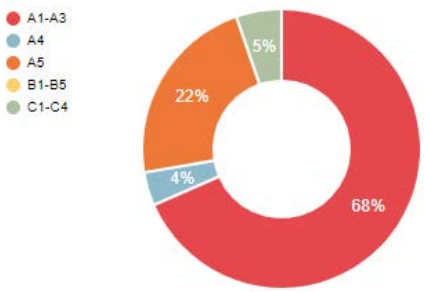


Workflow and Output from BH Structures Web-based Embodied Carbon Calculator

Embodied Carbon Material Split



Embodied Carbon Module Split



4. Embodied Carbon Reduction Strategies

Innovation is deeply engrained in the history of Buro Happold, through early pioneering work with tensile membrane structures to delivering world class iconic buildings. Throughout this history our clients have valued our efficient designs and sustainable approach to structural engineering. Reducing the embodied carbon of our designs is an extension of this history and a key aspect of our global firm wide sustainability goals. We aim to reduce the embodied carbon intensity of our designs by 50% by 2030.

As we seek to achieve that goal we are making embodied carbon intensity a key metric in our design process, to be considered together with more established metrics including design requirements, constructability and cost.

We have identified an array of strategies and focuses to reduce embodied carbon in our designs. These include:

Material choice – explore more structural framing options and consider hybrid approaches.

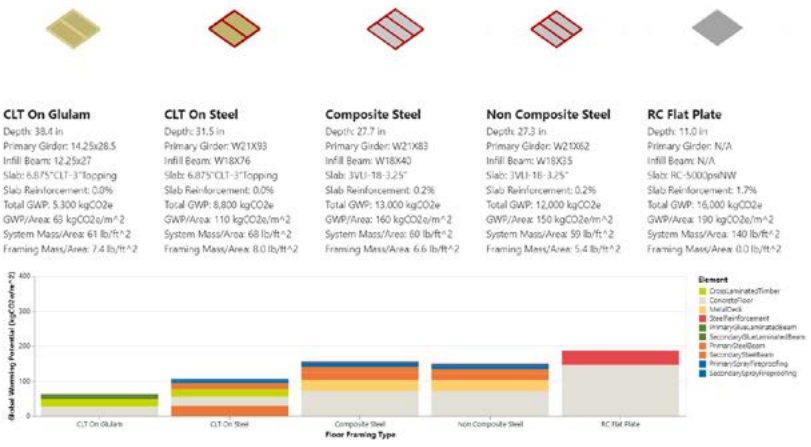
Early Comparative analyses – under comparative analyses of embodied carbon intensity during the initial project phases to assist in material selection decisions.

Material usage – optimize the usage of the materials selected.

Material specification – through our designs, Specifications and General Notes documents drive reductions in embodied carbon, the uptake of new technologies and accountability within the industry.

Embodied Carbon tracking – track embodied carbon intensity during the later project phases.

We are seeing some clients join us in establishing goals to reduce embodied carbon in their projects. Either through challenging us to demonstrate how we will drive reductions or by placing embodied carbon requirement on aspects of the project



Example of Comparative Floor Framing Analysis Dashboard

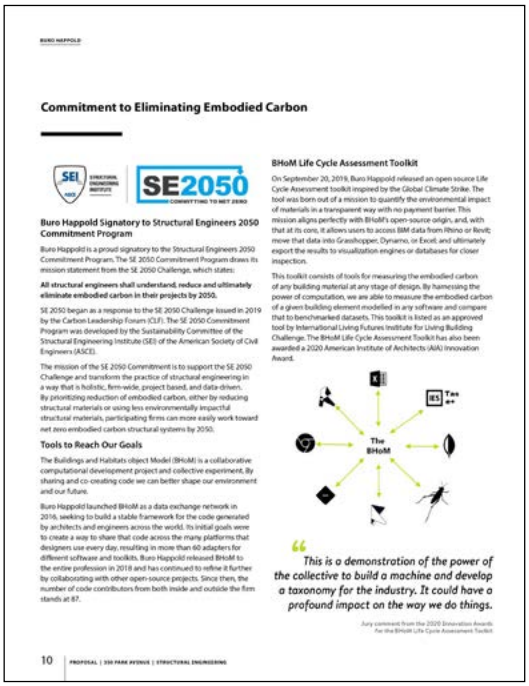
The focus in year three will be on implementing our reporting workflow and using early embodied carbon analyses to inform our design choices and benchmark our progress. Our goals are to reduce embodied carbon by circa 15% every two years as we work towards the 50% reduction goal for 2030.

