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Industry CPD

Incorporating carbon assessments into your modelling workflow

This CPD module, sponsored by Trimble, explores the benefits of integrating ongoing carbon assessments into the modelling workflow for a structure.

Continuing professional development (CPD) ensures you remain competent in your profession. Chartered, Associate and Technician members of the Institution must complete a specified amount each year. All CPD undertaken must be reported to the Institution annually. Reading and reflecting on this article by correctly answering the questions at the end is advocated to be:

1 hour of verifiable CPD

A significant portion of a building's final carbon value (estimated at around 50%) is 'locked in' through decisions made early in the RIBA Plan of Works (PoW). While carbon calculations themselves are nothing new, the key is to calculate and consider carbon throughout the construction sequence, integrated within your existing 3D modelling workflows. Only then can the built environment benefit from greener and more informed decision making.

A fundamental part of approaching embodied carbon is to understand the level of carbon present in a building and the impact design decisions will have on this level. Having access to this reliable data built-in during the modelling process will enable teams to consciously adapt the design and make greener choices, sharing these options with the client and making the whole process a more collaborative effort. If we are to succeed, carbon needs to be considered as a primary factor during the modelling workflows, in much the same way as cost, time and quality are already considered.

It's never too early to consider carbon

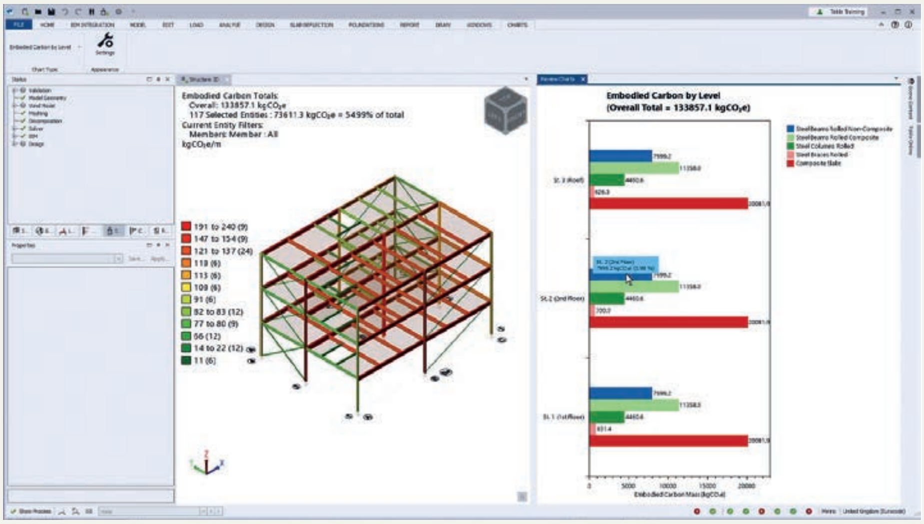
As the rise of carbon reduction tools designed for use at the very early concept stages of a project suggests, it is never too early to consider carbon. In fact, intelligent, early-stage optioneering tools – such as Structural PANDA, a start-up developed by the University of Cambridge and Price & Myers and with a direct link to Tekla Structural Designer – can offer engineers real value and contribute to informed and collaborative discussions.

Used correctly, these tools (often designed to be used in conjunction with design and analysis software) can provide structural engineers, and wider interdisciplinary project teams, with a starting point and basis for further analysis. By inputting initial structural requirements, such as number of storeys, loading requirements and the basic building shape, the tool output can include potentially thousands of code-compliant design options, featuring a variety of foundation types, decking types, frame types, grid spacings and material choices. These results can be generated as graphs, charts and reports, enabling interdisciplinary teams to make informed decisions and providing the data and ideas for further collaboration.

As well as providing added value and insight, with enhanced early optioneering, such tools can also offer engineers significant time savings. For example, the Structural PANDA plug-in referenced earlier can reportedly save two weeks' design time and reduce project costs by as much as 20% (www.structuralpanda.co.uk).

Connected workflows

By opting for connected plug-in tools, users can output selected solutions from these early



↗FIGURE 1: Building carbon assessments in design software (such as Tekla Structural Designer) allows engineers to better understand the impact of their decisions

optioneering tools into their preferred structural design and analysis software.

During the Concept Design phase, these initial designs and options can be explored, modelled and refined further, utilising structural analysis software to plan out the building or structure. By making decisions regarding the grid type, column layout, load transfers and substructure (for example), engineers can determine the most efficient, sustainable and cost-effective structural design.

Generally speaking, this stage of the RIBA PoW equates to Stages A1–A5 of the building and infrastructure lifecycle stages, which is when in-built carbon calculator tools can come into play. With live carbon calculations and the added insight offered into the performance of the building, these tools can inform better and greener decisions.

