Carbon Leadership Forum

EMBODIED CARBON IN THE BUILT ENVIRONMENT: SESSION 4 – Structures and Embodied Carbon

August 21, 2020

www.carbonleadershipforum.org

Carbon Leadership Forum

Research

- Data assessment
- Data methodology
- Policy
- Strategies

Resources

- Newsletters
- Toolkits
- Curricula
- References

Network

- Local hubs
- Focus groups
- Online community
- NGO roundtable
- Members

Initiatives

- SE 2050 Challenge
- EC3 Tool
- Events
- Etc.

Sponsors

- Organizations
- Foundations
- Individuals

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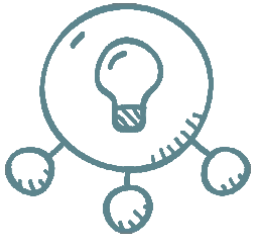
Network Overview

Communication and knowledge building platform



~6,500 members from industry, nonprofits, governments, academia

Common mission to accelerating the transformation of the building sector to radically decarbonize buildings and building materials through collective action

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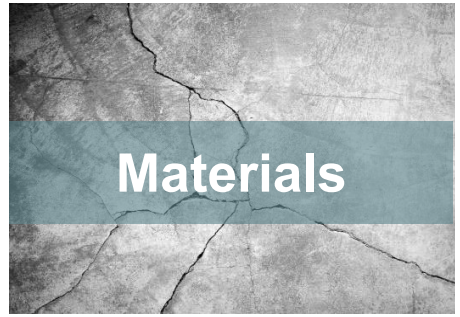
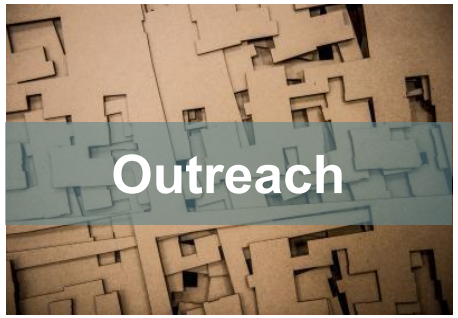
Network Focus Groups: 10+ Focus Groups





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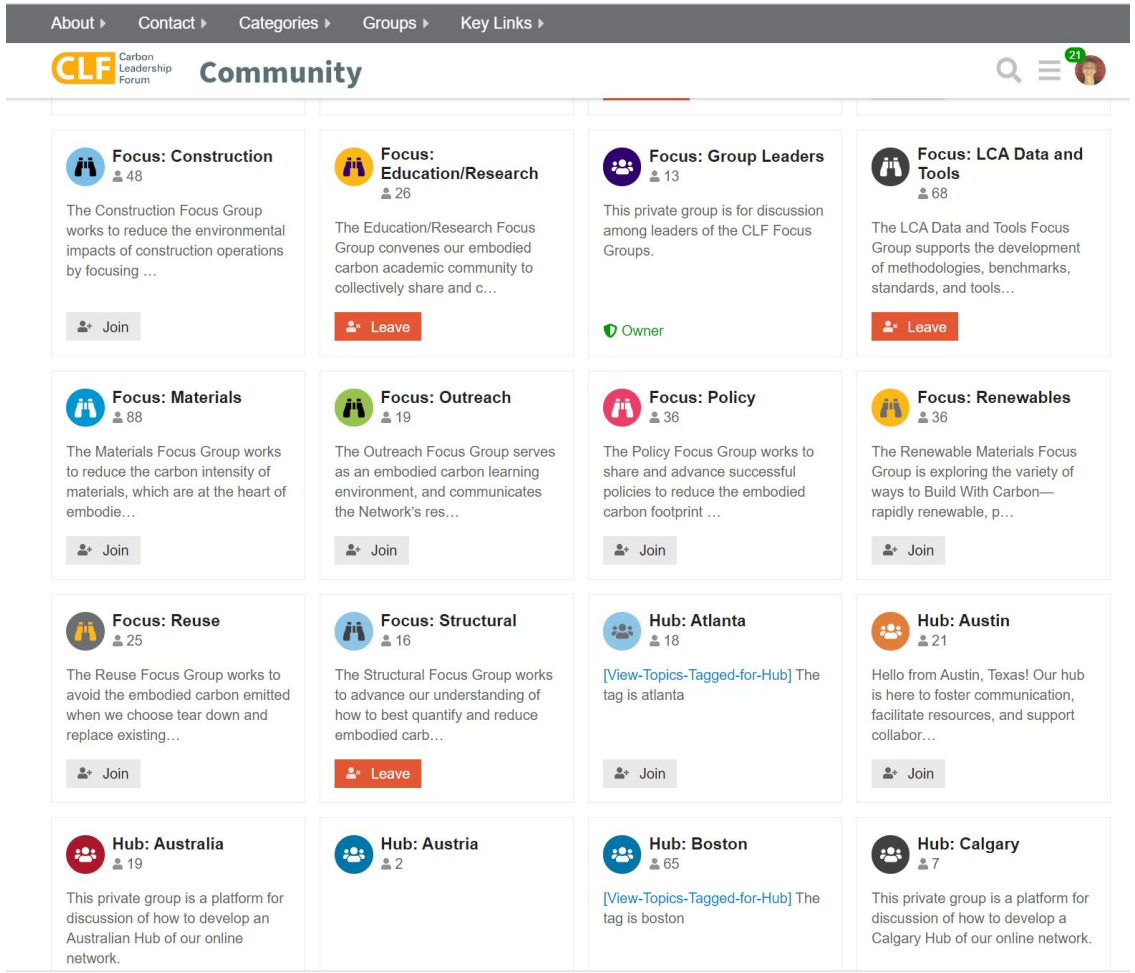
Growing a Global Movement https://community.carbonleadershipforum.org/

- 1,692 Community Users
- 10 Focus Groups
- 29 Regional Hubs
  - Atlanta
  - Austin
  - Boston
  - Chicago
  - Los Angeles
  - New York City
  - Portland
  - Rocky Mountain
  - San Francisco
  - Seattle
  - Vancouver
  - Yellowstone



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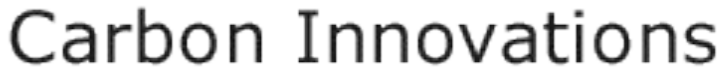

ADRIAN SMITH + GORDON GILL | AIA SEATTLE | AMBIENT ENERGY | ARKIN TILT | BRIGHTWORKS | CLIMATE EARTH | COUGHLIN PORTER LUNDEEN | KATERRA | LMN ARCHITECTS | LUND OPSAHL | NATIONAL READY MIXED CONCRETE CO | NRMCA | SHKS | SIEGEL & STRAIN ARCHITECTS | WRNS STUDIO

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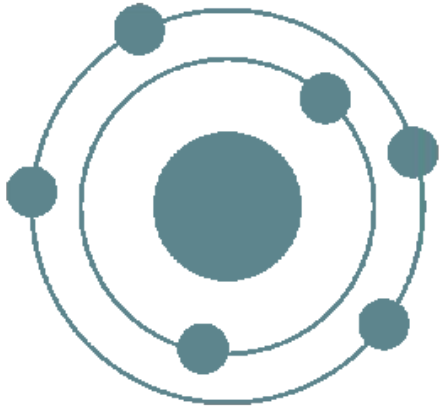
Series Overview

Research, case studies, strategies to measure and reduce embodied carbon

Six online sessions



Subject matter experts

AIA CE Credits

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Disclaimer

Webinar Series Disclaimer

This session is provided as part of the Carbon Leadership Forum's Network 2019 Webinar Series. We invite guest speakers to share their knowledge and insight on topics related to carbon emissions attributed to building materials. The series aims to introduce topics that lead participants to think and talk about building industry strategies for reducing carbon emissions.

Mention of trade names or commercial products does not constitute endorsement or recommendation for use. Please note the opinions, ideas, or data presented by speakers in this series do not represent members of the Embodied Carbon Network or constitute endorsement by the Network.

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Logistics

- 15-20 minute Q&A session after presentations
- To receive AIA continuing education credit: send your AIA member number today to info@carbonleadershipforum.org
- To access past webinar recordings, visit: http://carbonleadershipforum.org/news-and-events/webinars/

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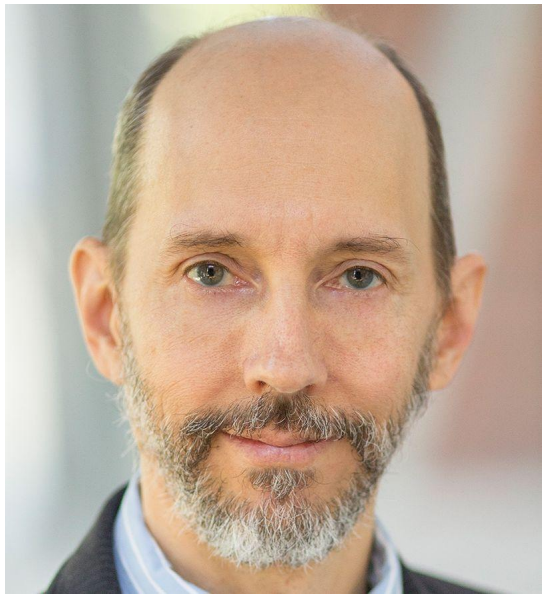
Webinar Overview

Megan Stringer
Associate Principal
Holmes Structures



Mark Webster
Senior Consulting Engineer
Simpson Gumpertz & Heger

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Webinar Overview

Mike Cook
Partner of Buro Happold and Professor of Creative Design in the Department of Civil Engineering at Imperial College

Orlando Gibbons
Structural Engineer
ARUP

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SE2050

COMMITTING TO ZERO

www.SE2050.org

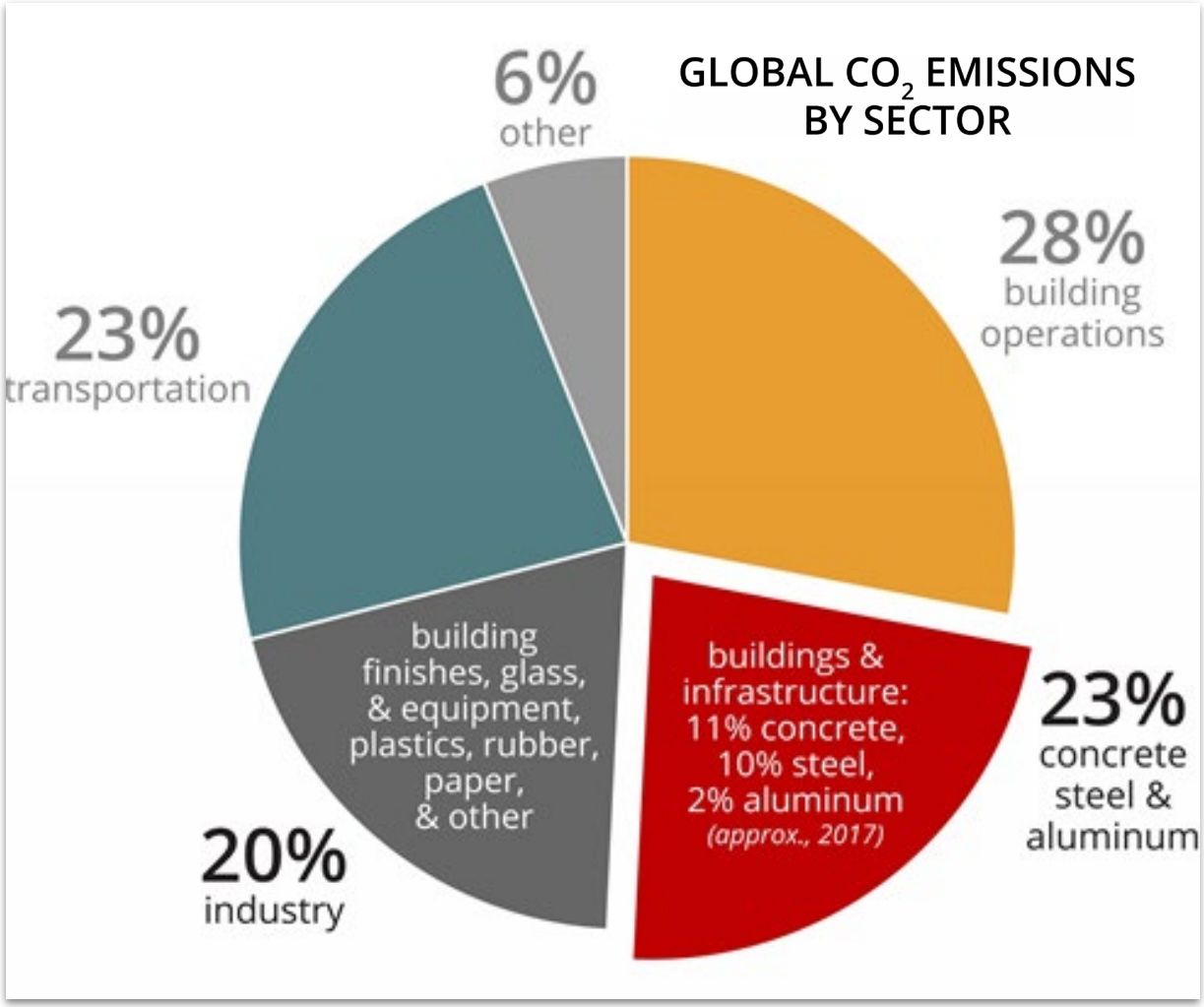
SEI

ASCE

STRUCTURAL ENGINEERING INSTITUTE

Megan Stringer, S.E., LEED AP BD+C
Associate Principal, Holmes Structures
Co-Chair, SEI Sustainability Committee
Megan.Stringer@holmesstructures.com

One quarter of global CO_2 emissions are associated with production of structural materials



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Data Sources: Global Alliance for Buildings and Construction, *2018 Global Status Report*; IEA

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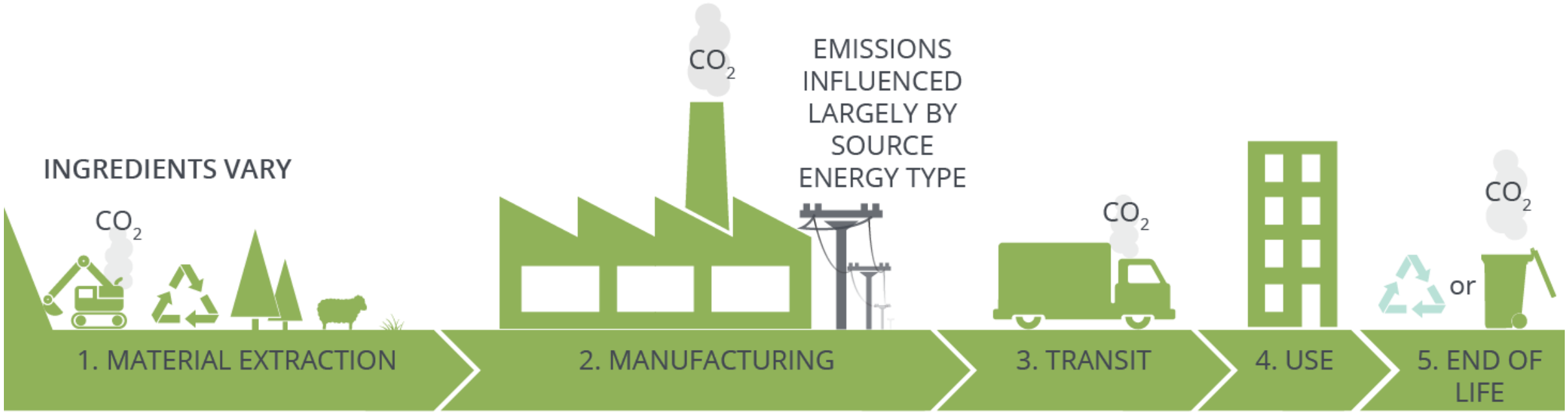
Embodied Carbon = Greenhouse Gas Emissions = Global Warming Potential
(excluding operational carbon)



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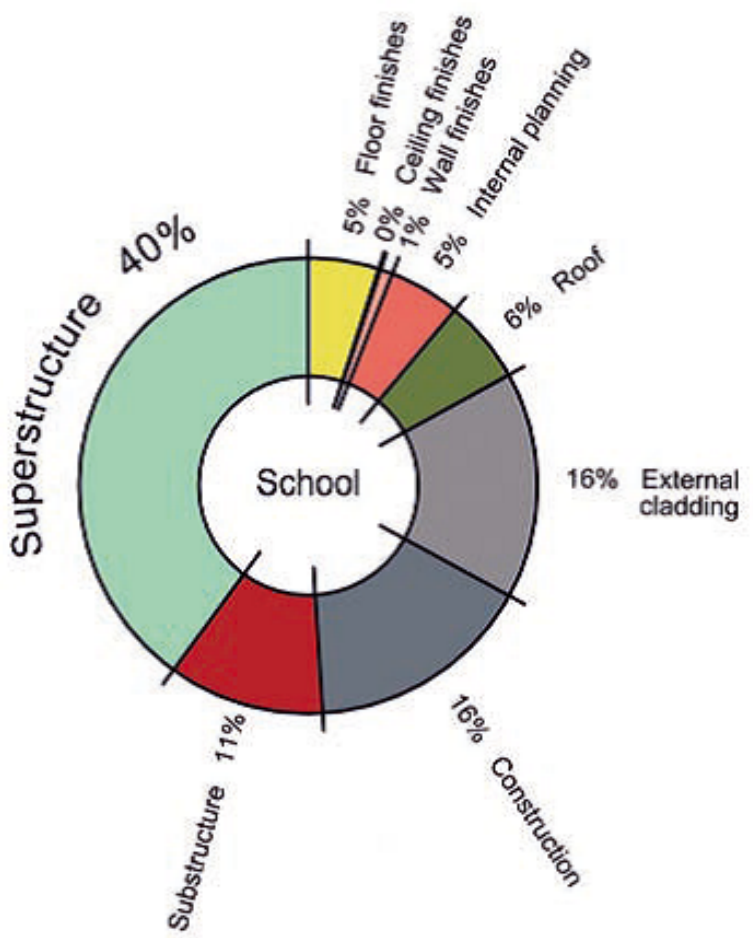
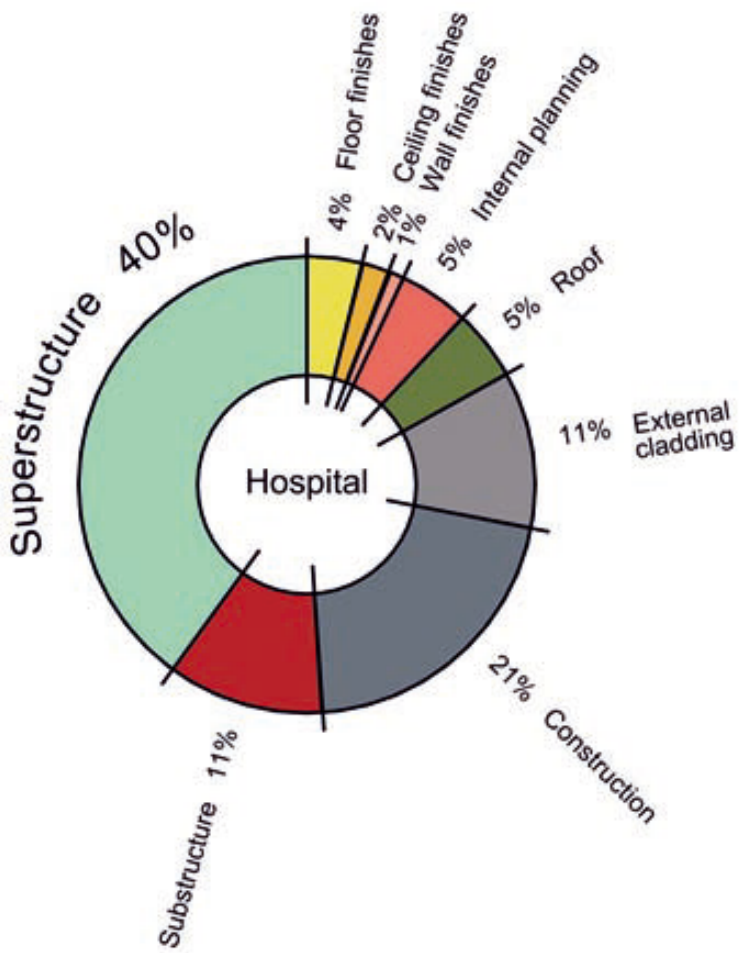
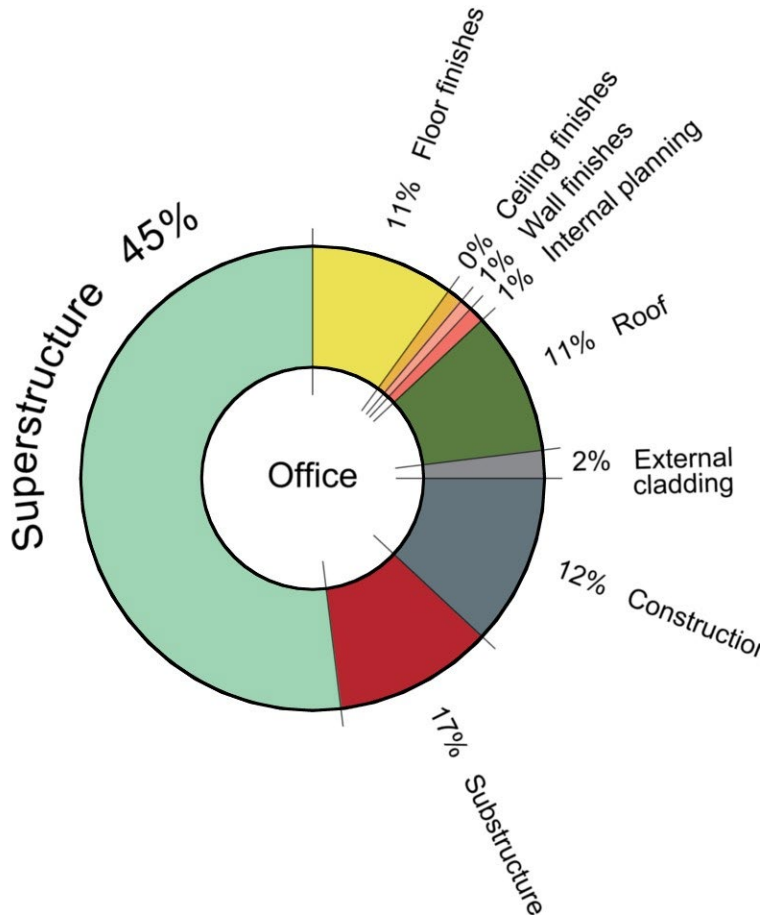
OVER 50% OF UPFRONT EMBODIED CARBON COMES FROM STRUCTURE







