ASD Westok

WESTOK CELLULAR BEAM GRID STUDY
FOR COMMERCIAL OFFICE BUILDINGS (Mar 2022)

Introduction

In 2021, ASD Westok issued our first comprehensive grid study. This study compared the impact of beam type, loading, beam spacing, and bay size for a typical commercial office development. Building on the findings of that initial study, we have extended our research. The extended study not only confirms the key conclusion of the original study, with the Westok ribbon-cut beam providing the optimum solution with respect to embodied carbon, but also expands the research to explore additional aspects of the grid.

Grid Study

The parameters of our 2021 grid study were quite wide as it encompassed:

- Three beam types (ribbon-cut, UB, plate);
- Four beam spans (9m, 12m, 15m & 18m);
- Two different beam centres (2.5m and 3.75m), and
- Two different office loading scenarios (q_k = 2.5 + 1kN/m² and 4 + 1kN/m²)

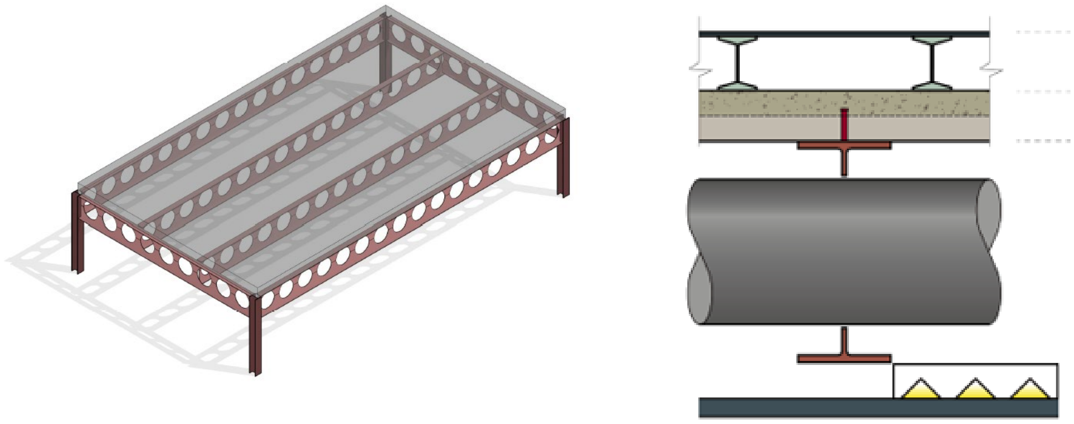

Figure 1 Typical grid layout & floor cross-section

The study detailed the arising floor-plate steel kg/m² and A1-A3 embodied carbon kgCO_2e/m² for the different forms of cellular beams manufactured by ASD Westok.

The study indicated that:

- For all design scenarios considered, the Westok ribbon cut beam offered the lightest solution;

- Longer-spanning solutions using Westok ribbon-cut beams offered lighter floor steelwork intensities than alternatives on a shorter grid;

The drawback of the grid study was its restriction to a straightforward review of the steelwork only, i.e. the primary and secondary beams.

So whilst informative with respective the floor steelwork, there was no review of the impact of slab type and column size, which are clearly integral components of the grid or bay under review.

Extended Grid Study

We are now pleased to extend the study with due consideration of the following additional aspects of the grid:

- Metal deck slab, comprising
    - The deck itself
    - Anti-crack mesh reinforcement
    - Concrete
- Column section allowance for the bay
- A further allowance for connection steelwork

The particular parameters reviewed are as follows:

- 2.5m c/c beams – slab: 140mm thick slab using 50mm re-entrant deck
- 3.75m c/c beams – slab: 140mm thick slab using 60mm re-entrant deck
- Columns size: average weight of column stack averaged per storey assuming a 6 storey structure
- Connections: 5% of beam + column weight

Discussion

The extended study further backs up the key conclusion of the original study with the Westok ribbon-cut beam providing the optimum solution with respect to embodied carbon.

LETI's excellent Climate Emergency Design Guide (1) suggests approximately half of the embodied carbon in a typical office structure is contained in the superstructure.