Harvard University, Science and Engineering Complex. Image: Brad Feinknopf

5. Advocacy

At Buro Happold we recognize the role that embodied carbon holds in a broader building decarbonization effort and embraces structural engineers as critical gatekeepers for reducing embodied carbon. Structural engineers hold tremendous credibility within the design team. We exist to ensure that a building is safe to inhabit. By being a messenger for embodied carbon and reduction strategies relating to structure, that responsibility is extended to a safe planet to inhabit for future generations.

We seek opportunities to share this perspective with our clients, both those that have ambitious carbon reduction goals as well as those who are just learning about the importance of embodied carbon. We achieve this by highlighting our commitment and our approach in qualifications documents as well as including for embodied carbon and life-cycle assessment scope in our offerings.



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Commitment to Eliminating Embodied Carbon

SE2050

Buro Happold Signatory to Structural Engineers 2050 Commitment Program

Buro Happold is a proud signatory to the Structural Engineers 2050 Commitment Program. The SE 2050 Commitment Program draws its mission statement from the SE 2050 Challenge, which states:

All structural engineers shall understand, reduce and ultimately eliminate embodied carbon in their projects by 2050.

SE 2050 began as a response to the SE 2050 Challenge issued in 2019 by the Carbon Leadership Forum (CLF). The SE 2050 Commitment Program was developed by the Sustainability Committee of the Structural Engineering Institute (SEI) of the American Society of Civil Engineers (ASCE).

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, either by reducing structural materials or using less environmentally impactful structural materials, participating firms can more easily work toward net zero embodied carbon structural systems by 2050.

Tools to Reach Our Goals

The Buildings and Habitats object Model (BHoM) is a collaborative computational development project and collective experiment. By sharing and co-creating code we can better shape our environment and our future.

Buro Happold launched BHoM as a data exchange network in 2016, seeking to build a stable framework for the code generated by architects and engineers across the world. Its initial goals were to create a way to share that code across the many platforms that designers use every day, resulting in more than 60 adapters for different software and toolkits. Buro Happold released BHoM to the entire profession in 2018 and has continued to refine it further by collaborating with other open-source projects. Since then, the number of code contributors from both inside and outside the firm stands at 87.

BHoM Life Cycle Assessment Toolkit

On September 20, 2019, Buro Happold released an open source Life Cycle Assessment toolkit inspired by the Global Climate Strike. The tool was born out of a mission to quantify the environmental impact of materials in a transparent way with no payment barrier. This mission aligns perfectly with BHoM's open-source origin, and, with that at its core, it allows users to access BIM data from Rhino or Revit; move that data into Grasshopper, Dynamo, or Excel; and ultimately export the results to visualization engines or databases for closer inspection.

This toolkit consists of tools for measuring the embodied carbon of any building material at any stage of design. By harnessing the power of computation, we are able to measure the embodied carbon of a given building element modelled in any software and compare that to benchmarked datasets. This toolkit is listed as an approved tool by International Living Futures Institute for Living Building Challenge. The BHoM Life Cycle Assessment Toolkit has also been awarded a 2020 American Institute of Architects (AIA) Innovation Award.

"This is a demonstration of the power of the collective to build a machine and develop a taxonomy for the industry. It could have a profound impact on the way we do things.

Jury comment from the 2020 Innovation Awards for the BHoM Life Cycle Assessment Toolkit

Sample Buro Happold qualifications document

Arizona State University, Rob and Melani Walton Center for Planetary Health. Image: Bill Timmerman

In addition Buro Happold is an active advocate about embodied carbon within the wider industry, through committee participation, presentations, articles and publications.