Ref: Arup, *Embodied Carbon Study,* Concrete Centre 2012.

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http://www.carbonleadershipforum.org/

SE 2050 *Challenge*

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

Summer 2019

SE 2050 concept was incubated by the Carbon Leadership Forum

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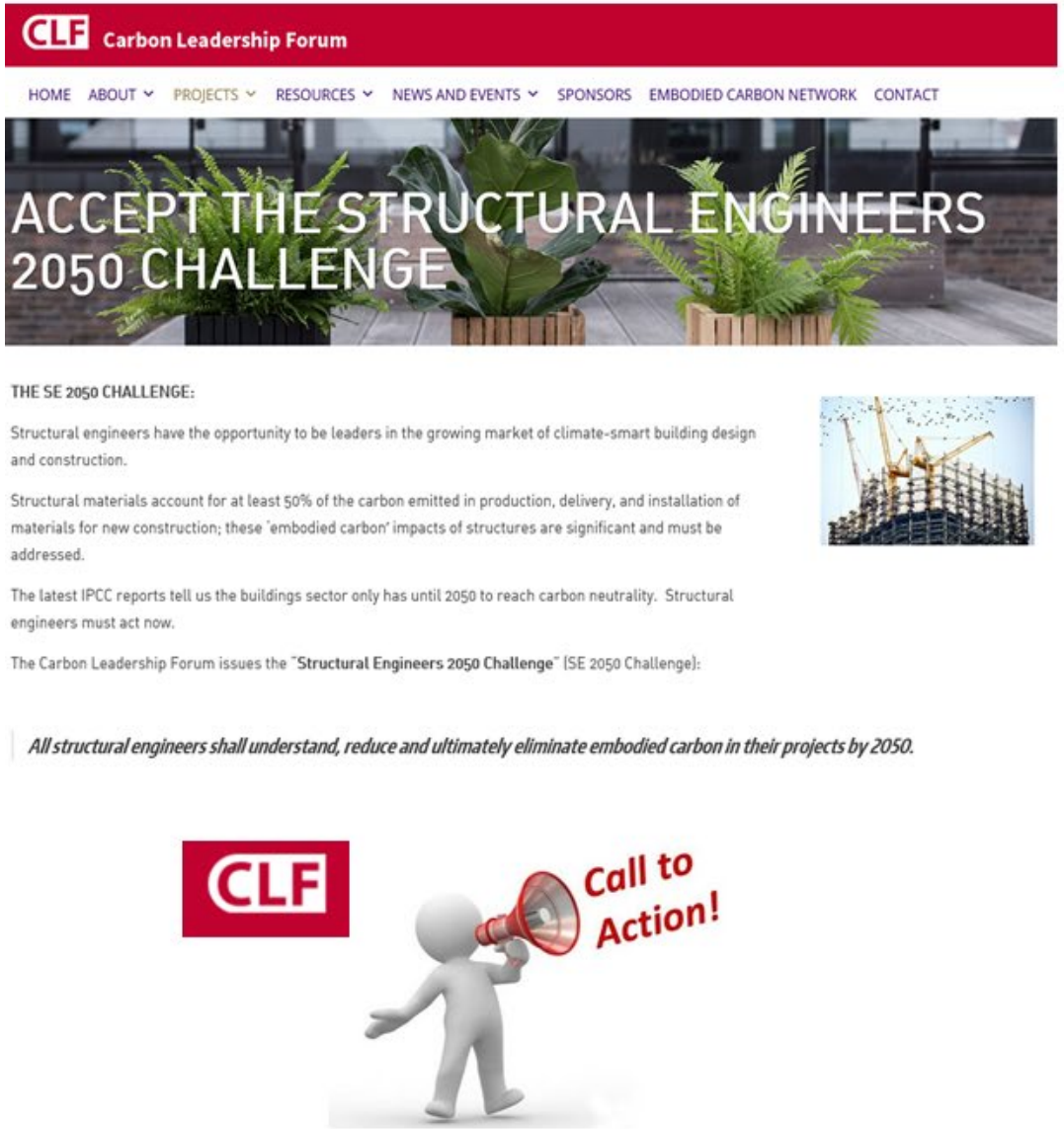

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Launching November 2020

SE2050

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Sustainability Committee

Advancing sustainability in the structural engineering community.

www.SE2050.org

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“Can you include some language in your proposal for embodied carbon?”

“Do you know what embodied carbon is?”

“Does everything have to be timber now?”

“How much embodied carbon in a ‘typical’ floor frame?”

“Will our design be impacted?”

“Isn’t this going to impact my schedule?”

“…[confused look]…”

“How much will this cost?”

“What’s the best way to reduce embodied carbon on this project?”

“Do these embodied carbon numbers look right?”

“There’s NO way you can get to zero by 2050”

“Is that just about adding more fly ash to the mix?”

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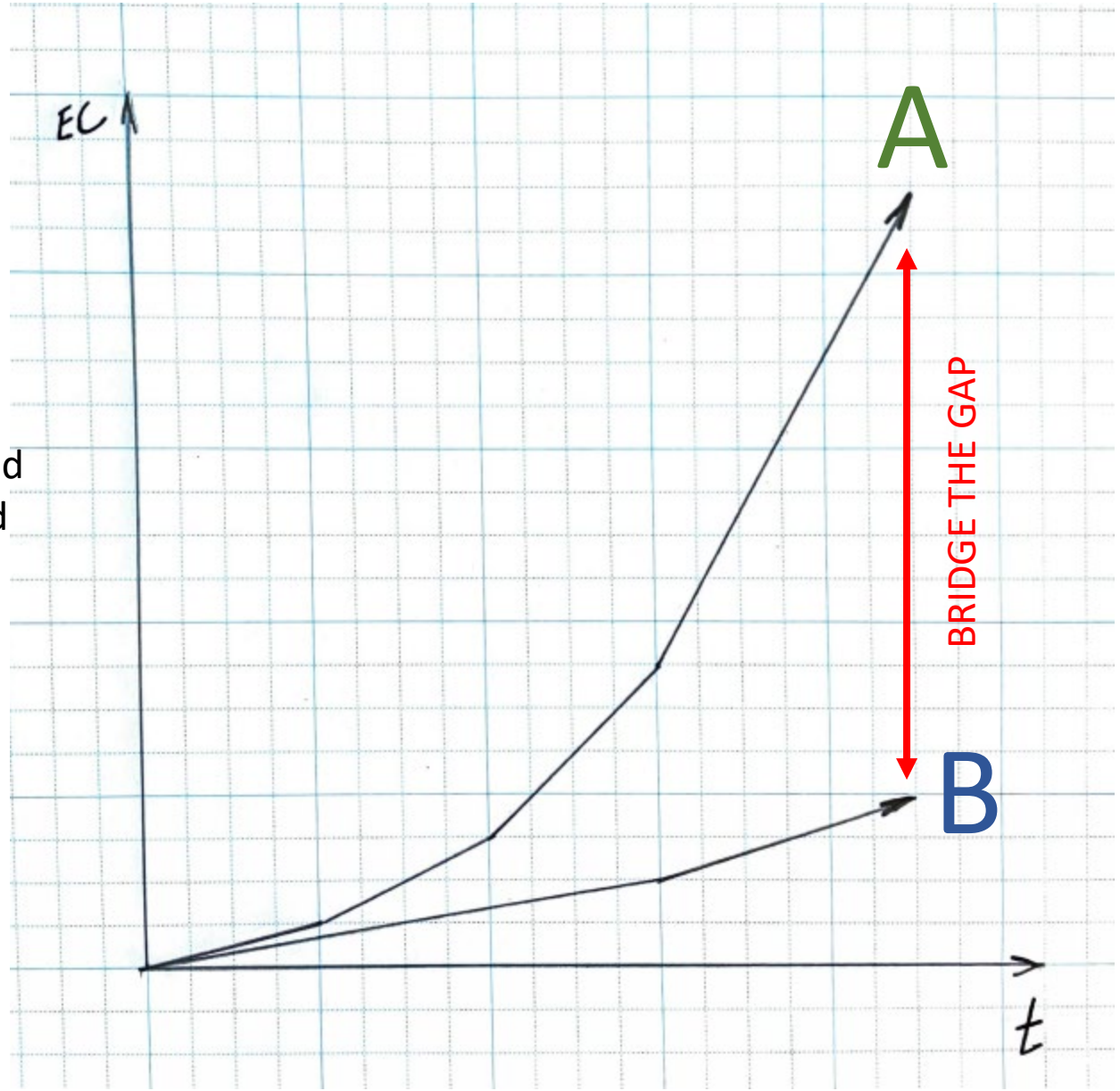
A

- The need is understood
- Increasing focus
- Rapidly increasing enthusiasm
- Let's get to Zero *in a few decades*
- We need SE's to design and specify net zero embodied structural systems *very soon*



B

- What is Embodied Carbon?
- How can I reduce it?
- How much Embodied Carbon in my system TODAY?
- Can we get to ZERO?
- How do I measure Embodied Carbon?
- Standard of Care
- Did Galileo have to deal with this?

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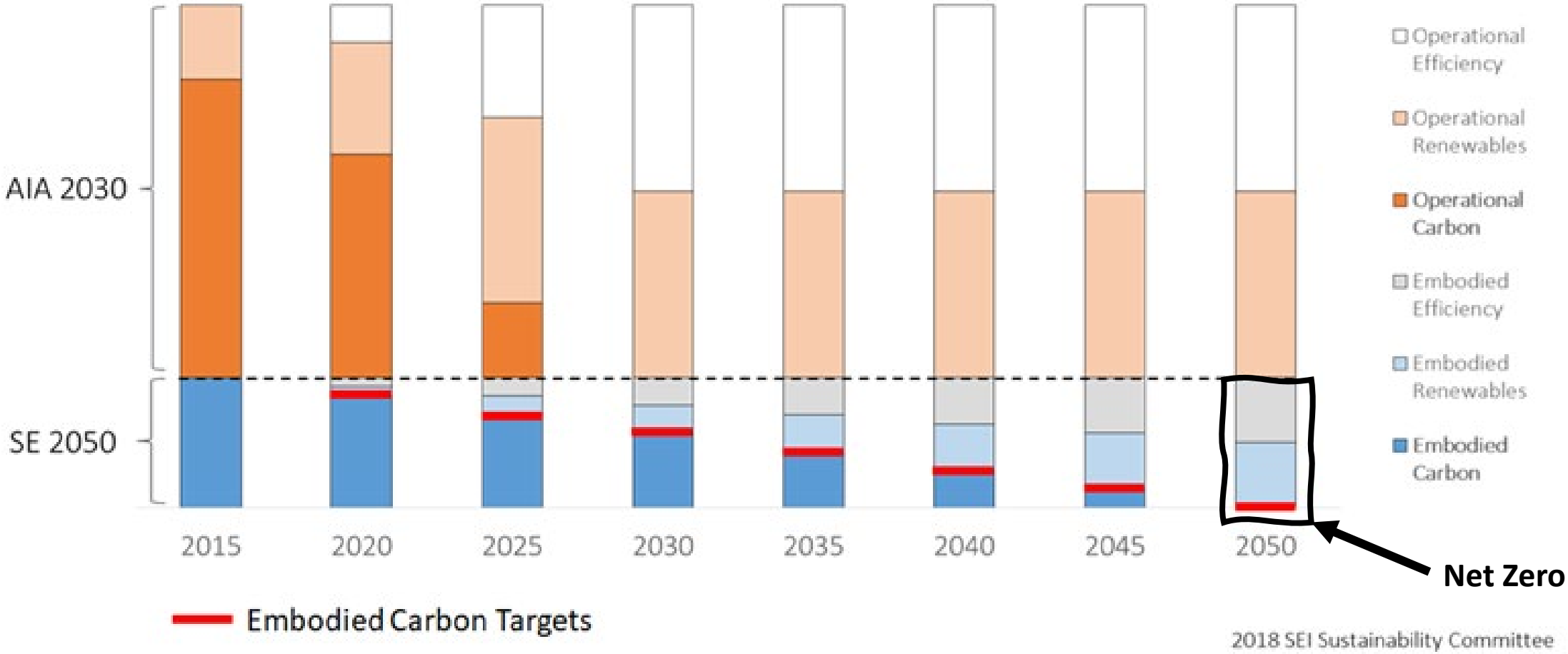
SE 2050 + AIA 2030



2018 SEI Sustainability Committee

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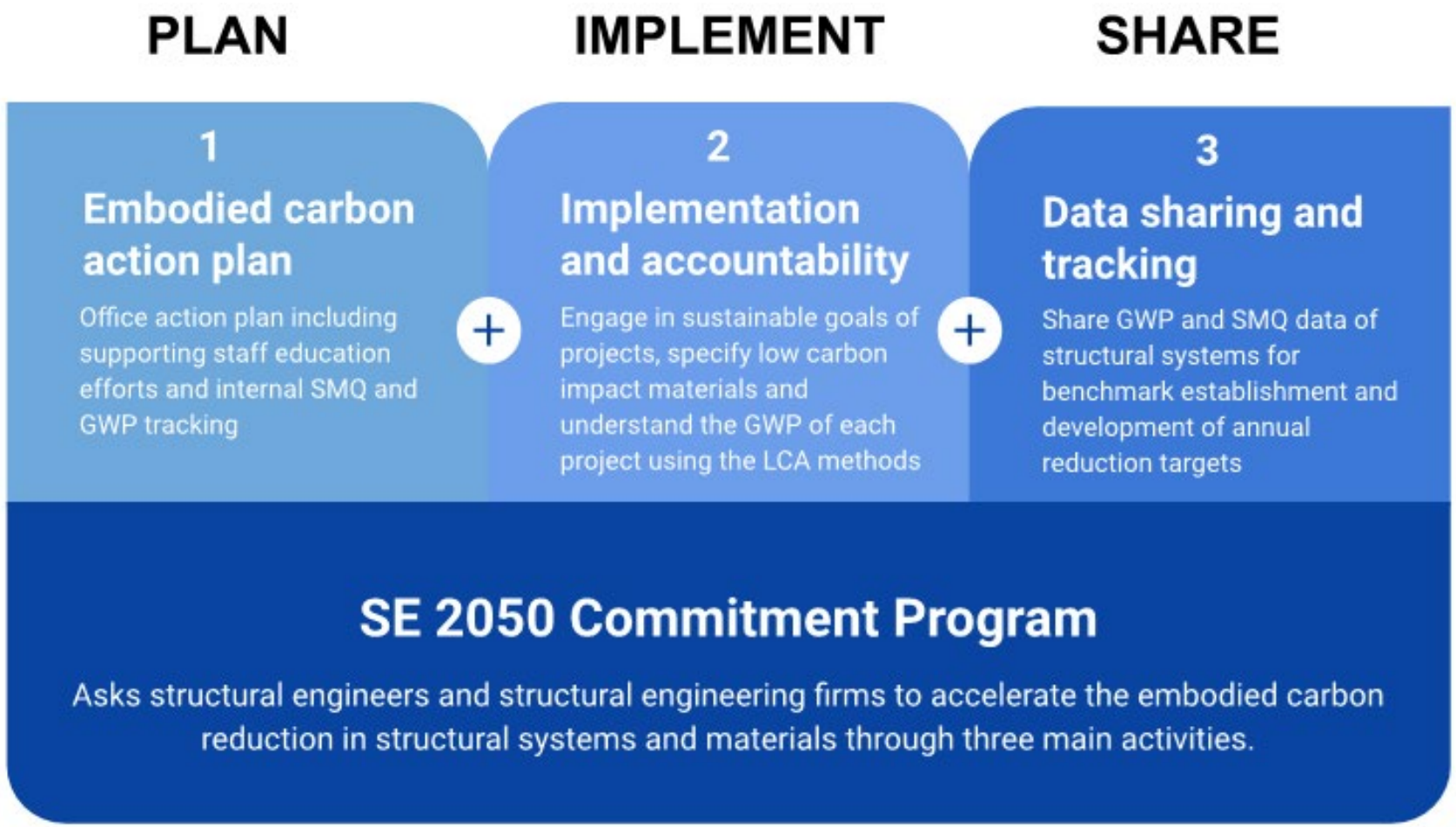

Education, advocacy, accountability, firm culture

2-Way Street Commitment

- Our ask *of* the Profession
- We Commit to Providing Resources and Support *to* the Profession