References: 1) LETI Climate Emergency Design Guide - https://www.leti.london/cedg

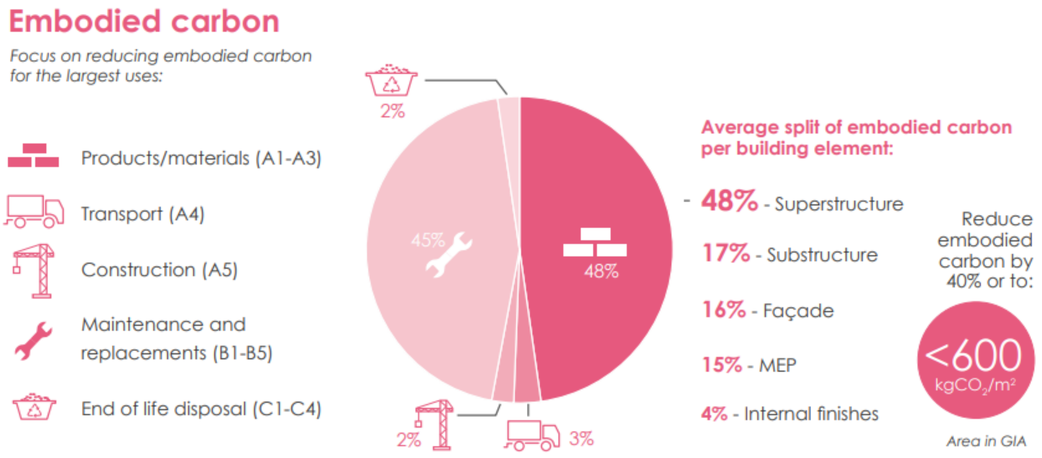

Figure 2 Embodied carbon breakdown for a commercial office building - LETI

A targeted reduction to less than 600 kg Co_2e/t for an office structure would allow ca. 300 kg Co_2e/t for the superstructure itself.

Best practise for 2030 for non-domestic buildings could entail a further reduction to a more ambitious target of 350 kg Co_2e/t with ca. 175 kg Co_2e/t an appropriate targeted value for the superstructure.

The extended grid study demonstrates that clear-span solutions can be delivered today at very attractive A1-A3 values in the range of 120-150 kg Co_2e/t using UK average section parent values.

Other Take-aways

Due consideration of all factors such as SLS and ULS performance, fire, vibration, fabrication and procurement etc are required and each project must be examined on its merits, however the study shines a light on other key aspects with respect to embodied carbon:

- Despite occasional reference to the benefits of short-span construction, it's evident that longer spanning solutions offer very attractive embodied carbon values.

- Extending spans beyond 9m does not generate onerous embodied carbon increases, as the total embodied carbon value is generally dictated by the other grid components which are not sensitive to the beam span considered. This logic does not carry over to other construction framing materials;

- With this is mind, one must then also consider the other well recognised benefits of clear-span structural steelwork construction: highly flexible floor-spaces, speed of construction, early site demobilisation and building occupancy; future flexibility and offsite quality controlled manufacture;

References: 1) LETI Climate Emergency Design Guide - https://www.leti.london/cedg

- The decision to opt for a concrete metal deck slab is significant, and designers need to carefully consider the metal deck profile itself (re-entrant vs trapezoidal) as well as the deck gauge.

- Metal deck design based on the worst span or commonly occurring span requires careful thought also. Wholesale specification based on a critical case may be unwise. Consider optimisation vs repetition carefully where bay sizes vary;

- Slab thickness and concrete grade are important aspects also. Notwithstanding the importance of fire design and the benefit of damping with respect to vibration, over specification is not called for and will carry an unnecessary carbon penalty;

- It is not the intent of the study to re-open the EAF vs BF debate with respect to appropriateness of designers specifying EAF material, however adoption of EAF sections and/or deck would reduce the embodied carbon values further. For illustration purposes, graphs are provided with ribbon-cut and UB sections adopting EAF and UK section average embodied carbon values;

ASD Westok's Technical Advisory Service

ASD Westok have developed simple tools to rapidly calculate the embodied carbon value of a steelwork grid, and it is our intention going forward to provide embodied carbon values for our beam designs and grids.