Carbon calculations

Through having carbon calculations built into design software **(Figure 1)**, the time barrier of calculating carbon is removed, enabling engineers to better understand the impact of their design decisions and spend more time optimising solutions.

It also gives you the ability to run various carbon comparisons, rather than simply calculating the carbon value of your final structural model. By using building information modelling (BIM) software, engineers can set up models and run a variety of different comparisons – such as changing the grid, the layout, the materials used – and then assess which has the lowest carbon footprint.

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During the design process, it’s understandable that engineers may not have time to go over and optimise every single member and individual structural component. Some carbon calculators allow you to easily view the lowest utilisations alongside the highest-carbon members. The benefit of this is that, rather than spending time optimising small members that contribute little to the total carbon value, engineers can instead optimise fewer larger members that contribute more to the total carbon value.

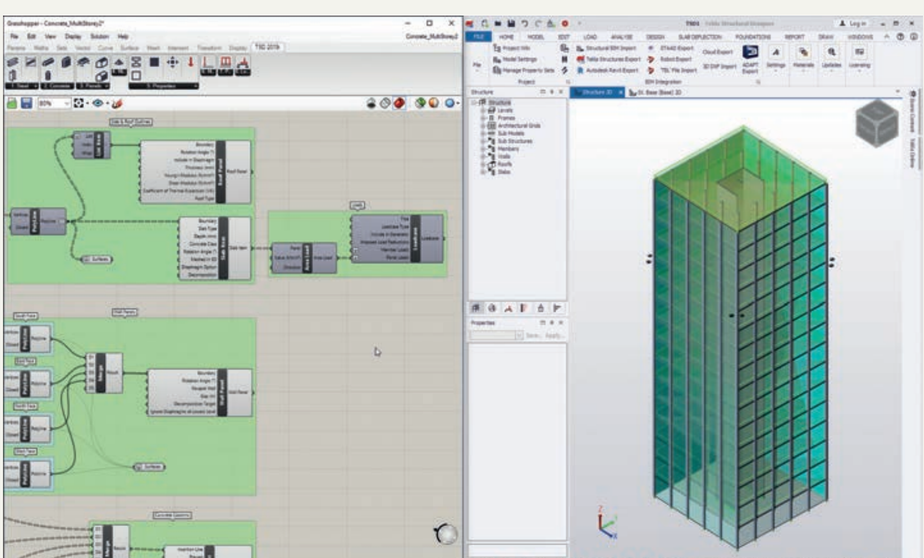
While many still choose to carry out calculations and record results manually in Excel spreadsheets, carbon calculators (such as the one offered in Tekla Structural Designer) offer a more streamlined, automated and efficient process.

Parametric modelling

Taking the theme of carbon optioneering – facilitated by carbon calculation tools – further, it feeds into parametric design, or data-driven design as it can also be known. Parametric design is guided by a set of interconnected variables, functions and rules, which generate or control the design output into a parametric BIM tool.

By using parametric design add-on tools **(Figure 2)**, such as Grasshopper and Rhino, engineers can set carbon as the key driver or parameter and then allow the computer software to automatically generate possible design iterations; in turn, identifying which structural design leads to the best outcome in terms of carbon emissions.

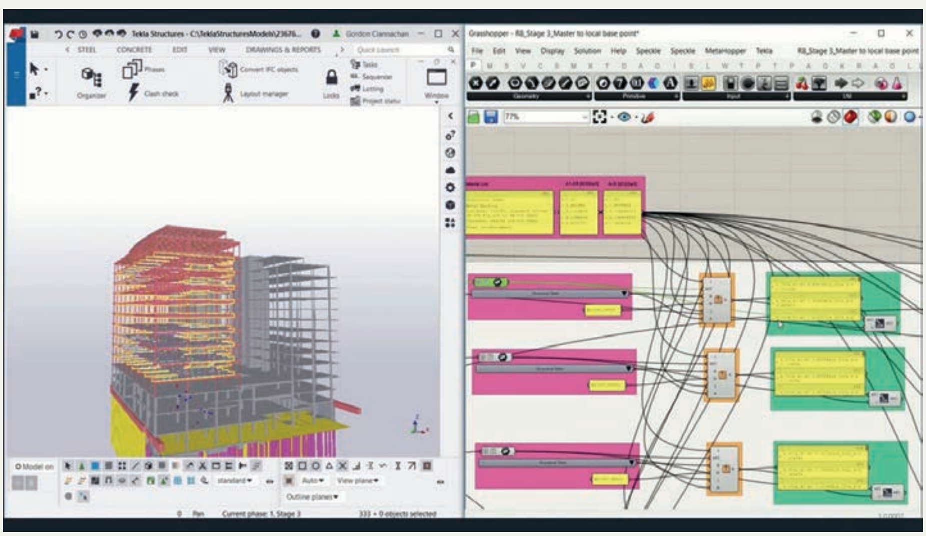
A real-life example of this is on King’s Cross R8 (one of the final development projects in London’s central neighbourhood), with Arup’s use of parametric modelling at the heart of all project workflows, pushing or pulling data and geometry to and from Tekla Structures to improve the efficiency of everyday tasks **(Figure 3)**. Engineers created a script that automated