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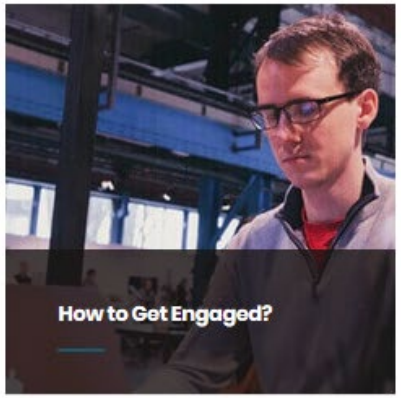
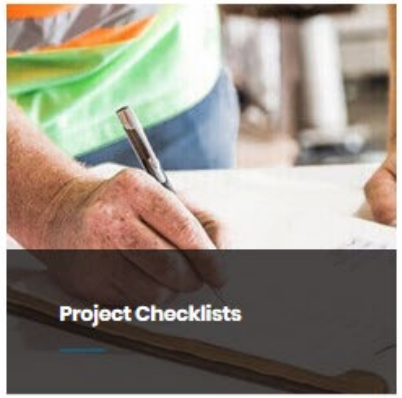
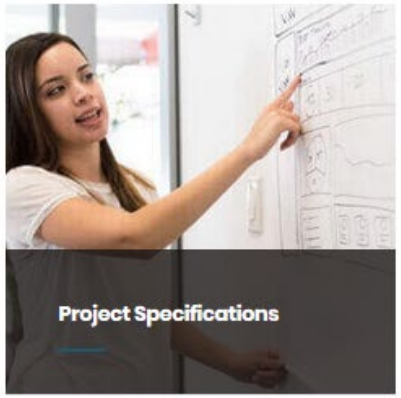
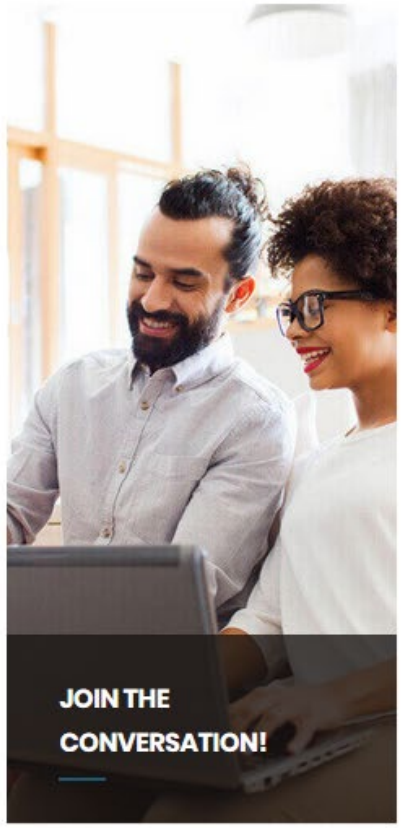
WAYS TO ENGAGE

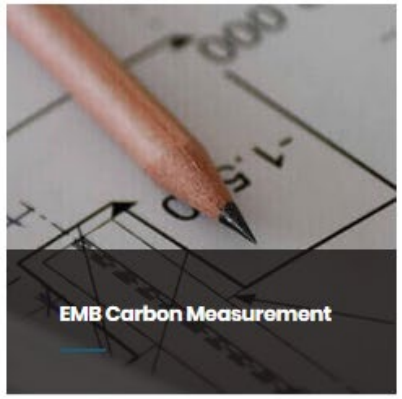
Helpful Resources

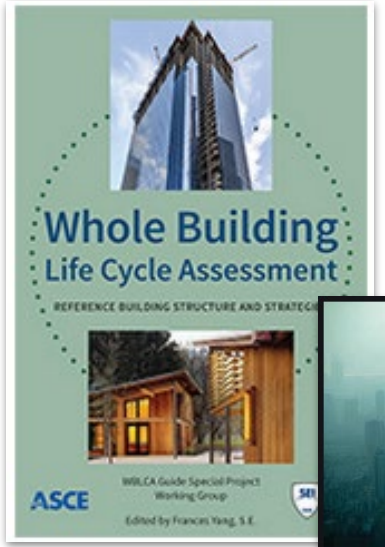


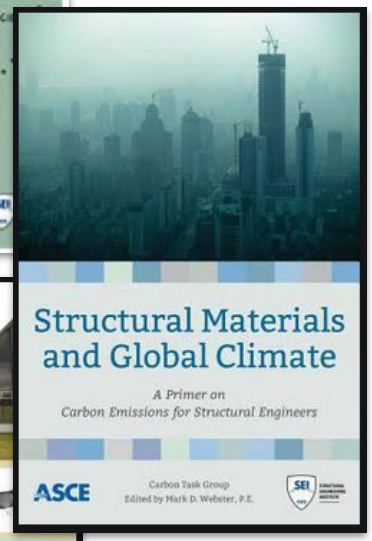


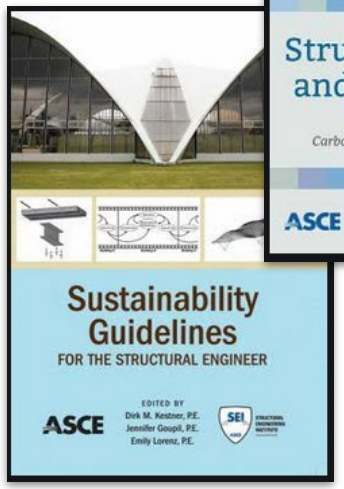












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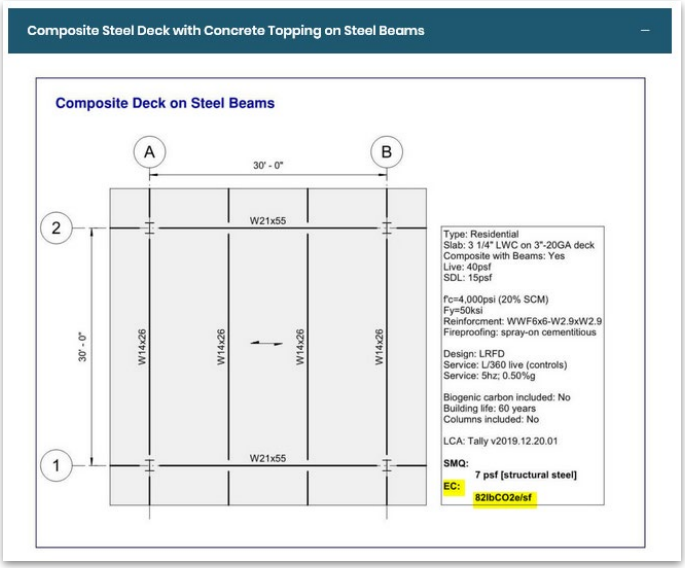

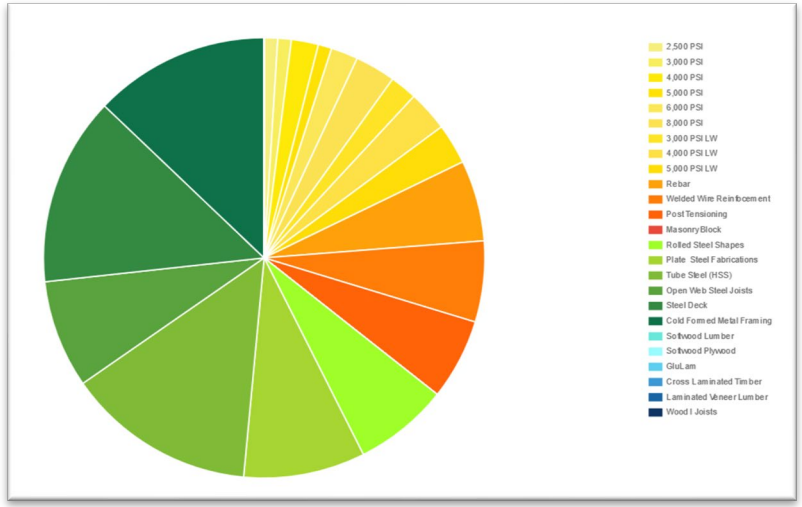

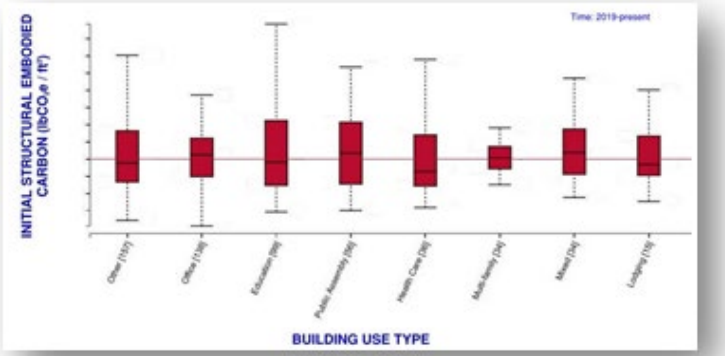

EMBODIED CARBON INTENSITY DIAGRAMS

Check out diagrams of structural material quantities and embodied carbon intensities for typical structural framing schemes to assess where you are against a baseline.

View Diagrams

ECOM

ECOM is a simple embodied carbon estimator to calculate the approximate (E)mbodied (C)arbon (O)rder of (M)agnitude based on your structural material quantities.

Calculate Now

EMBODIED CARBON BENCHMARKS

Check out the national trends of embodied carbon in structural systems that we have collected, and see how your project compares.

View Trends

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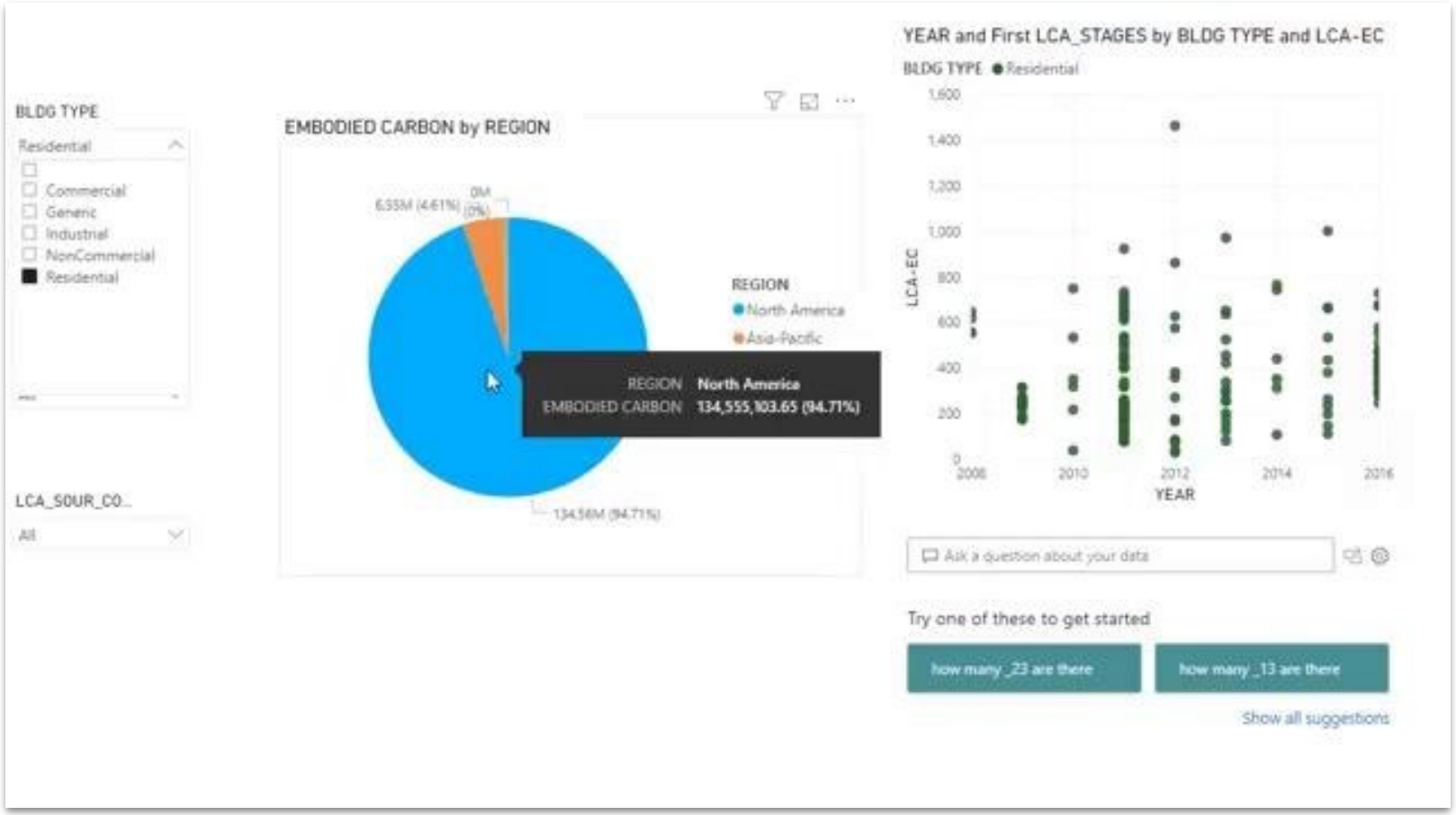

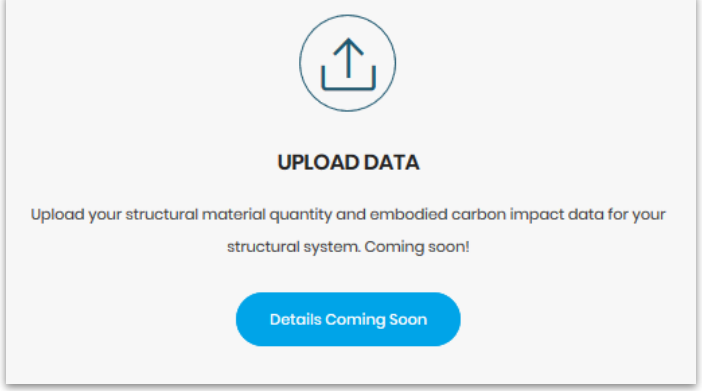

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DDx

AIA

Design

Architects

Contractors

EC3

As-built

Project-Level Connection

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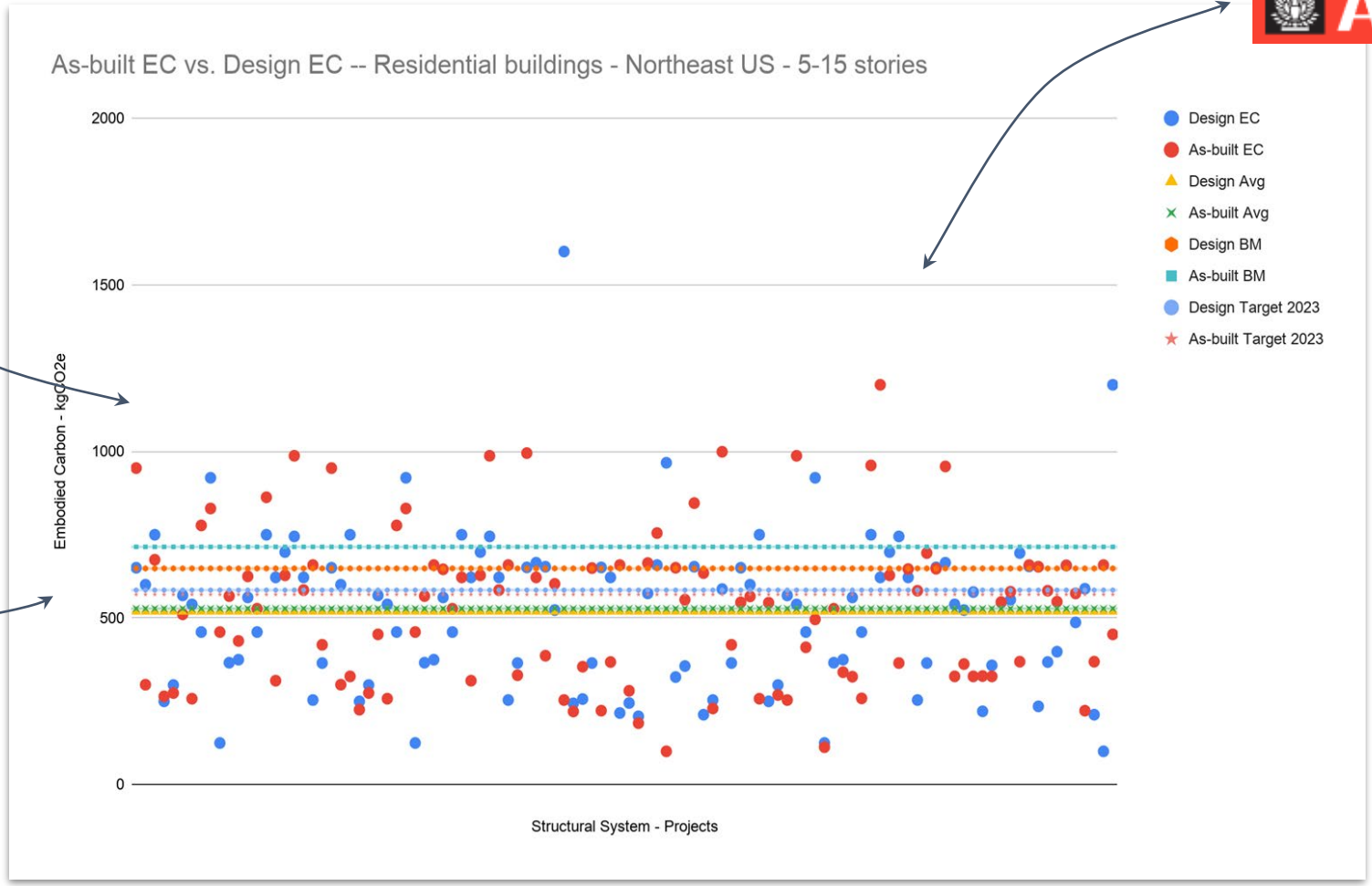
Design

Structural Engineers



NCSEA National Council of Structural Engineers Associations

and beyond..

The Institution of StructuralEngineers

JSCE Japan Society of Civil Engineers

SESOC Structural Engineering Society New Zealand

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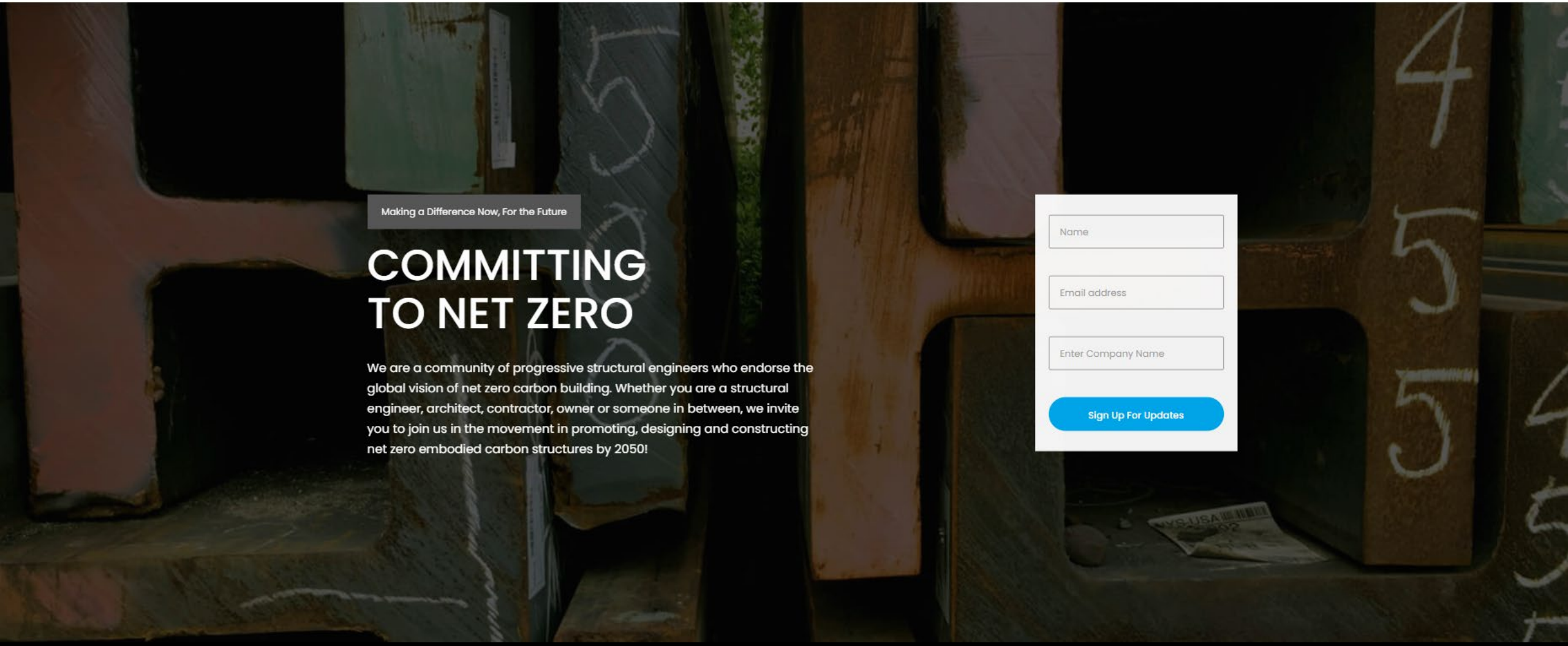

www.SE2050.org

Thank You.