When opting for a metal deck slab, deck profile, concrete grade, beam span, the arising shear stud resistance and ultimately the composite beam design are all inter-related factors which will vary on a project by project basis.

Westok can assist with option-engineering to arrive at the optimum solution with respect to embodied carbon and appropriate procurement routes. Our technical advisory engineers are knowledgeable on these topics and are well placed to advise. We also offer CPD seminars focusing on sustainability.

Hybrid solutions adopting Westok cellular beams and cross-laminated timber (CLT) floor units are gaining traction, and we will extend our grid study shortly to review this.

Westok's Cellbeam software calculates and reports the embodied carbon values of the design, and now facilitates CLT slab input also.

Conclusions

The extended study further backs up the key conclusion of the original study with the Westok ribbon-cut beam providing the optimum solution with respect to embodied carbon.

The graphs below document the results of the extended study.

To discuss the results of the grid-study further, please contact us on
westok.design@asd.ltd

References: 1) LETI Climate Emergency Design Guide - https://www.leti.london/cedg

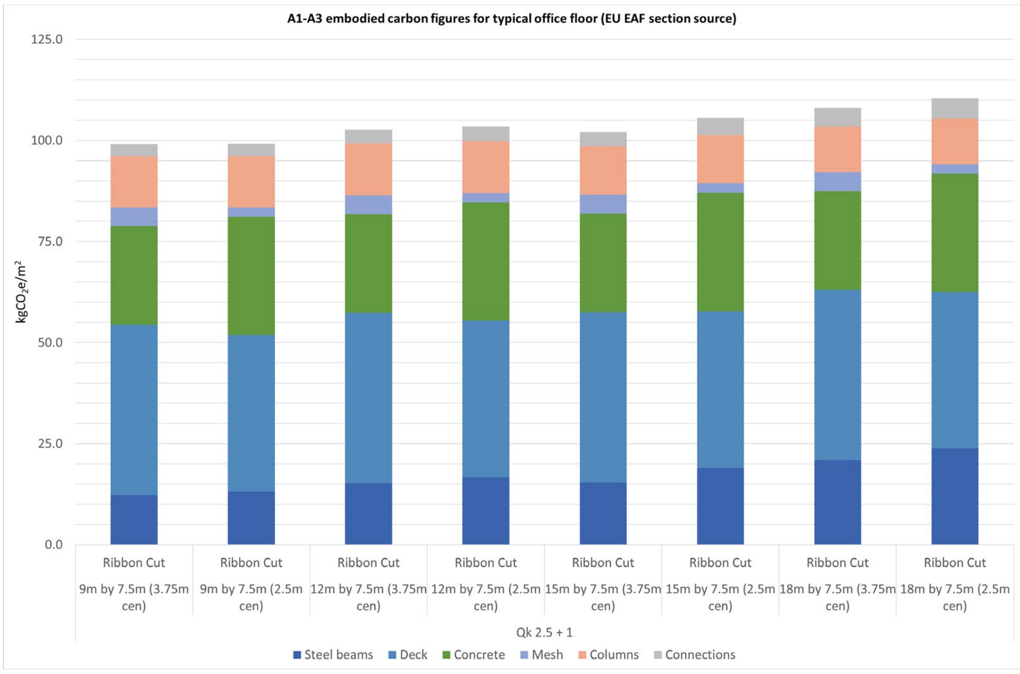

Figure 3 Westok ribbon cut beams based on EAF manufacture: q_k = 2.5 + 1kN/m²

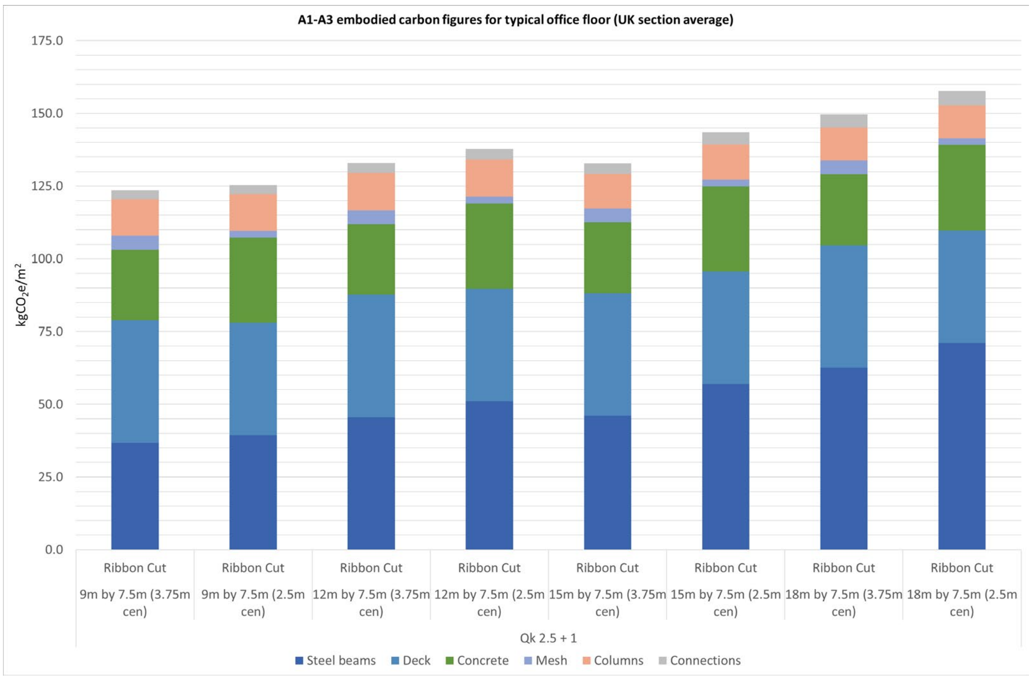

Figure 4 Westok ribbon cut beams based on UK section average manufacture: qk = 2.5 + 1kN/m2

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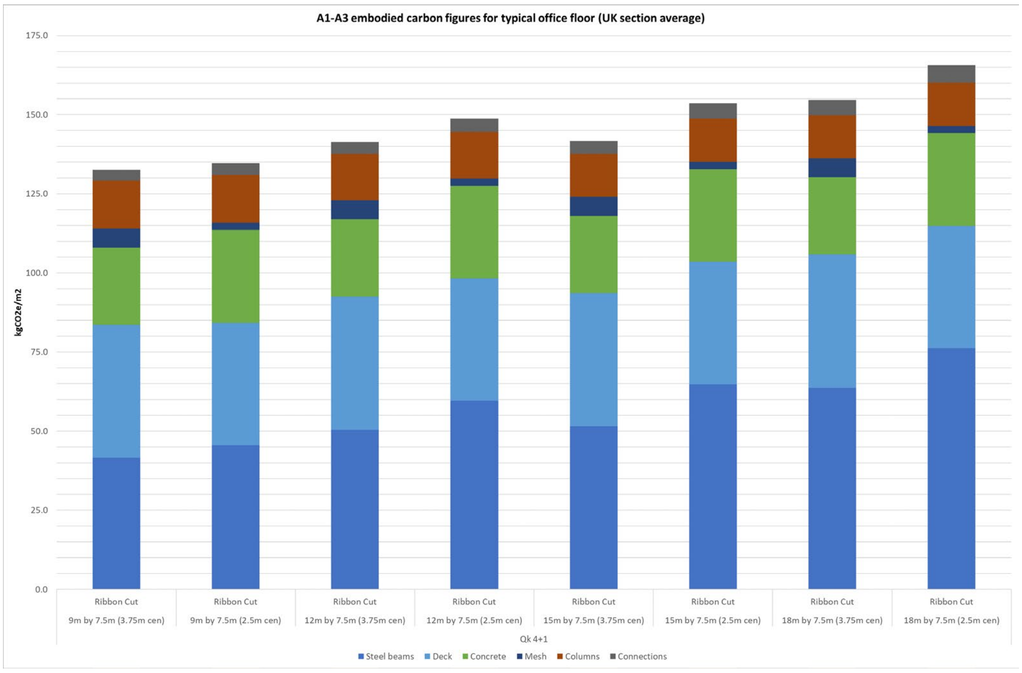

Figure 5 Westok ribbon cut beams based on UK section average manufacture: qk = 4 + 1kN/m2