Direct Advocacy for CalGreen Code Amendments for Embodied Carbon (2023)

Embodied carbon choices in action at Arizona State (4/17/2023)

ULI San Francisco Oakland Mass Timber Tour (7/26/23) - Andy Rastetter presented an introduction on embodied carbon and the benefits of mass timber

AIA Chicago Webinar, "Facades and Embodied Carbon: Presented by Buro Happold" (10/19/23) - Luke Lombardi, Paulina Szpiech, Suzanne Provanzana, and John Ivanoff presented

Structural Design of Mass Timber: University of Pennsylvania, Amy Gutmann Hall (11/8/23) - Eric Harvan and Stephen Curtis o-presented to DVASE

"Waste Not, Want Not: Architects and Engineers Reduce Construction's Excesses and Minimize Carbon Emissions through Reuse" (2023) - Article in Architectural Record which Luke Lombardi contributed to

UC Berkeley ARCH 150 Structural Sustainability Guest Lecture (11/28/23) - Luke Lombardi presented to undergraduate lecture class at Berkeley

AIA CA Webinar, "Strategizing for Success: How to Design and Procure Low Carbon Concrete" (11/30/23) - Luke Lombardi presented

CALGreen Embodied Carbon Series: Whole Building Life Cycle Assessment for Code Compliance (3/13/24) - Luke Lombardi presented

NASCC Presentation on Adaptive Reuse at Minnesota Zoo (3/21/24) - Fraser Reid presented

CALGreen Embodied Carbon Series: Implications of Material Procurement for Design Professionals (4/10/24)

Toward a Hybrid City: "Inter-Building" with Mass Timber (4/11/24) - Eric Harvan co-presented to AIA New York

ULI NEXT Educational Presentation on Sustainability and Embodied Carbon (4/17/24) - Andy Rastetter presented

Our goal for the future is to continue our work towards holistic carbon assessments, drive the adoption of low carbon technologies, and approaches and to share our lessons learned.

We are proud to support the SE 2050 initiative and highlight this to our collaborators.

Buro Happold signs Structural Engineers 2050 Commitment Program

Crystal Bridges Museum of American Art. Image: Timothy Hursley

6. Appendix - Project Spotlights

> Buro Happold is clear in its mission to be recognised as a leader in sustainability. We must focus on delivering a sustainable and equitable built environment, delivered with the power of collective action across our industry.

Duncan Price, Partner and Global Sustainability & Climate Change Lead at Buro Happold

Minnesota Zoo Treetop Trail. Image: Gaffer Photography

Minnesota Zoo Treetop Trail

Apple Valley, MN

Completed 2023

Reimagining a decommissioned asset

Located on 485 acres, the Minnesota Zoo is the fifth largest zoo in the US – home to more than 4,400 animals, with 68 threatened and endangered species among the 485 species seen by more than 1.2 million visitors each year.

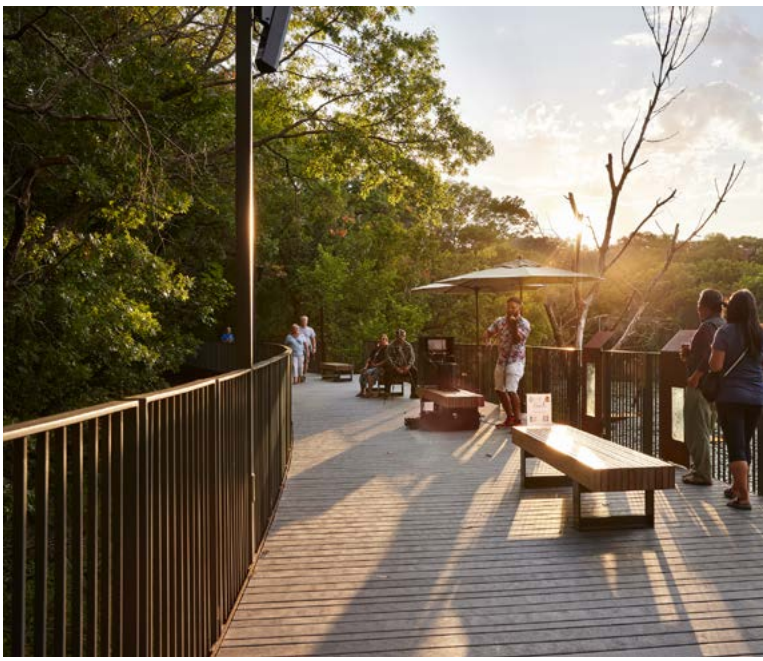
Influenced by our work on New York City's High Line elevated park, the Zoo worked with Buro Happold, Meyer Borgman Johnson (MBJ) and Snow Kreilich Architects to transform a former 1970s monorail track into the world's longest elevated pedestrian loop. The new trail weaves its way through the zoo on a 1.25-mile journey over wildlife exhibits, lakes, and marshes and through the forest canopy.