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Associate Principal, Holmes Structures
Megan.Stringer@holmesstructures.com

ACHIEVING NET ZERO/ SE 2050 RESOURCES

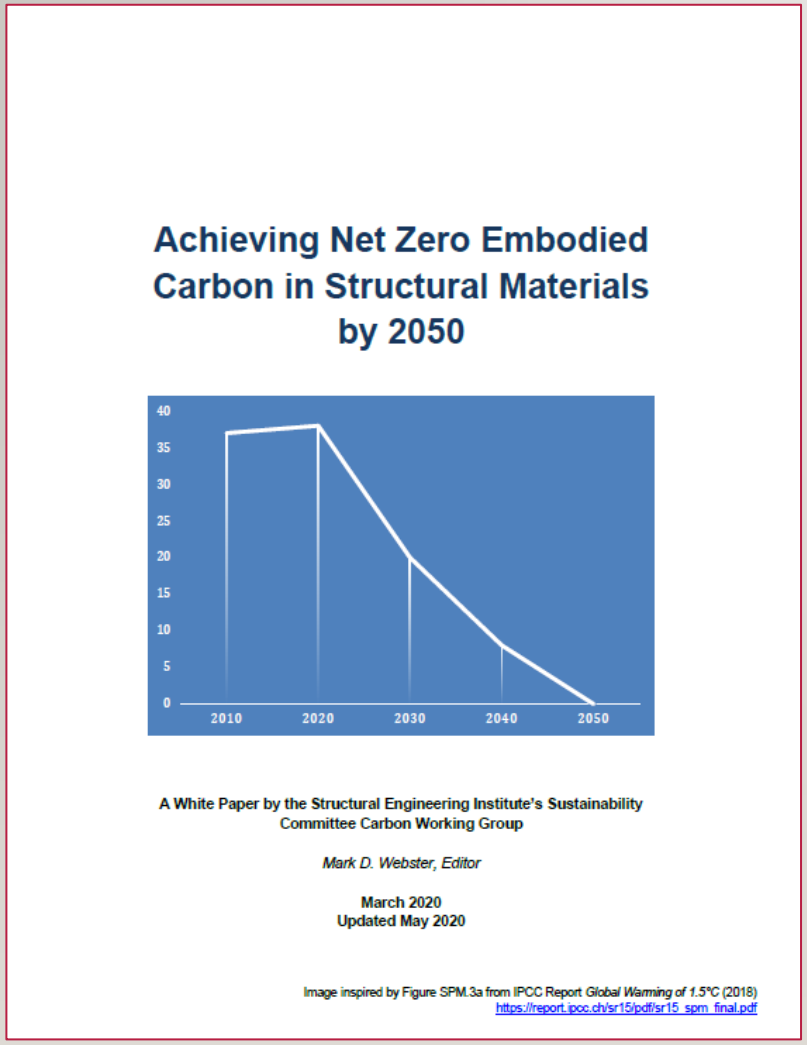
MARK D. WEBSTER, P.E., LEED AP BD+C

SIMPSON GUMPERTZ & HEGER

SIMPSON GUMPERTZ & HEGER

Engineering of Structures and Building Enclosures

ACHIEVING NET ZERO EMBODIED CARBON



- White Paper published in March 2020
- This paper addresses the first question many engineers ask about eliminating embodied carbon in construction:
- *How is that even possible??*

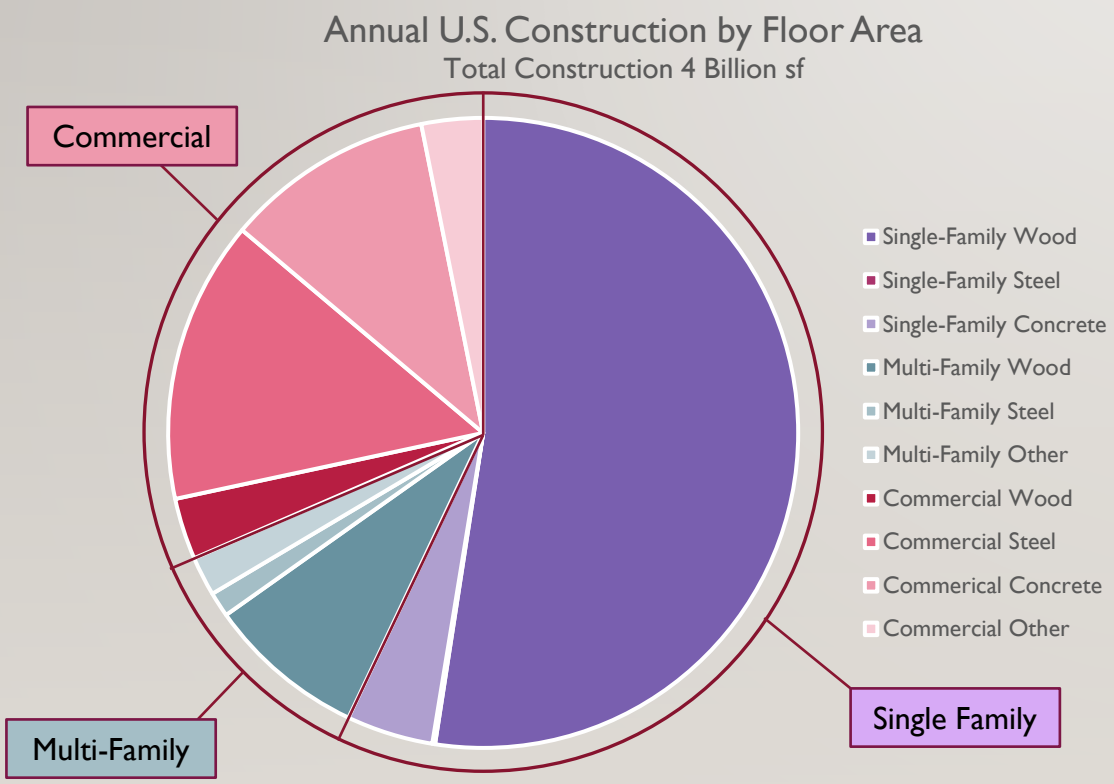
https://seisustainability.files.wordpress.com/2020/05/how-to-get-to-zero-200525.pdf

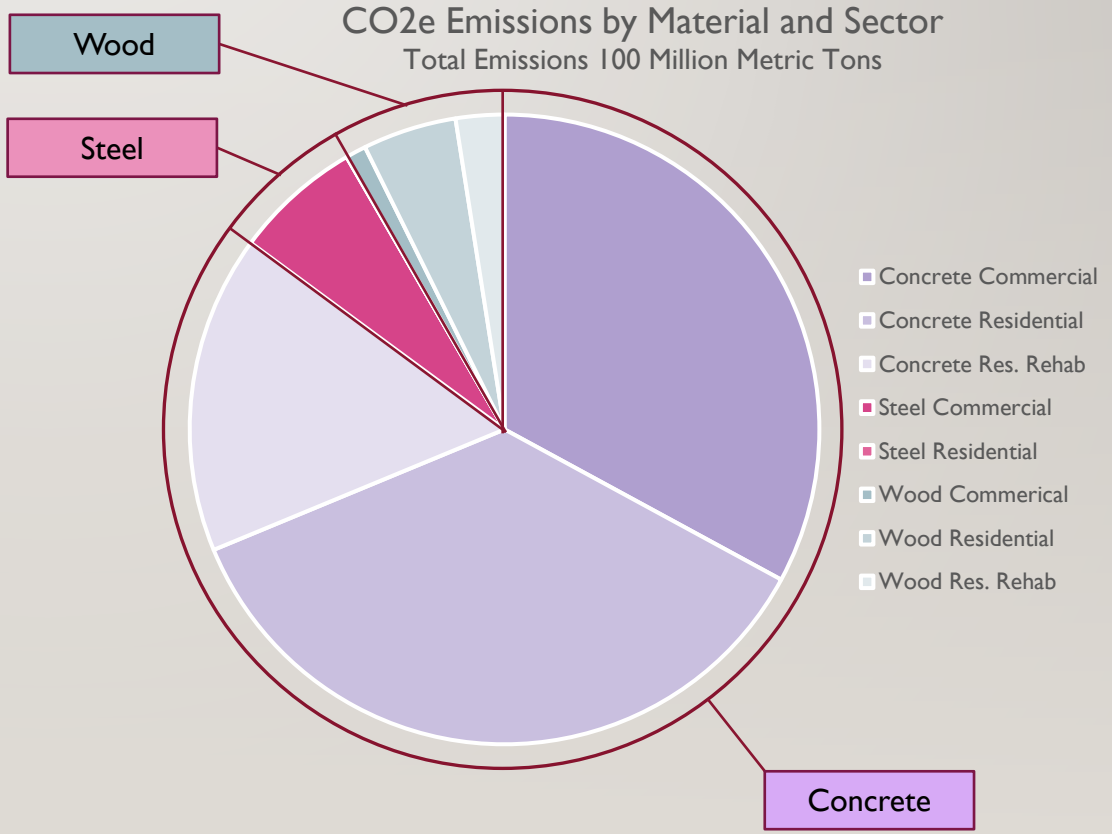
ACHIEVING NET ZERO EMBODIED CARBON

- Defining the Challenge

Takeaways:

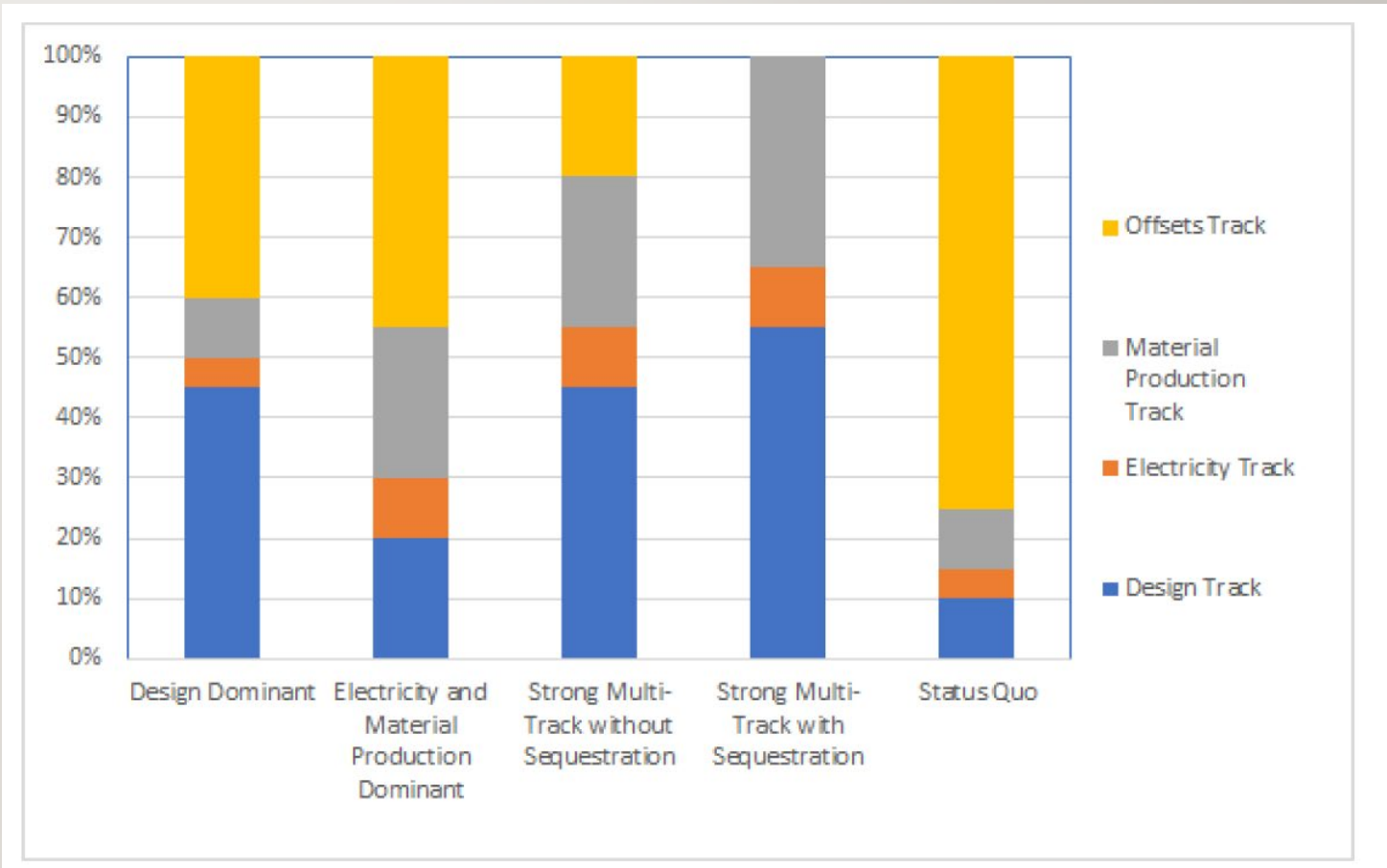
- Residential must be part of the solution.
- Concrete demands the most attention.





ACHIEVING NET ZERO EMBODIED CARBON

- Four Tracks:
  1. Design improvements implemented by engineers and architects.
  2. Greening the electrical grid.
  3. Improving material production.
  4. Carbon offsets.

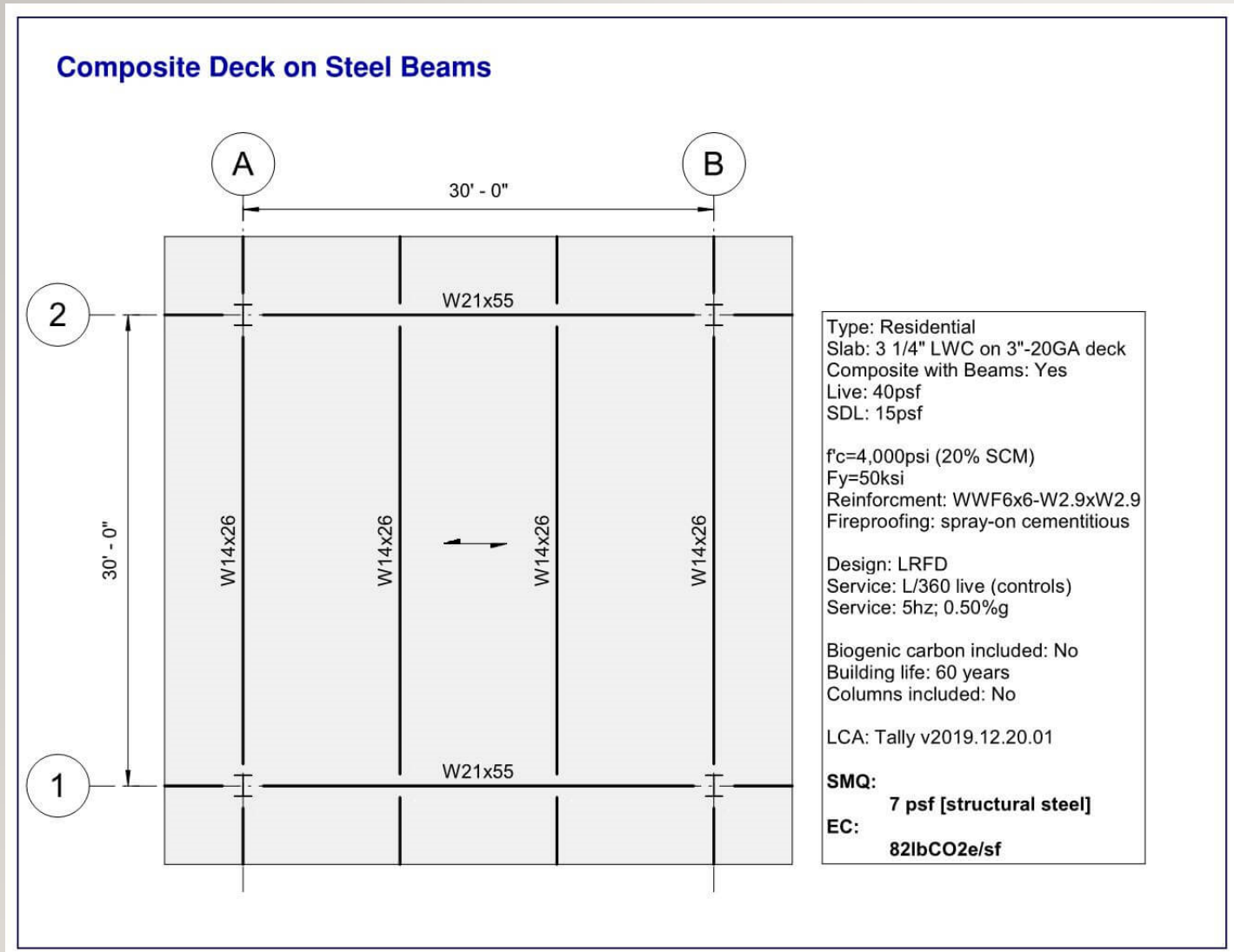


May be combined in different proportions.

SE 2050 RESOURCES

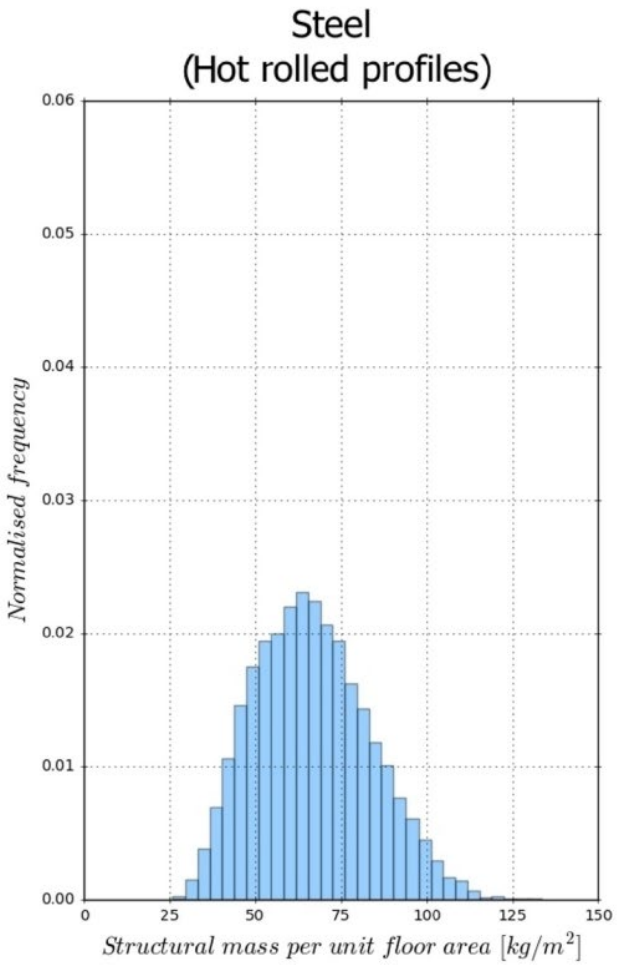
- The Carbon Working Group is currently developing education resources to support the SE 2050 Initiative.
- Resources will be organized into five "buckets."
    1. Embodied Carbon
    2. Materials
    3. Strategies
    4. Tools & Data
    5. Case Studies
- We are developing our own educational resources in addition to linking to outside resources.
- These resources will be available on the SE 2050 website.