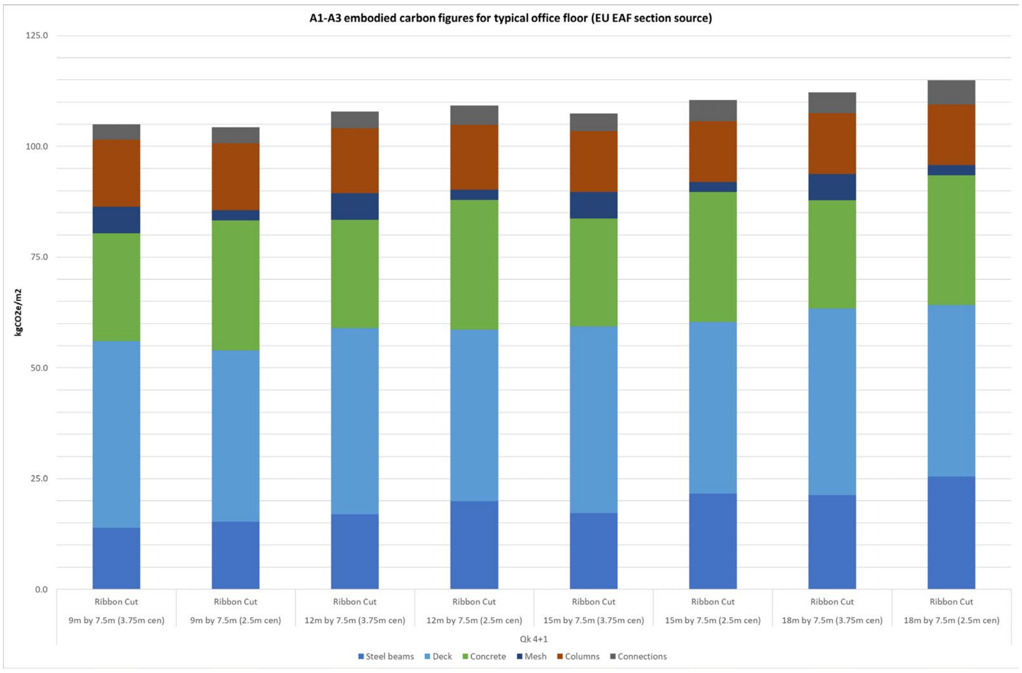

Figure 6 Westok ribbon cut beams based on EAF manufacture: qk = 4 + 1kN/m2

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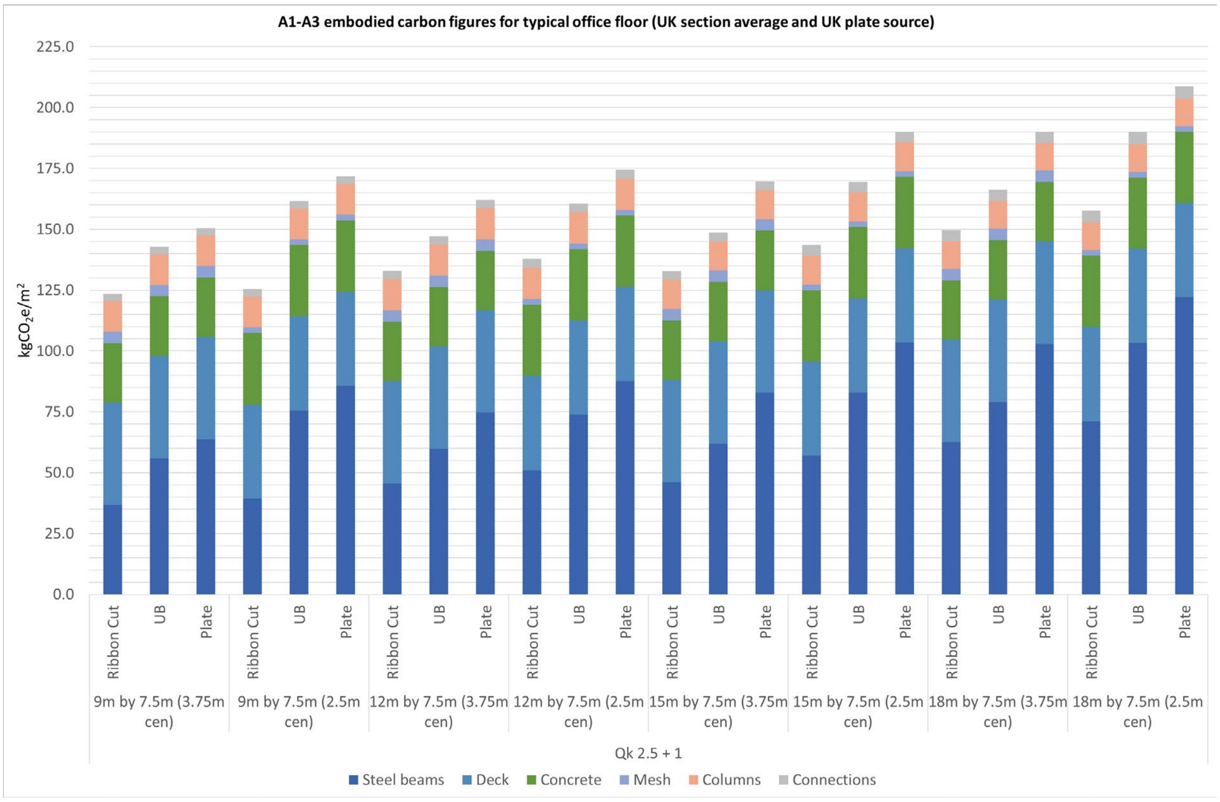