Due to the limited capacity of the existing structure and its sensitivity to additional loading, the initial engineering analysis was critical to defining the design basis for the new trail. The width of the walkway and material selection then had to be carefully tuned to limit the level of required structural strengthening. The project team tested multiple options and scenarios for trail width and decking system, which led to the selection of a lightweight steel-framed decking system to match the original Corten structure.

The steel-framed decking system provided the lowest embodied carbon option and enabled the trail to be constructed in prefabricated modules, which was a key consideration due to the access constraints of the site. Based on the scale of the existing structure, unique site conditions and limited access, the team conceived an ingenious construction approach using a custom trolley system which was built to ride along the existing monorail beam. This enabled access across the entire length of the trail and allowed the zoo to remain operational throughout the duration of the project.

The trail incorporates four distinct "access points" to enhance the user experience, prioritize accessibility, and provide opportunities for respite, wayfinding, interpretation, and enhanced engagement with the zoo's programming and exhibits. Today, the trail stands emblematic of the Zoo's mission: to connect people, animals, and the natural world to save wildlife.

Images: Gaffer Photography



Services

- Structural engineering


LOUIS KAMPER BUILDING
Gig speeds to the most homes.
xfinity

Book Tower Redevelopment

Detroit, MI

Completed 2023

An intricate reimagining of a Detroit landmark

Services

- **Structural engineering**
- **MEP engineering**
- **Lighting design**
- **Energy analytics**
- **Facade engineering**

Originally opened in 1927 as the tallest building in Detroit, the Italian Renaissance-style tower was vacated in 2009 following financial struggles. Bedrock acquired the property in 2015 with a vision to reimagine the building as a vibrant, 500,000 ft2 mixed-use development, featuring a new hotel, retail, office, residential, galleries, restaurants and bars, as well as event, meeting, and green spaces.

Working with ODA and the wider design team, Buro Happold provided multidisciplinary services for this extensive redevelopment of Book Tower and the adjoining Book Building.

Our structures team's careful optimization of the design of the structural upgrade—as well as new MEP equipment with a 20ft high brick screen wall—had a huge impact on reducing the embodied carbon and cost of the project by delivering a major reduction in steel, with an innovative intervention in the design.

Adaptive reuse is considered one of the greenest ways to build. Our experts modelled the amount of embodied carbon saved by retaining the structure compared to tearing it down and building new. Demolition and rebuild would have required more than 9,000 MT CO2e (including 22,000 tons of structural demolition waste and 2,000,000 gallons of water that would be used in dust dampening during the demolition). This compared to an embodied carbon level for the adaptive reuse of just 1,400 MT CO2e—an 85% embodied carbon saving compared to demolition and rebuild.

The redevelopment of Book Tower represents one of the largest adaptive reuse projects undertaken by Buro Happold in North America, offering a successful example of this type of project and providing Detroit with a significant catalyst for its wider regeneration.

Left and top image: Bedrock Detroit

Images: Lake|Flato Architects

University of Pennsylvania, Amy Gutmann Hall

Philadelphia, PA, USA

Completion expected in 2024

Philadephia's first mass timber building

Teamed with Lake | Flato and KSS Architects, Buro Happold is providing structural engineering together with MEP, lighting design and analytics services for the University of Pennsylvania on a new Data Science Building, Amy Gutmann Hall.

The 116,000ft^2, mass timber building's planned academic features include active learning classrooms and collaboration spaces; a data science hub; research centers for new socially aware data science methodologies and novel, bio-inspired paradigms for computing.

The building will be Philadelphia's first Mass Timber building, and at 6 stories, it will one of the tallest Mass Timber structures in the region.

The mass timber structural system both reduces the building's carbon footprint by 52% relative to concrete and 41% relative to steel and creates a warm, tactile and welcoming environment

Services

- Structural engineering
- MEP engineering
- Lighting design
- Analytics

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