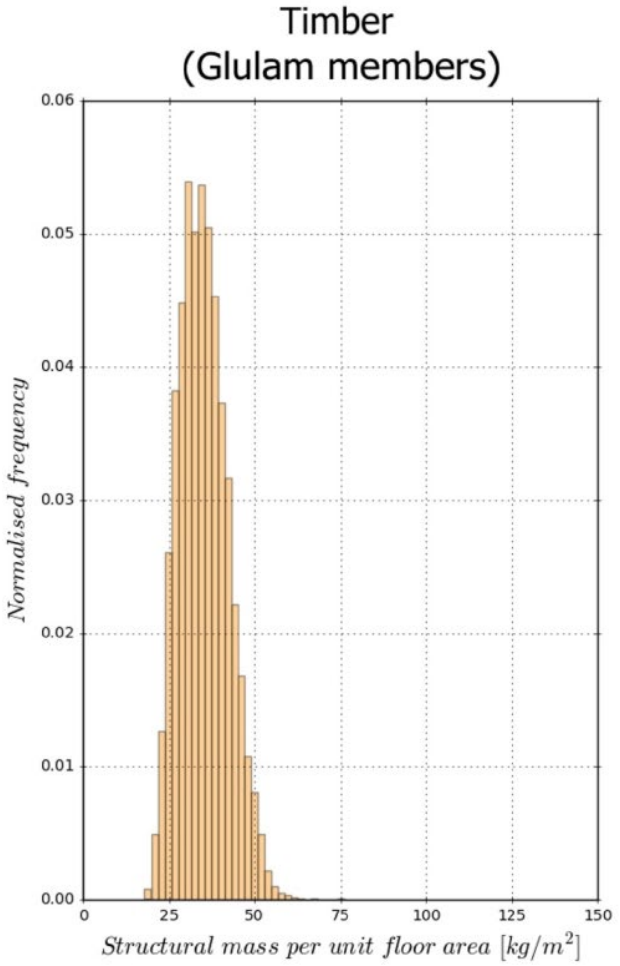
EMBODIED CARBON INTENSITY DIAGRAMS



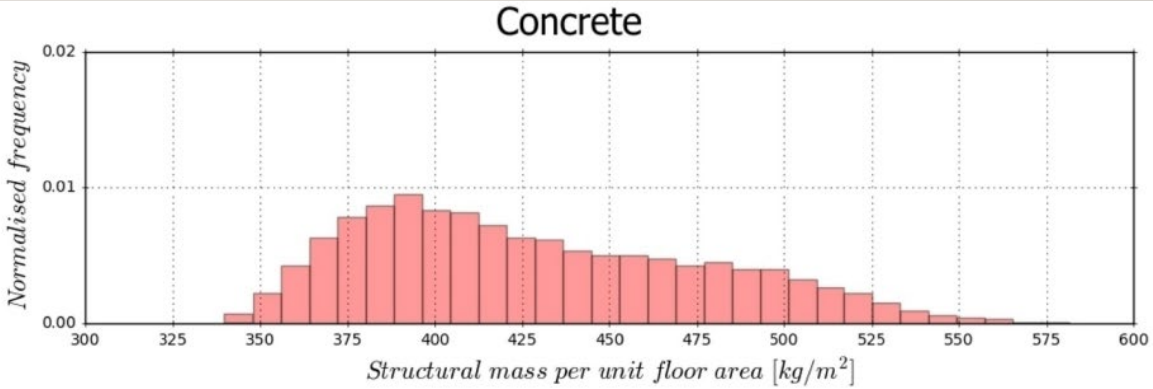
- Embodied Carbon = 82 lb CO_2e/sf
- Planning to add concrete- and timber-framed bays in the near-term, others later.
- Offers basic carbon literacy.

EMBODIED CARBON INTENSITY DIAGRAMS





- Our committee member Jay Arehart of the University of Colorado Boulder is leading an effort to adapt a fascinating parametric study quantifying structural materials in different building types by researchers from Edinburgh Napier University to generate embodied carbon impacts.



TIPS FOR GETTING STARTED WITH EMBODIED CARBON

How Structural Engineers Can Begin to Learn about Embodied Carbon

- Getting Started with Embodied Carbon
- Whole Building Life-Cycle Assessment
- Reducing Embodied Carbon in Structural Materials

How Structural Engineers Can Get Involved with Embodied Carbon Reductions in their Projects

How Architects Can Engage their Structural Engineers on Embodied Carbon Reductions

TIPS FOR GETTING STARTED WITH EMBODIED CARBON

How Structural Engineers Can Get Involved with Embodied Carbon Reductions in their Projects

- Bring EC up with clients: communicate excitement, knowledge, and design to reduce it.
- When writing proposals offer WBLCA services and to attend green building charrettes.
- When working on LEED projects, encourage client to pursue WBLCA credit and offer to help.
- Be ready to provide clients with EC estimates for different structural systems and materials.
- Ask clients if the project has a carbon budget.

THANK YOU!

Mark D. Webster, PE, LEED AP BD+C
mdwebster@sgh.com

For more information check out the
upcoming SEI V-Tech session:
"Sustainability, Embodied Carbon, & SE2050"
15 September 2020 4:00 ET

SIMPSON GUMPERTZ & HEGER
Engineering of Structures
and Building Enclosures

The Institution of Structural Engineers

Climate Emergency Response

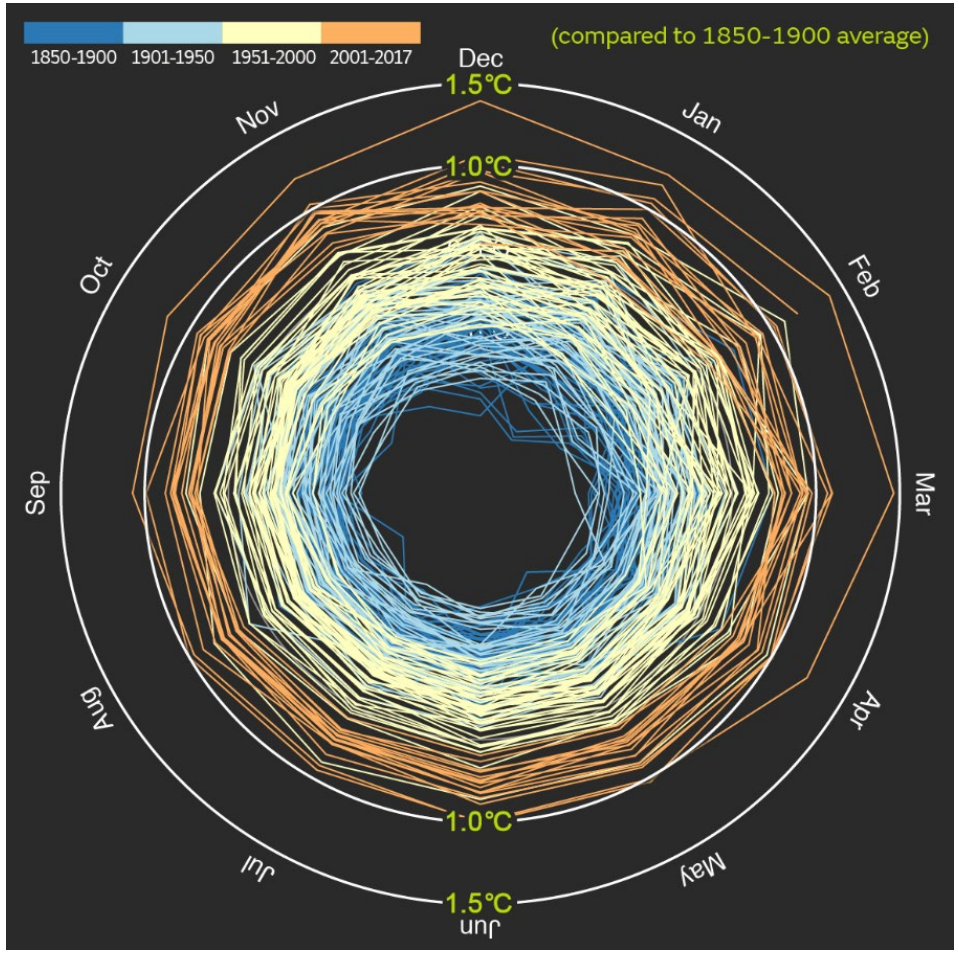
The Creation of a Task Force

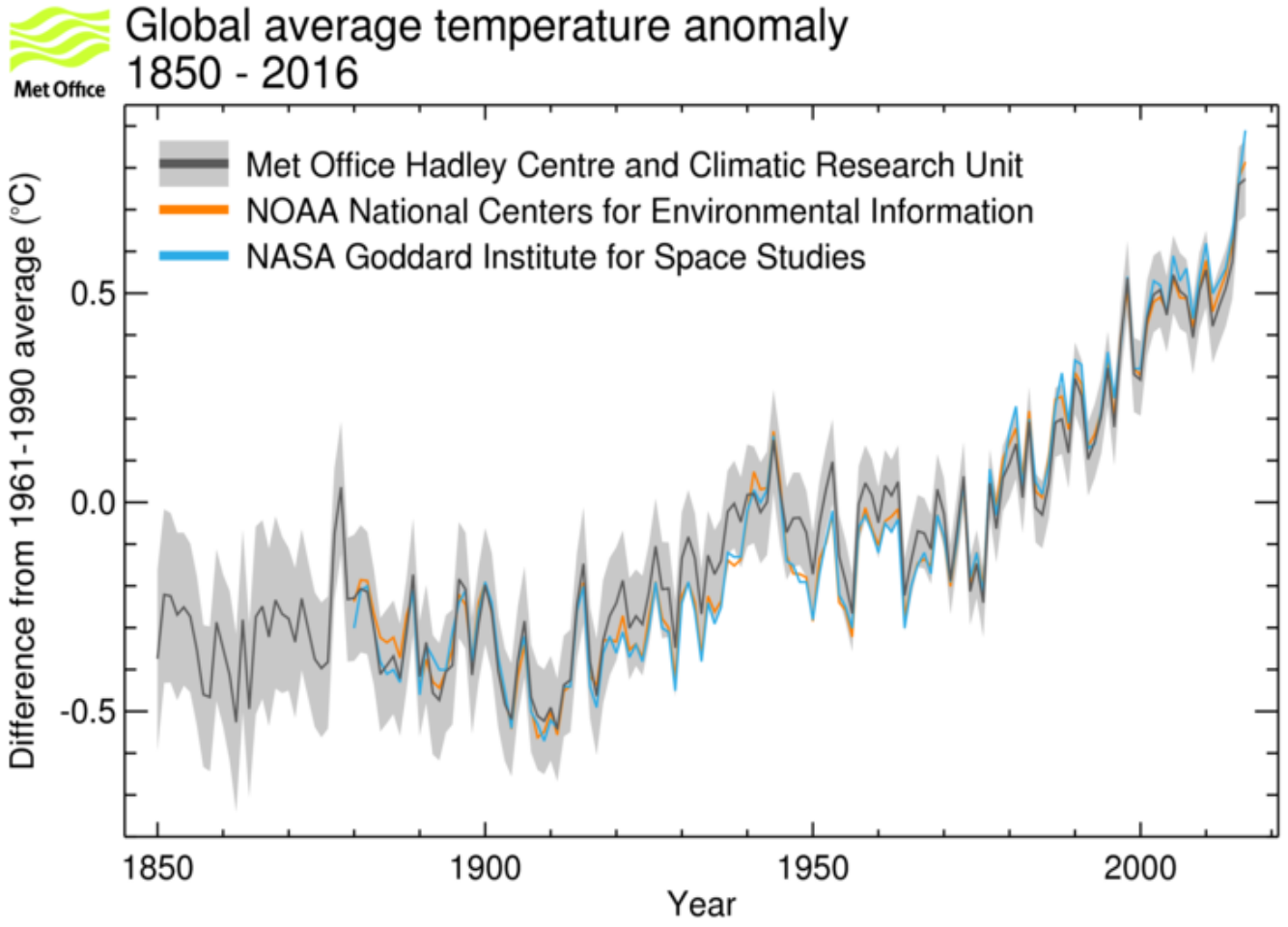
The bigger context for structural engineers: 2018/19

UN Sustainable development goals

Graphics by Jerker Lokrantz/Azote

Climate Emergency: The evidence has become undeniable





Climate Emergency: Destroying the very thing that supports us

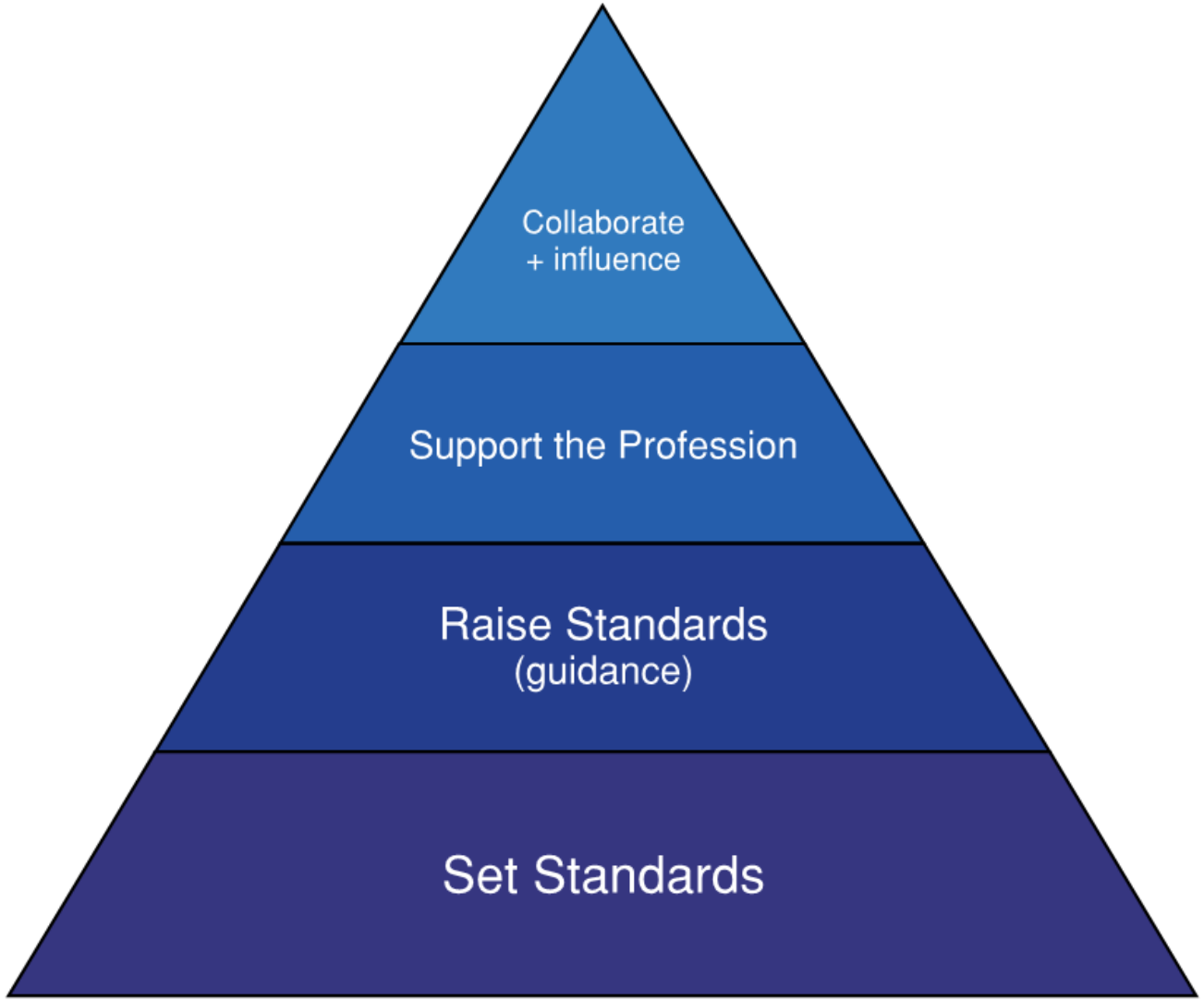
Structural Engineers Declare Climate Emergency June 2019

The crises of climate breakdown and biodiversity loss are two of the most serious issues of our time. Buildings and construction play a major part, accounting for nearly 40% of energy-related carbon dioxide (CO2) emissions whilst also having a significant impact on our natural habitats.

For everyone working in the construction industry, meeting the needs of our society without breaching the earth's ecological boundaries will demand a paradigm shift in our behaviour. Together with our clients, we will need to commission and design buildings, cities and infrastructures as indivisible components of a larger, constantly regenerating and self-sustaining system in balance with the natural world.

The research and technology exist for us to begin that transformation now, but what has been lacking is collective will. Recognising this, we are committing to strengthen our working practices to create structural engineering outcomes that have more positive impact on the world around us.