Figure 7 Westok ribbon cut, Westok UB & Westok plate beams based on UK section average manufacture: qk = 2.5 + 1kN/m2

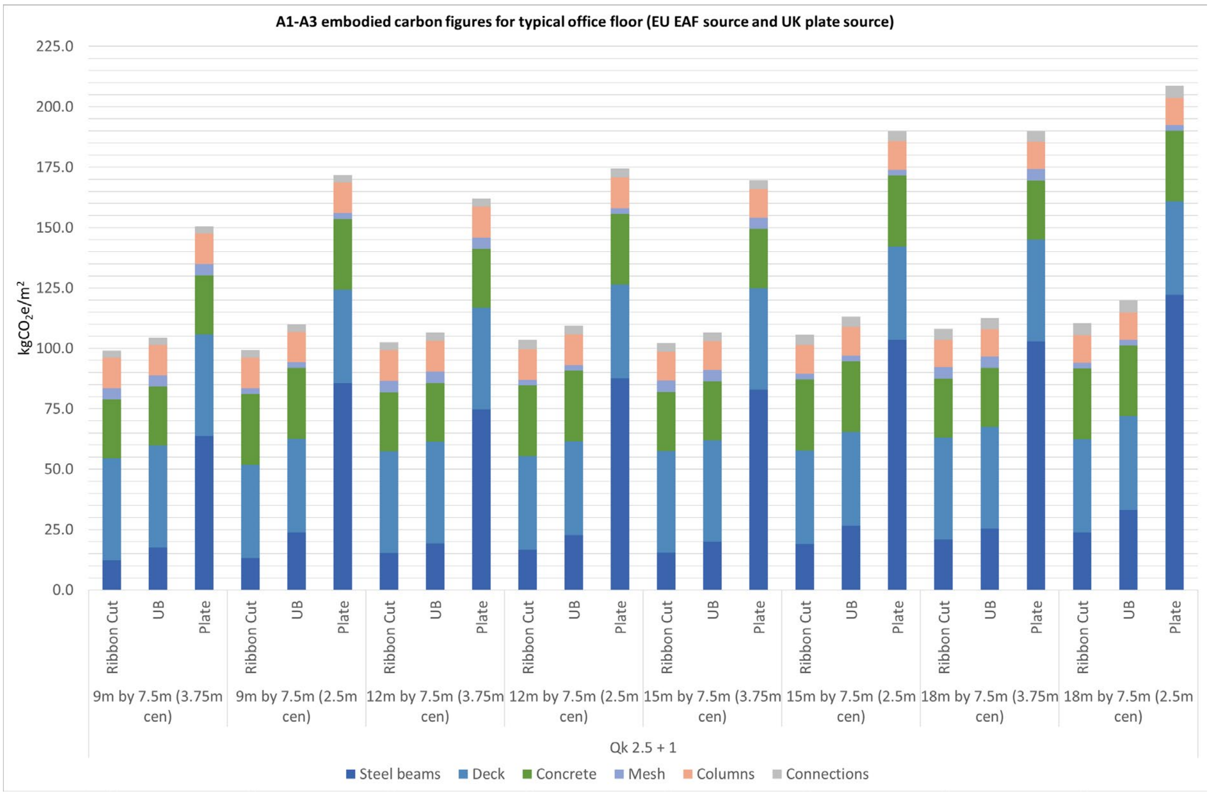

Figure 7 Westok ribbon cut, Westok UB & Westok plate beams based on EAF manufacture: qk = 2.5 + 1kN/m2