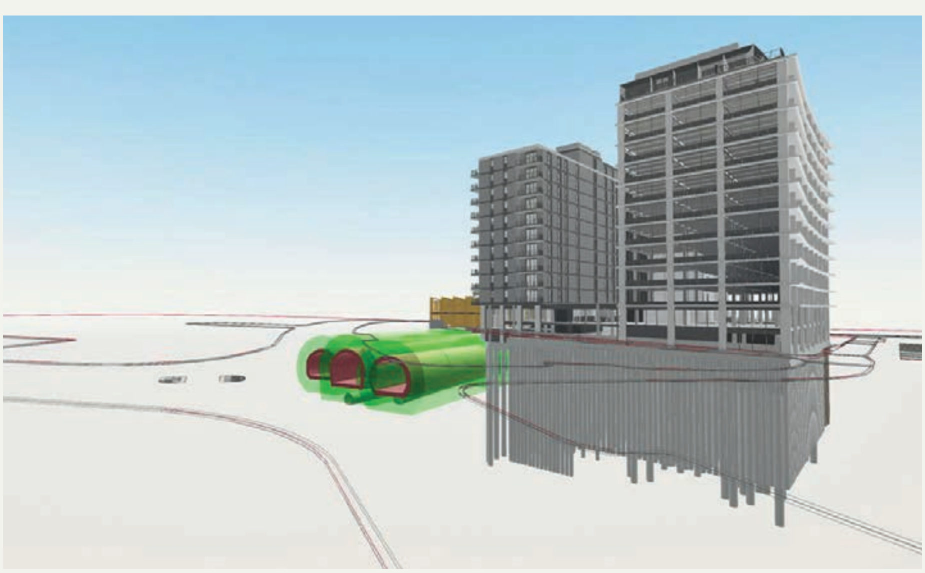
↗FIGURE 2: Integrating parametric tools with design software (such as Grasshopper with Tekla Structural Designer in this example) allows engineers to set carbon as a key driver for the design

FIGURE 3: Arup's King's Cross R8 project in London made use of parametric modelling

a) R8 development



b) Parametric scripts for design



c) Model of structure

> **"BY USING PARAMETRIC DESIGN ADD-ON TOOLS, ENGINEERS CAN SET CARBON AS THE KEY DRIVER OR PARAMETER**

the calculation of the loads bearing down on the concrete columns and walls, which helped to further optimise the design and reduce the amount of concrete in the foundations.

Arup also used the Tekla–Grasshopper integration to develop its own scripts for calculating the embodied carbon footprint of all structural elements.

Level of detail

Moving on to the Spatial Coordination and Technical Design stages of the RIBA PoW, where the model is enhanced and built upon, designed to manufacturing level of detail. Including collaboration with other disciplines on the project, including mechanical, electrical and public health (MEP) services, cladding, fire protection and utilities, the structure's carbon value will increase dramatically, due to the increased level of detail contained within the model. Structural modelling software enables detailers to 'spec up' the building, detailing all of the individual connections, welds, plates and bolts – in the case of a steel-framed building. While they may be small components, there can be thousands and thousands of them within a single model.

It is because of this additional detail being brought into the 3D model that continuing to report on carbon as the project progresses is so important. While structural design and analysis software can offer educated assumptions on carbon, it is detailing software that provides the constructible, as-built model, with carbon calculators here able to offer a truer figure.