IStructE Response: Climate Emergency Task Group - Oct 2019



Workstreams

1 Cross-Industry Collaboration *(Mike Cook)*

Working with steering groups of other institutions

Ensure a coordinated effort

2 Supporting the Profession *(Ed Clark)*

Support collaboration between firms

Strengthen collective professional capability

3 Membership Guidance *(Will Arnold)*

Development of guidance/CPD

Materials, lean design, decision-making, brief-setting…

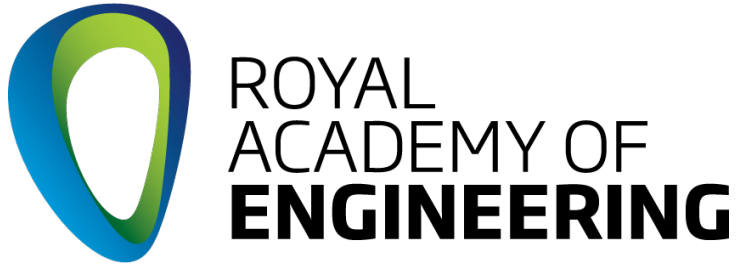
4 Setting Standards *(Tim Ibell)*

Across IStructE committees and panels

Professional standard-setting

1) Cross-Industry Collaboration

Dr Mike Cook – mike.cook@burohappold.com



2) Supporting the Profession

Ed Clark – ed.clark@arup.com

Sustainability Conference

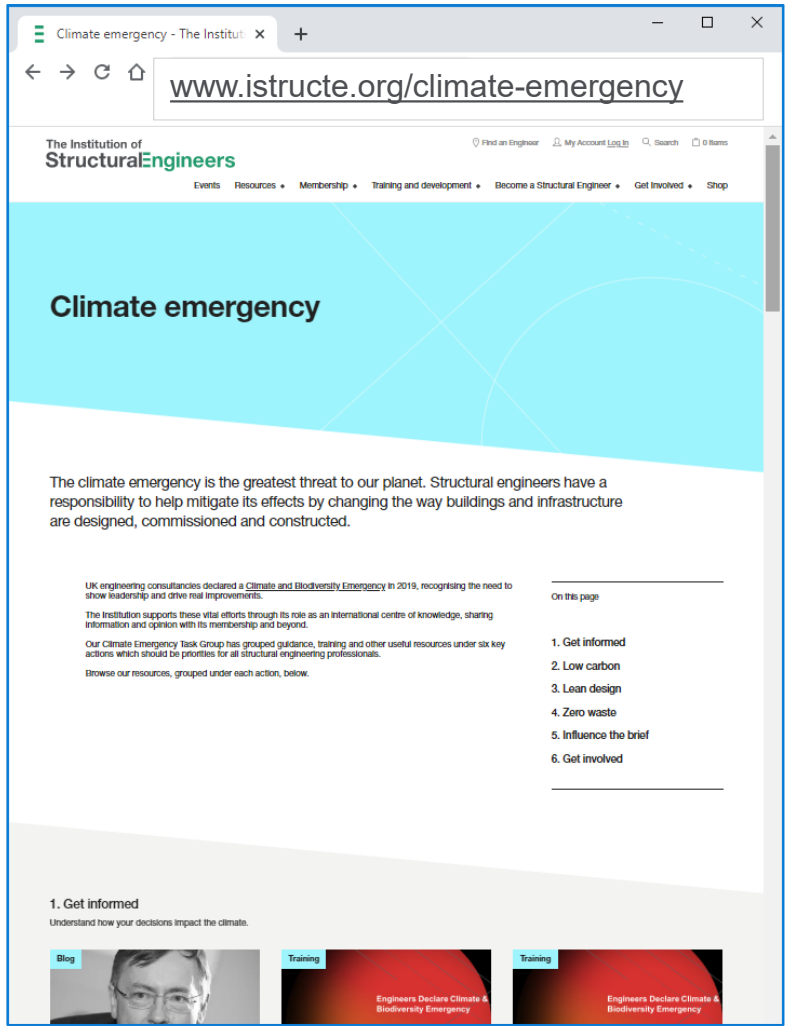
Possible webinars:
IStructE Climate Emergency Resources
How to Count Embodied Carbon
Small scale alternatives to the ‘traditional’ approach
Questioning a brief
Top 10 things to do at concept design stage
Reimagining existing buildings
A new tool for sustainable design; the IStructE Plan of Works

SE Declares Conference

Structural Engineers Declare: **170 signatory firms**
Civil Engineers Declare: 104 signatory firms
Building Services Engineers Declare: 85 signatory firms

3) Raising Standards

Will Arnold – william.arnold@arup.com



SIX THEMES FOR CLIMATE GUIDANCE

1. Get informed
2. Low carbon
3. Lean design
4. Zero waste
5. Influence the brief
6. Get involved

3) Membership Guidance to Raise Standards

Published

June

Guest Editorial – Mike Cook (CETG)
Framework for Change – Mike Cook, Will Arnold (CETG)
Structural Engineer's Responsibility – Will Arnold (CETG)
Nothing is Better than Something – Tim Ibell (Bath Uni)

July

How to Count Embodied Carbon – John Orr (Cambridge Uni), Orlando Gibbons (Arup)
Structural Engineer's Responsibility – Ben Gholem (P&M)
How can we Create and Industry whilst Building Nothing? – James Norman (Bristol Uni)
Introduction to Circular Economy [blog] – Eva MacNamara (Expedition, UKGBC)

August

Circular Economy and the Design Process – Eva MacNamara (Expedition, UKGBC)
Leaner Design; 10 Things To Do Now – Natasha Watson (Buro Happold)
Engineering for the Future; Resilient and Lean – Caroline Field (Arup)
Advocating for a 300mm Grid – David Treacy (ex-Ramboll)

Confirmed

September

Low Carbon Construction in Small and Medium Projects – Phil Isaac (SimpleWorks)
Modern Methods of Construction and Climate Change – Adrian Campbell (changebuilding), Giulia Jones (MACE)
Rationalisation versus Optimisation – Ian Poole (Mott Macdonald)

October

Carbon Targets – Will Arnold (CETG), Mike Cook (CETG), John Orr (Cambridge Uni), Orlando Gibbons (Arup), Duncan Cox (Thornton Tomasetti)
Influencing Architects – William Algaard
Existing Buildings 101 – Fiona Cobb

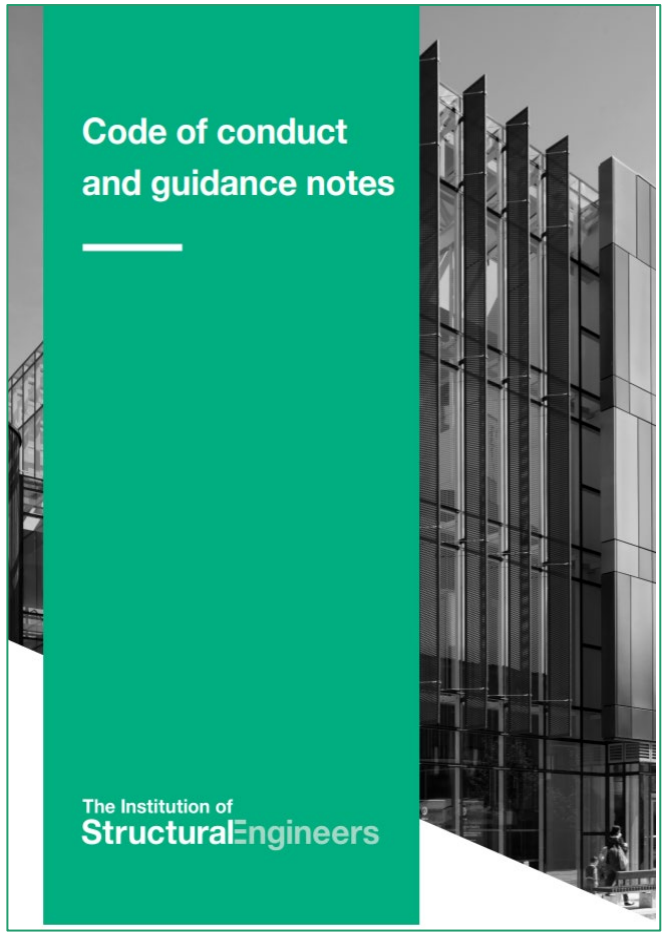
To-Do List

- Project Focus: UAE Enterprise Building (BDP)
- Safe Design When Going Lean (Paul McNulty)
- Reusing Foundations (Henry Tayler)
- What Engineers (Still) Do Not Know About Wood (Adrian Campbell, changebuilding)
- Ethics: What does the Code of Conduct currently require you to do?
- Sustainable Material Spec Notes (steel, concrete, timber, brick)
- Update on RAEng etc activities and government legislation
- Persuading Clients (Chris Wise!?)
- Business Case for Circular Economy
- Don't forget about operational carbon… The Structural Engineer's Role in collaborative design

All available at
www.istructe.org/climate-emergency

4) Setting Standards

Tim Ibell



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E membership@istructe.org

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Initial Professional Development (IPD)

Final report form

Candidate details

Full name: YOUNG ENGINEER Date:

Membership number:

Standard achieved

Core objective: 2.4 ENVIRONMENT

Standard achieved (please tick) A ☐ K ☐ E ☐ B ☒

Report

Please tell us how you have achieved the minimum standard, citing specific examples from projects you have worked on.

I CAN SHOW AN ABILITY TO SET CARBON TARGETS ON MY PROJECT, AND MEET THEM
I HAVE EXPERIENCE CONVINCING CLIENTS TO MINIMISE THE SCALE OF INTERVENTION
I LOBBIED MY LOCAL MP FOR POLICY CHANGE
I MENTORED YOUNGER ENGINEERS IN MINIMISING THEIR CARBON FOOTPRINT

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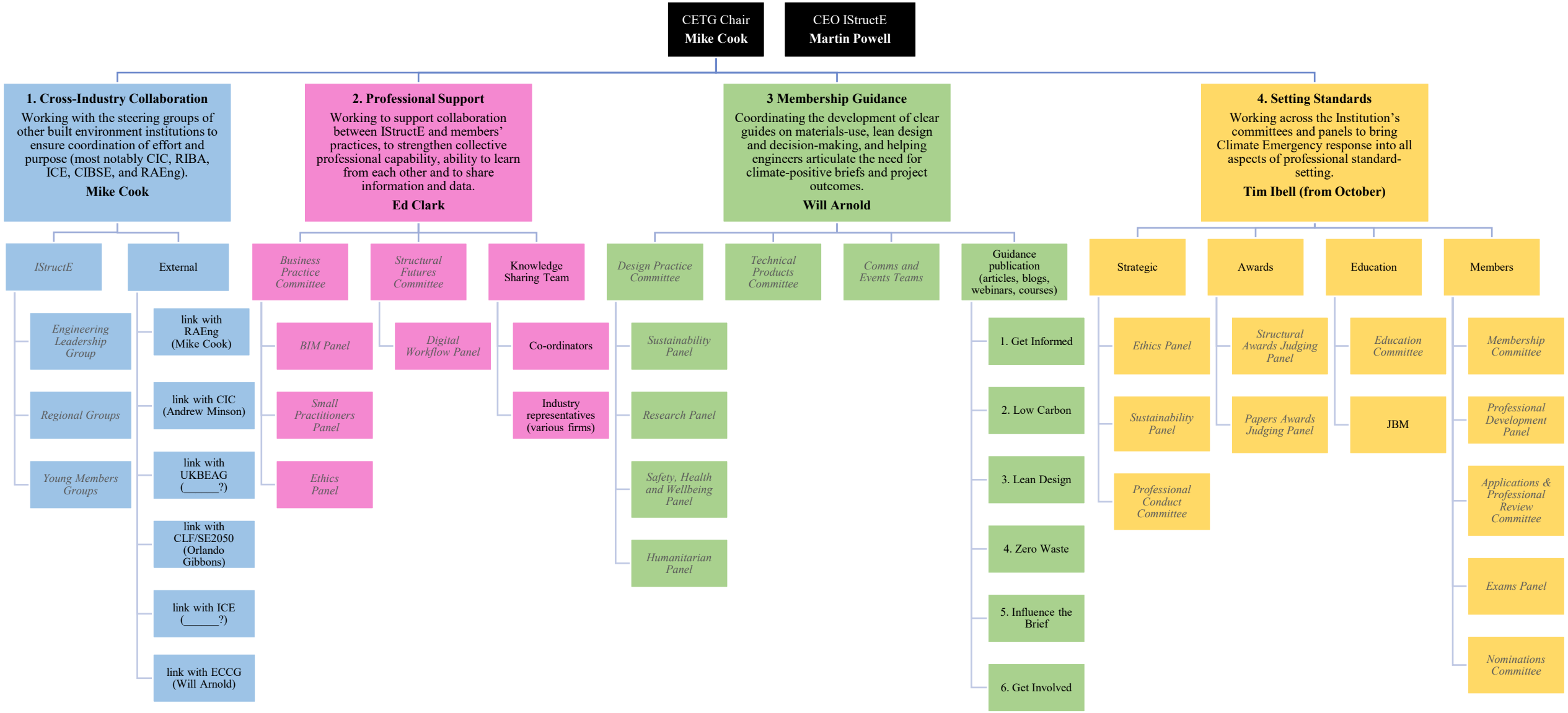
Continuing Professional Development (CPD)

What's involved

We expect you to undertake the recommended minimum amount each year (30 hours).

CETG Structure



Cross-Industry Collaboration

ROYAL ACADEMY OF ENGINEERING

CIC BUILT ENVIRONMENT PROFESSIONS TOGETHER

cabe

The Institution of StructuralEngineers

ice

RIBA

CIBSE

Construction Declares: is going global

- Raise awareness
- Advocate for faster change
- Mitigation a key measure of our industry's success
- Share knowledge and research on an open source basis.
- Evaluate all new projects against mitigating
- Upgrade existing buildings as alternative to new build
- Include life cycle costing, as part of the basic scope of work
- Adopt more regenerative design principles
- Further reduce construction waste.
- Accelerate the shift to low embodied carbon materials
- Minimise wasteful use of resources in engineering design

Structural Engineers Declare: **170 signatory firms**
Civil Engineers Declare: 104 signatory firms
Building Services Engineers Declare: 85 signatory firms

Get Involved!

climateemergency@istructe.org

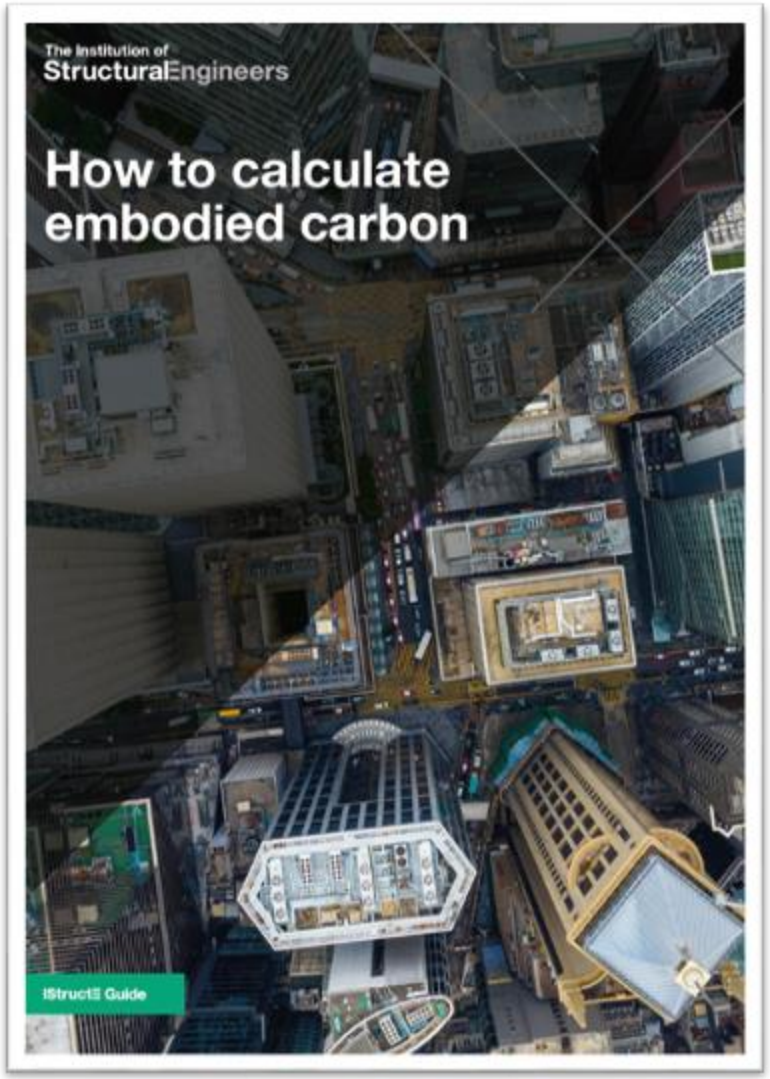
How to calculate embodied carbon

An introduction to the new IStructE guide

CLF webinar
21 August 2020

Orlando Gibbons (Arup)

Dr John Orr (University of Cambridge)



IStructE

Why do we need a guide like this?

UK Structural Engineers Declare Climate & Biodiversity Emergency

IStructE

We will seek to:

—— Raise awareness of the climate and biodiversity emergencies and the urgent need for action amongst our clients, collaborators and supply chains.

—— Advocate for faster change in our industry towards regenerative design practices and a higher Governmental funding priority to support this.

—— Establish climate and biodiversity mitigation principles as a key measure of our industry's success: demonstrated through awards, prizes and listings.

—— Share knowledge and research to that end on an open source basis.

—— Evaluate all new projects against the aspiration to contribute positively to mitigating climate breakdown, and encourage our clients to adopt this approach.

—— Upgrade existing buildings for extended use as a more carbon efficient alternative to demolition and new build whenever there is a viable choice.

—— Include life cycle costing, whole life carbon modelling and post occupancy evaluation as part of the basic scope of work, to reduce both embodied and operational resource use.

—— Adopt more regenerative design principles in practice, with the aim of providing structural engineering design that achieves the standard of net zero carbon.

—— Collaborate with clients, architects, engineers and contractors to further reduce construction waste.

—— Accelerate the shift to low embodied carbon materials in all our work.

—— Minimise wasteful use of resources in our structural engineering design, both in quantum and in detail.

We hope that every structural engineering practice operating in the UK will join us in making this commitment.

UK Structural Engineers Declare a climate emergency

This guide addresses:

- Share knowledge and research to that end on an open source basis
- Include life cycle costing, whole life carbon modelling and post-occupancy evaluation as part of the basic scope of work, to reduce both embodied and operational resource use.
- Accelerate the shift to low embodied carbon materials in all our work
- Minimise wasteful use of resources in our structural engineering design, both in quantum and in detail

IStructE

The need

- Address climate declares commitments
- People calculate embodied carbon in different ways. Variations in:
  - LCA scope (A1-A3, A1-A5, A-C)
  - Building elements scope
  - Reporting requirements
- It is a skill all structural engineers need
  - SMEs may rely on the IStructE guidance
- There are barriers to carbon calculation
  - Contentious issues & uncertainty
- Reinforce/expose existing guidance and standards

Purpose

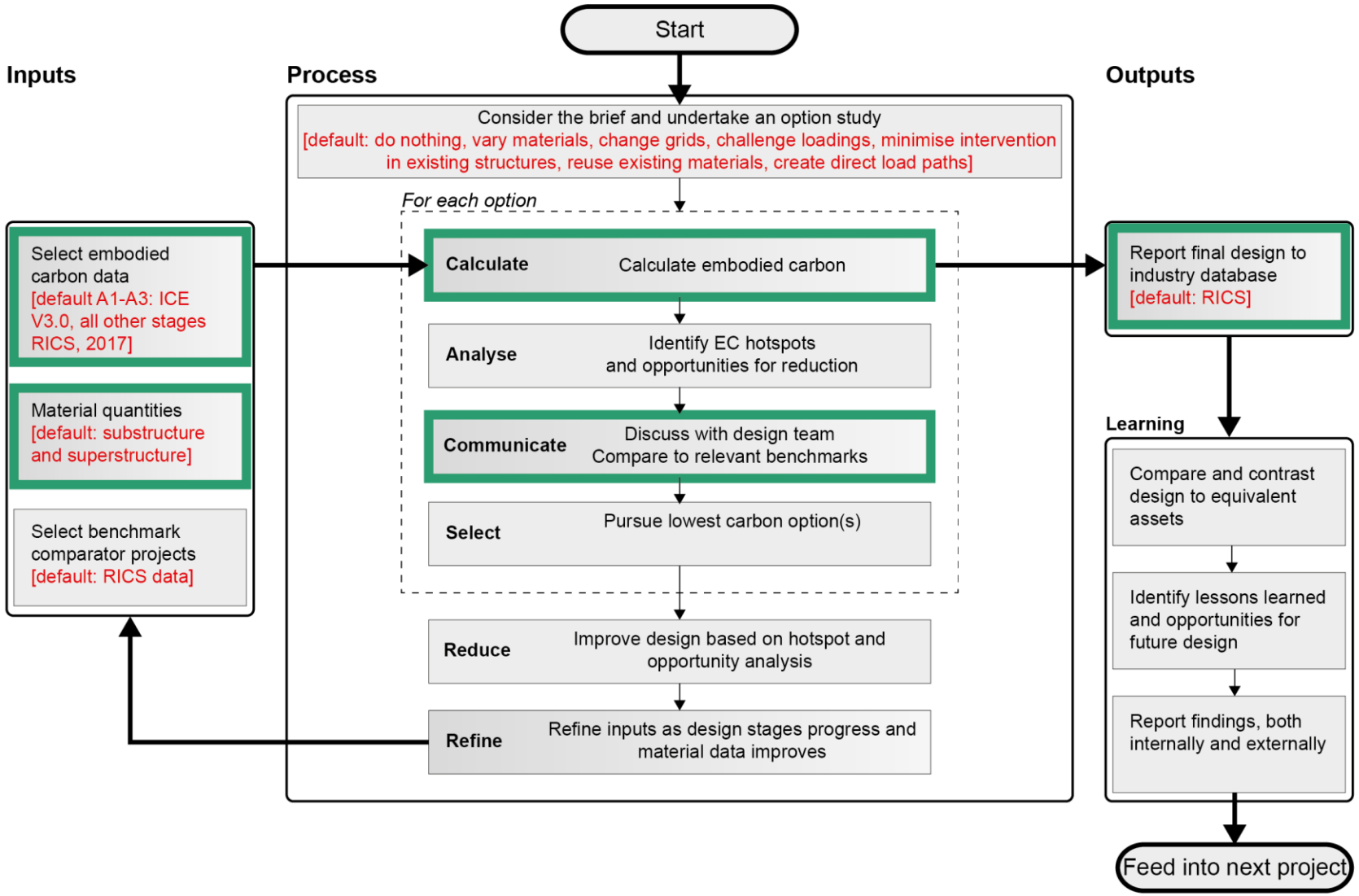
- Provide a common calculation method and assumptions
  - Enable meaningful design comparisons
- Develop carbon calculation capabilities
  - First step to making meaningful carbon reductions
  - Develop understanding of embodied carbon
  - Integrate it into the project process
- Break down barriers
  - Address contentious issues
- Help the profession find new ways to reach net zero

Principles

We must:

- Achieve net zero carbon before 2050
- Calculate embodied carbon on all projects
- Recognise carbon as one component of sustainability
- Evaluate design decisions against their carbon impact
- Communicate carbon insights to the project team
- Advocate and engage the project team to find ways to reduce carbon impacts
- Report module-based carbon data to an open source database

Scope



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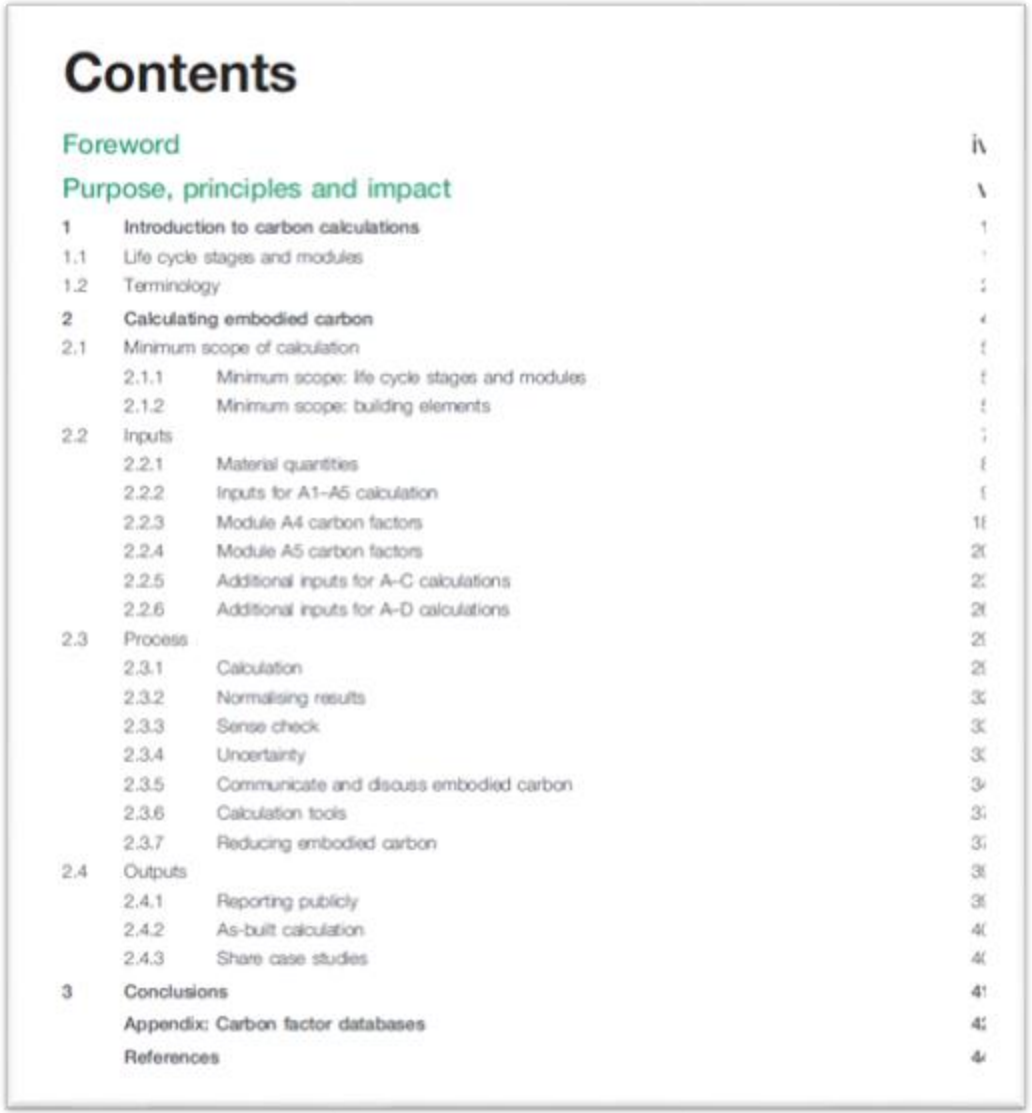
Scope



Contents

- Guide follows the process diagram
  - Inputs
  - Process
  - Outputs
- Easy to navigate

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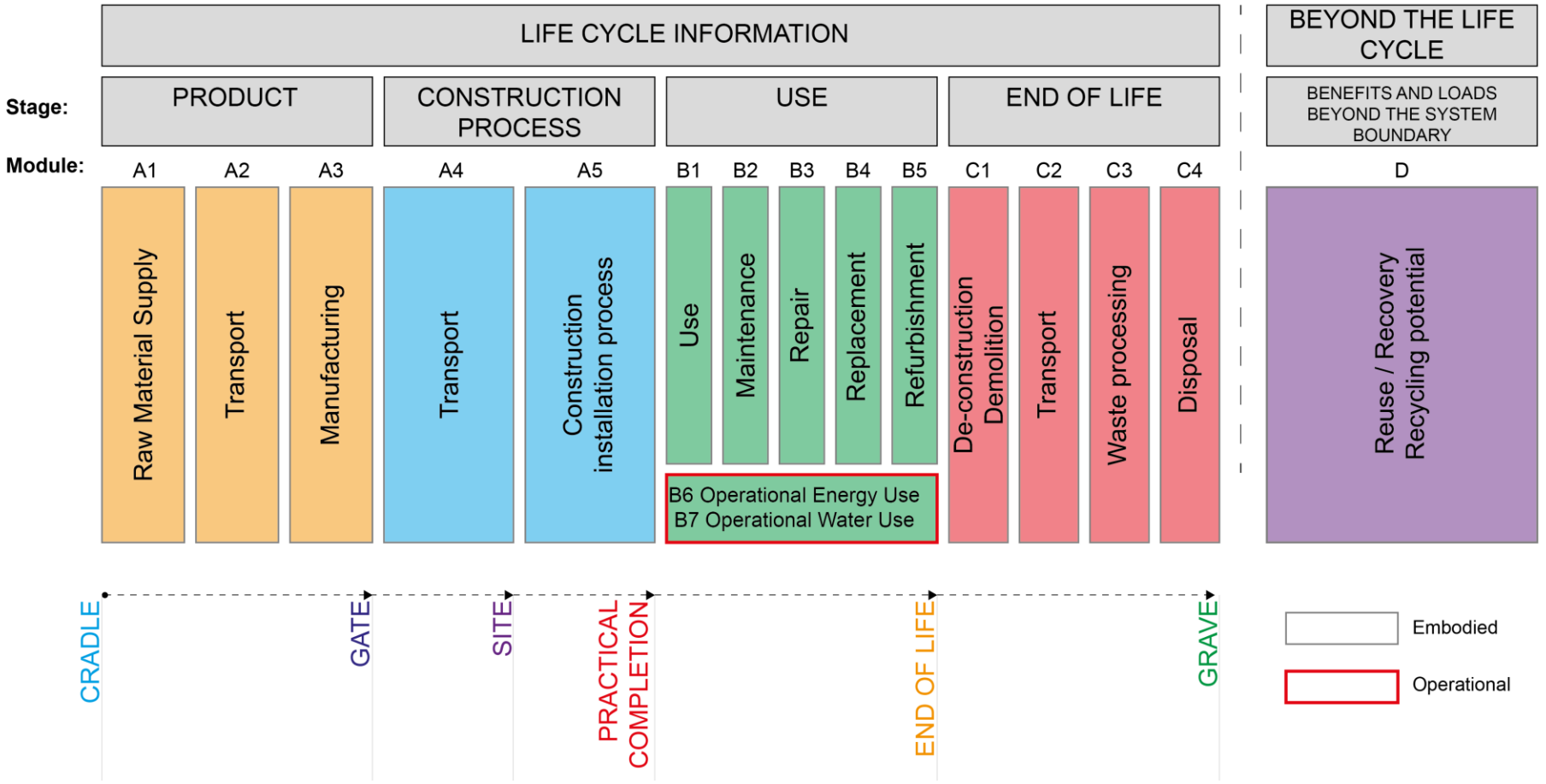
Scope

Life cycle stages



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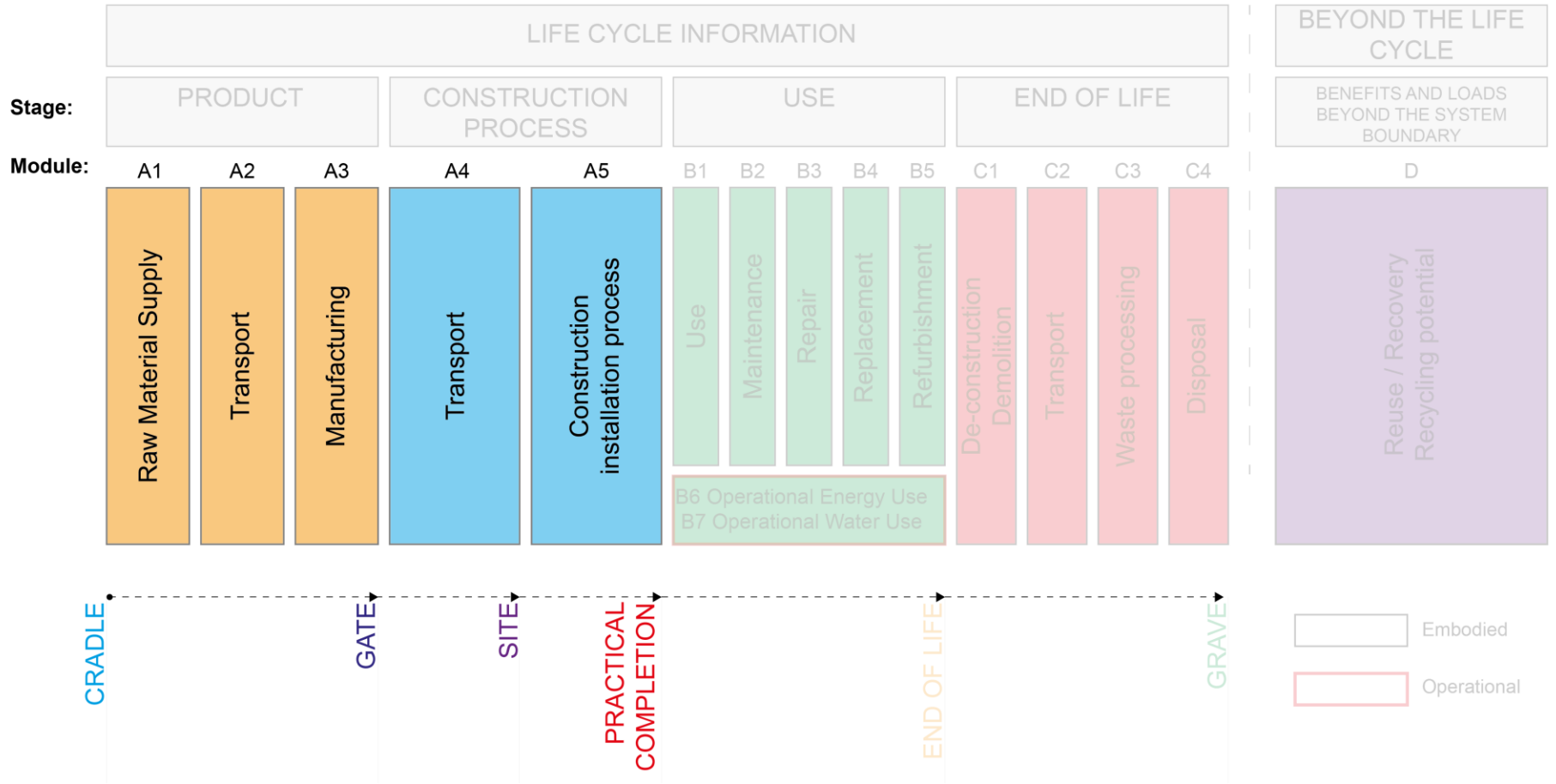
Minimum calculation

For structural elements



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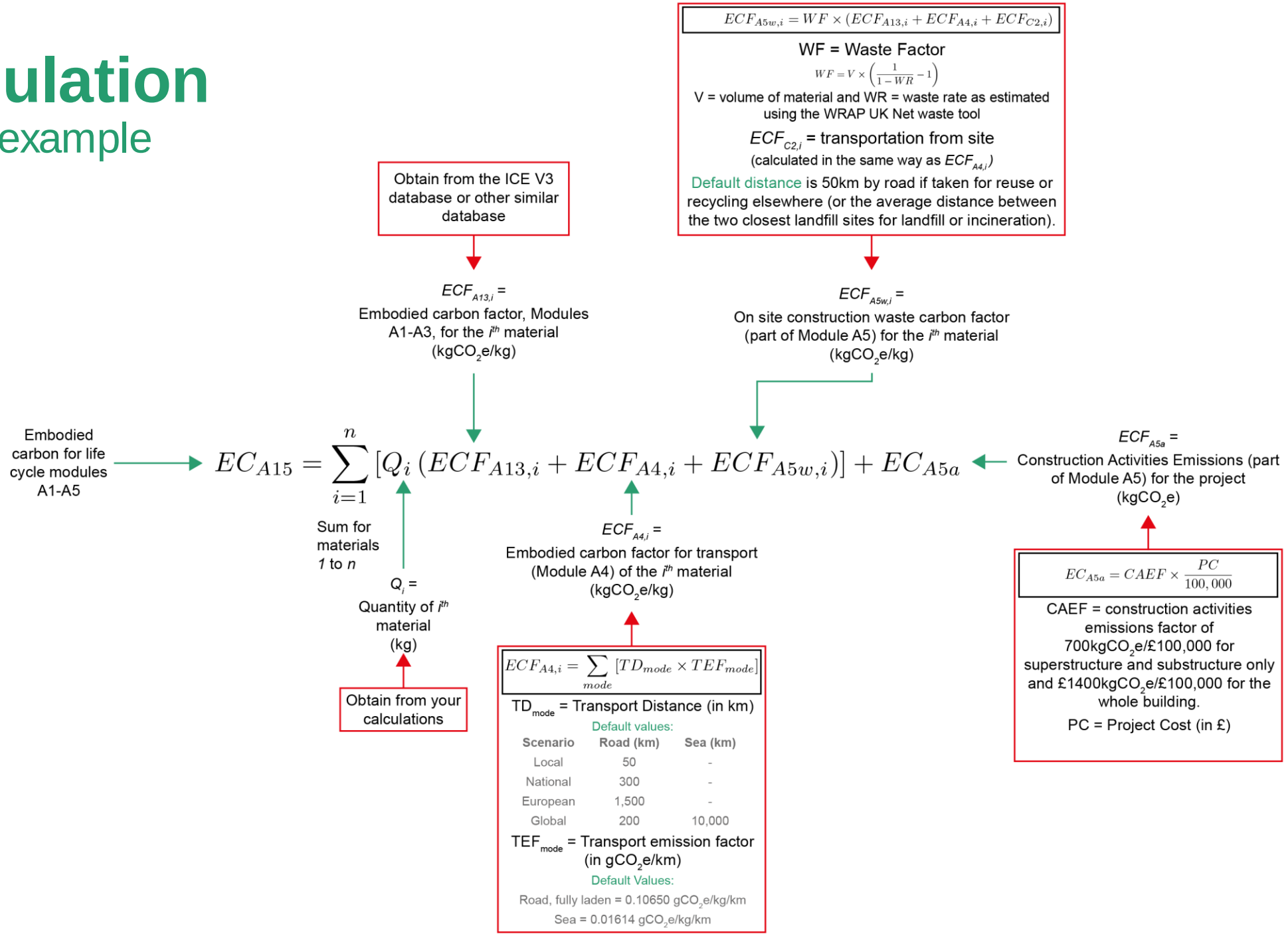
Calculation

A1-A5 example



Carbon factors

- For each life cycle module (A-D)
  - Principles to calculate it
  - Recommended values with refs.
- Table of A1-A3 carbon factors suggested for UK
  - ICEv3 and EPDs
- RICS professional statement references
- Advice on sequestration accounting
- Concrete, steel and timber supply chains and specification CO_2e impact
- Carbon factor databases
  - Appendix

Table 2.3: Suggested embodied carbon factors (ECFs) of common construction materials

Material	Type	Specification/details	A1–A3 ECF ($kgCO_2e/kg$)	Data source
Concrete	*In situ*: piling, substructure, superstructure	Unreinforced, C30/37, UK average ready-mixed concrete EPD[a] (35% cement replacement)	0.103	Ref. 16
		Unreinforced, C32/40, 25% GGBS cement replacement[b]	0.120	Ref. 15
		Unreinforced, C32/40, 50% GGBS cement replacement	0.089	Ref. 15
		Unreinforced, C32/40, 75% GGBS cement replacement	0.063	Ref. 15
		Unreinforced, C40/50, 25% GGBS cement replacement	0.138	Ref. 15
		Unreinforced, C40/50, 50% GGBS cement replacement	0.102	Ref. 15
		Unreinforced, C40/50, 75% GGBS cement replacement	0.072	Ref. 15
	Generic non-structural *in situ* concrete	Unreinforced, C16/20, 0% cement replacement with CEM I	0.113	Ref. 15
	Mortar/screed	1:4 cement:sand mix[c] with CEM I cement	0.163	Ref. 15
		1:4 cement:sand mix	0.149	Ref. 15

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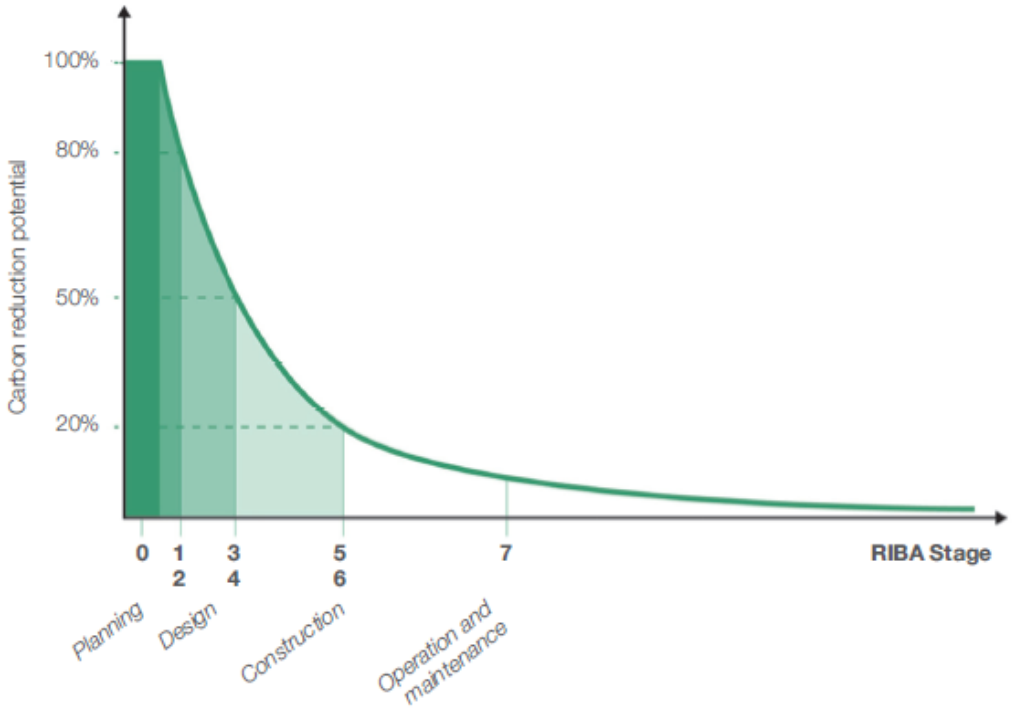
The rest of the process

- Normalising results
- Sense checks
  - Typical ranges of embodied carbon
- Embracing uncertainty
  - Do not let it deter you!
- Communication to the project team
  - Workshops
  - Reporting
- Calculation tools
- How to reduce carbon
  - Hierarchy
- Loads of tips (in red boxes)!