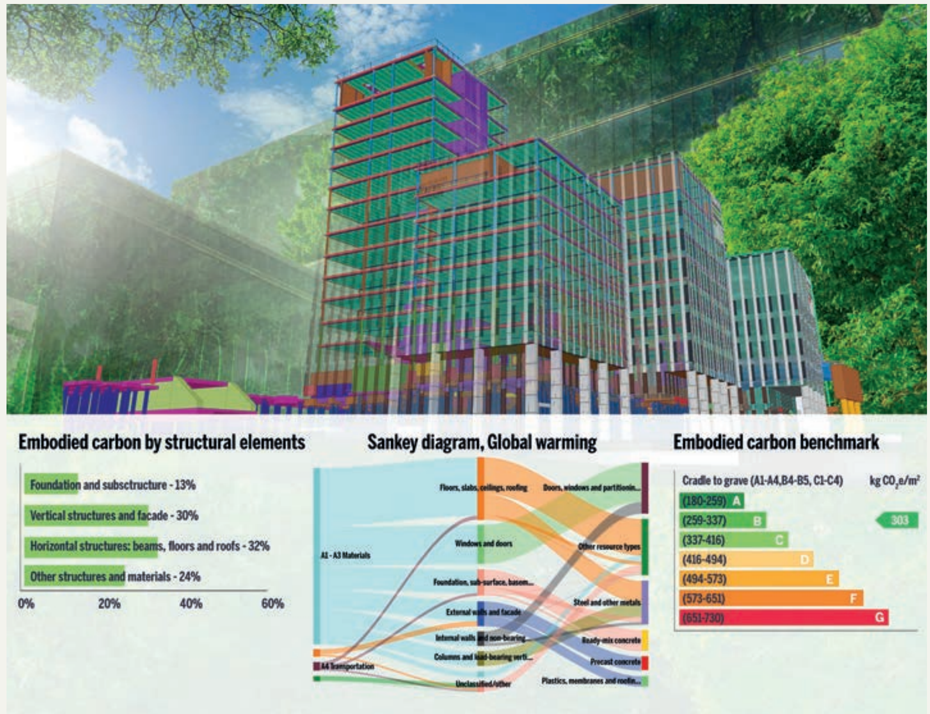
This is why it's important to have a modelling software with a high Level of Detail (LOD), satisfying the Level of Information Need. Put simply, the more accurate the model, the more accurate your carbon report will be. This also means that the embodied carbon figures can differ, depending on what modelling software is used on a project.

Carbon lifecycle

This view into the carbon impact of a structure can be taken further still, through the use of lifecycle analysis (LCA) tools. Looking at the carbon lifecycle sequence, the construction phase is only a small portion of a building's lifespan, with stages B1–C4 accounting for its operational use and its end-of-life.

As the name suggests, LCA tools cover the full lifecycle of a structure and provide truer, more extensive carbon reports from cradle to grave, taking into account factors such as: the thermal efficiency of a building, its usage, operational carbon, maintenance, potential refurbishments and its end-of-life.

With direct links between modelling software and LCA software **(Figure 4)**, data can be easily exported and imported, with the ability to run reports and present clients with a more comprehensive view of the projected carbon impact and performance of their building.



↗FIGURE 4: Integration with lifecycle analysis software (such as One Click LCA in this example) can provide cradle-to-grave carbon reporting

Conclusion

The process of calculating carbon should be an integral part of the design and engineering process. It should not be viewed as a means of ticking a box, or a task to be carried out once the structural model has already been built. Indeed, it goes hand in hand with structural design and analysis, and should be an integral consideration right from the outset of a project. Carbon tools can help to dictate and inform decisions made throughout the PoW, as well as form a basis of discussions and facilitate further collaboration between project stakeholders and disciplines.

With a variety of software tools available to assist, designed for use at different stages of the construction sequence, the process can be streamlined and automated, saving time while simultaneously providing enhanced and live visibility into the embodied carbon of your structure. Software interoperability is key, facilitating this connected workflow and the seamless transition of data into and out of carbon calculation tools.

By making use of the range of intelligent digital tools available, we can work to deliver the greener buildings and infrastructure of the future.

Questions

To claim your CPD certificate, answer the questions online at **www.istructe.org/industry-cpd**. The module will close on 31 October 2024.

1) How much carbon is estimated to be locked in through the decisions made during the early RIBA Plan of Works stages?
a) 10%
b) 20%
c) 40%
d) 50%

2) What are two benefits of being able to explore different sustainable solutions during early-stage design?
a) Allows me to explore options that I may not have previously considered and make more informed design decisions
b) Maximises the amount of embodied carbon
c) Allows me to give my client the most sustainable solution
d) Reduces the possibility of overdesign of structural elements

3) What is the benefit of being able to use parametric modelling tools during early-stage design?
a) Allows me to assess many solutions quickly and accurately
b) Overcomplicates the early-stage design process due to having too many possibilities
c) Encourages me to learn a scripting language and/or a software language
d) Requires me to undertake manual carbon calculations for each solution

4) At what stage of the workflow should carbon calculator tools be used, to provide the most value?
a) Only once the model has been finalised and approved
b) Throughout the RIBA workflow, to provide regular insight into the impact of design decisions
c) Only at the Concept Design phase
d) Once construction has commenced on site

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