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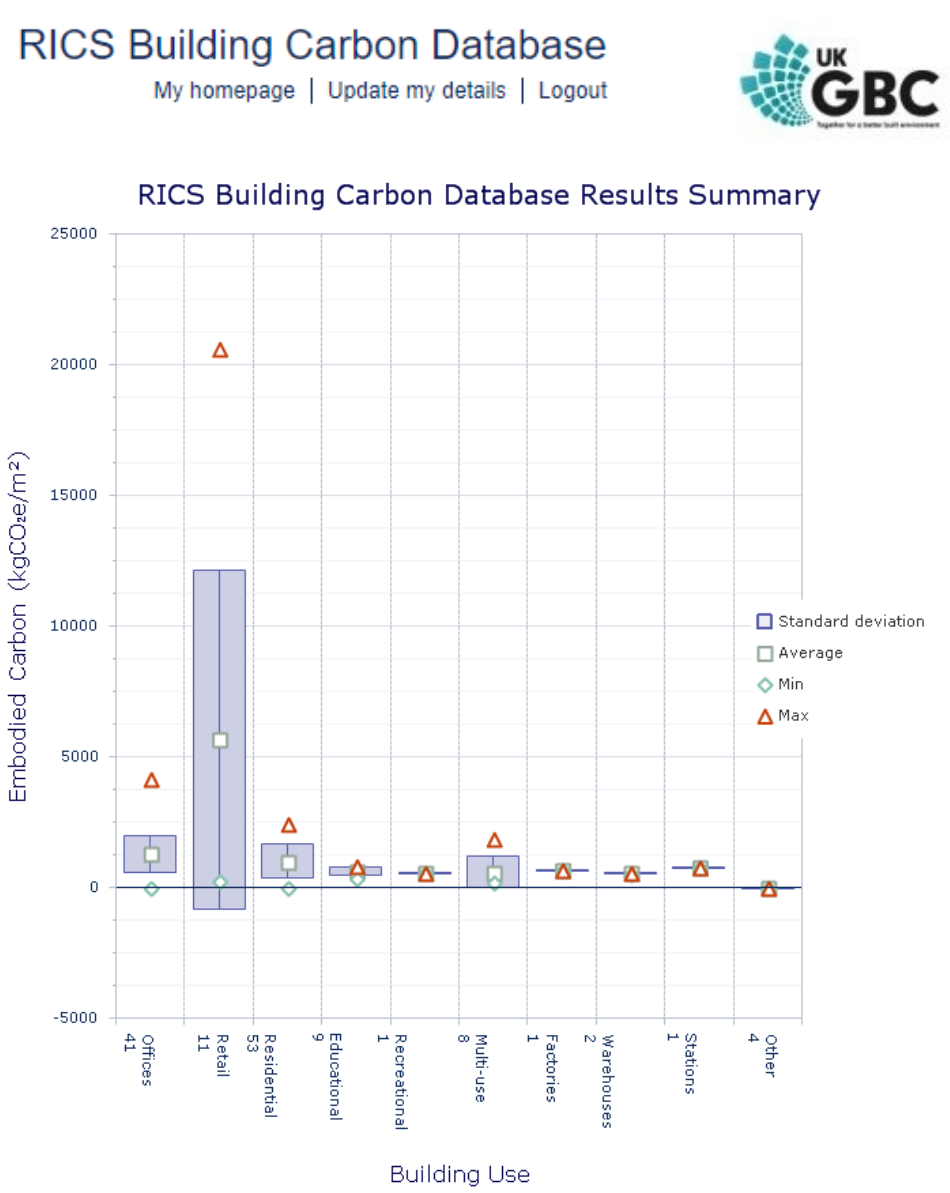
Outputs

- Report publicly
  - UK: RICS building carbon database
- As-built calculation
  - Understand the real eCO_2e
- Share case studies



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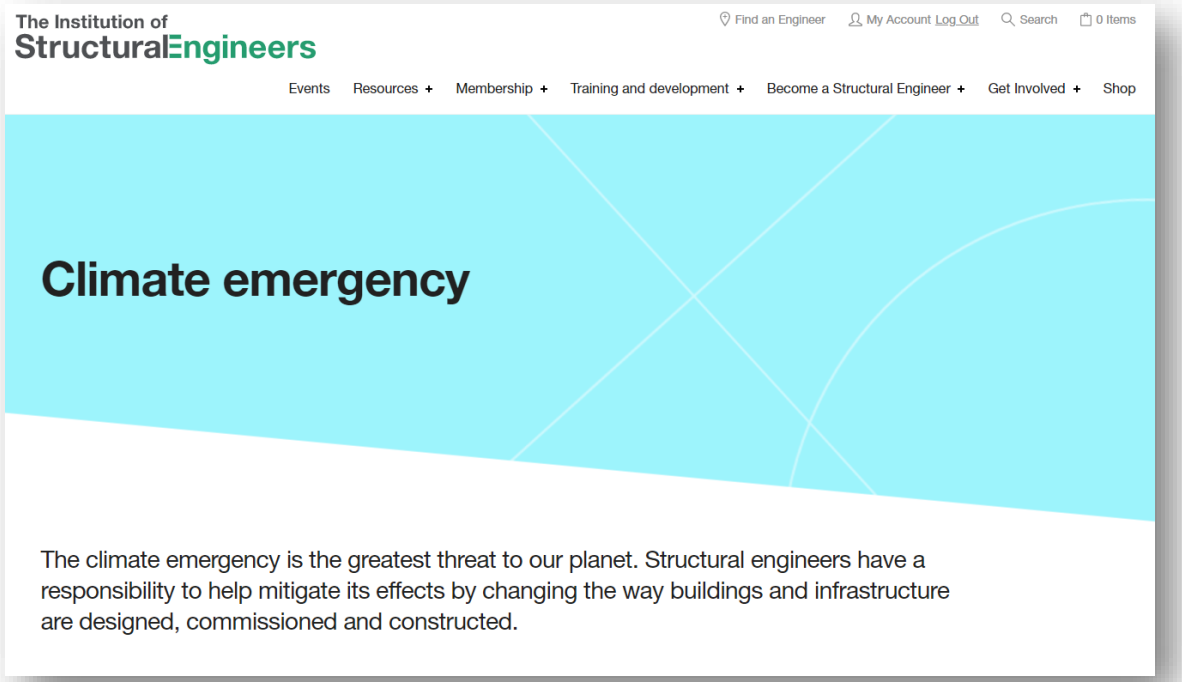
Complementary guidance to…

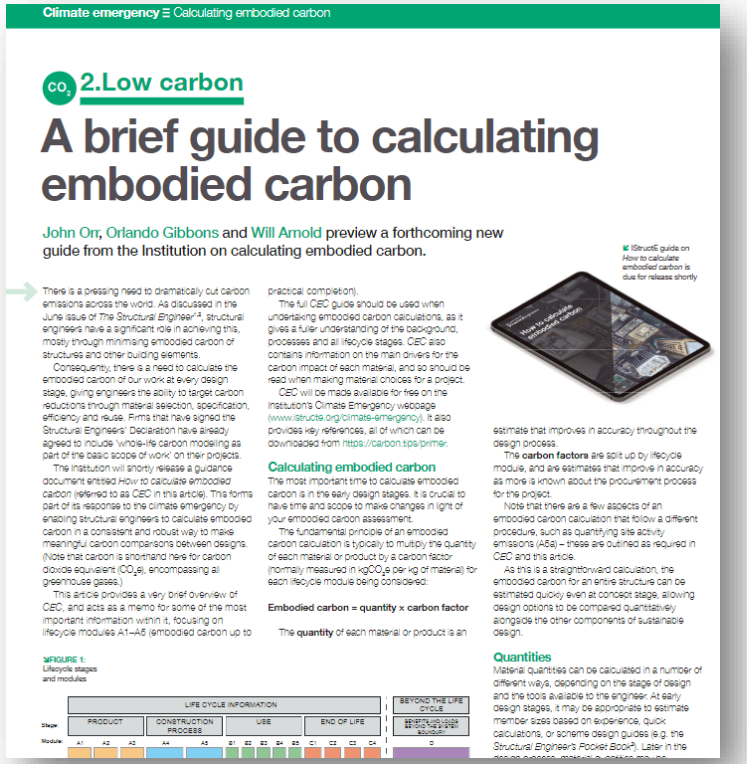
- RICS professional statement *Whole life carbon assessment for the built environment*
- LETI's *Embodied Carbon Primer*, available at: www.leti.london/ecp
- BS EN 15978
- BS EN 15804

Where can you find the guide?

Freely available at:
www.istructe.org/resources/climate-emergency/

You can already find a short primer to the guide in the [July 2020 edition of *The Structural Engineer* magazine]





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What next?

- Share widely!
- Launch webinar, 7th October 2020
- Future updates

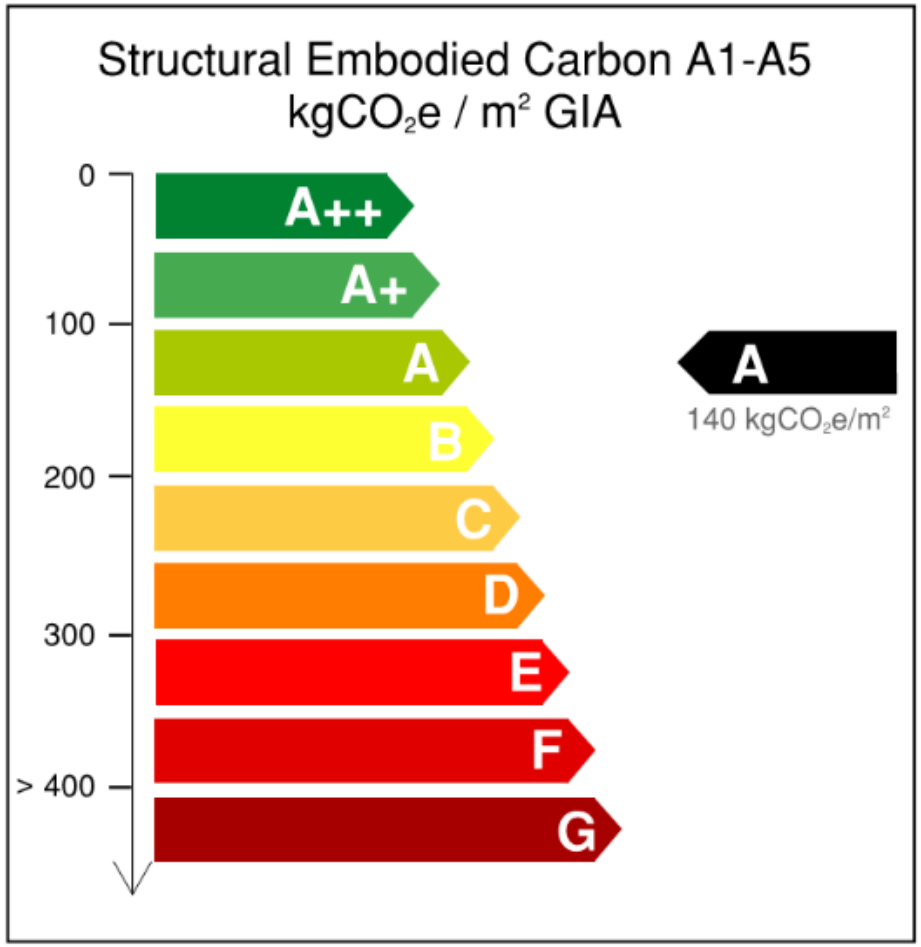
SCORES
A structural carbon rating scheme

Will Arnold (Arup, IStructE)
Mike Cook (Buro Happold)
Duncan Cox (Thornton Tomasetti)
Orlando Gibbons (Arup)
John Orr (University of Cambridge)

IStructE

What does good look like?

- Provide a framework for rating structural schemes and setting targets
- Familiar rating system to the layperson
- Sets carbon context by establishing a range
- Range determined based on project data from Arup, Thornton Tomasetti and Price & Myers



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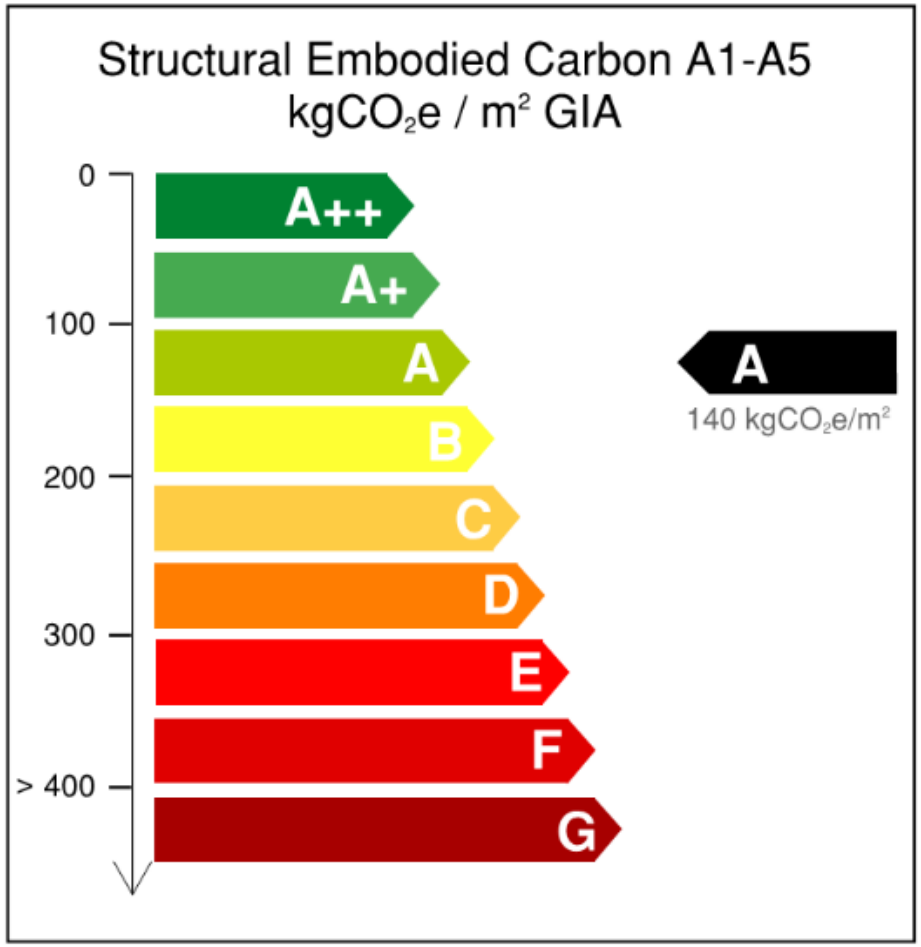
Project comparisons

- Comparisons of different options for the same scheme
- No differentiation made between building type
- Insight into which building types are more carbon intensive
- Basis for challenging the brief



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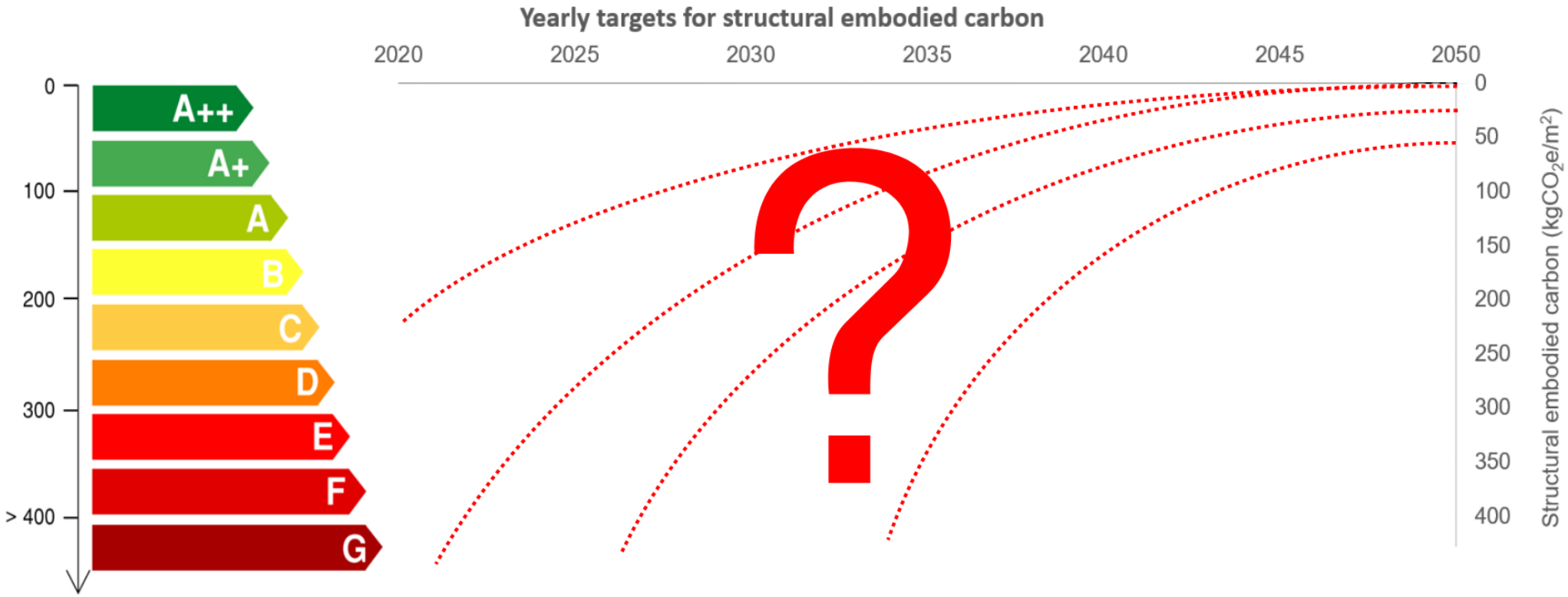
Setting targets

- Set the rating scheme against carbon budgets derived from IPCC requirements to keep within 1.5ºC



What's next?

- Finishing the review process

- *'Setting Carbon Targets'* paper to be published
  - Explains the rating scheme
  - Background on determining the SCORES range
  - Setting targets based on global carbon budgets

- Look out for it in the October 2020 edition of *The Structural Engineer*

Carbon Leadership Forum

Q&A

Thank You!

Network | 2020 Webinar Series

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