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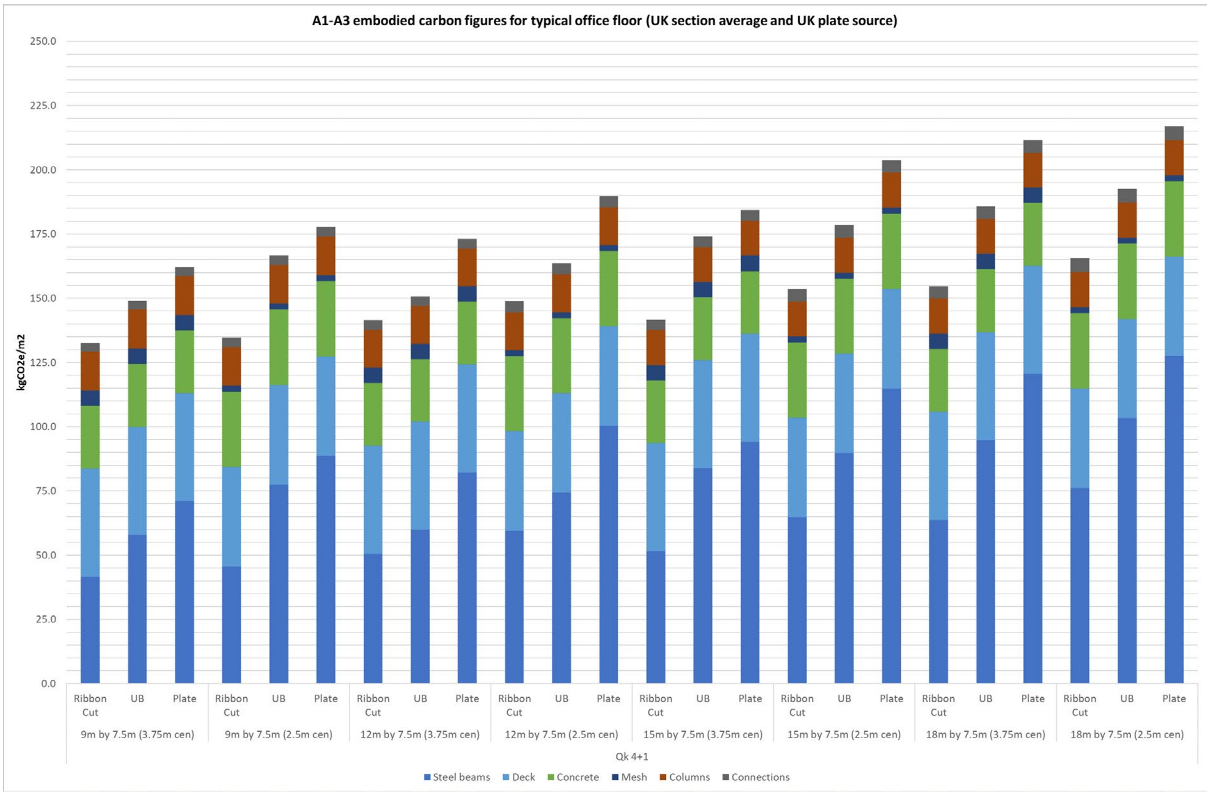

Figure 8 Westok ribbon cut, Westok UB & Westok plate beams based on UK section average manufacture: qk = 4 + 1kN/m2

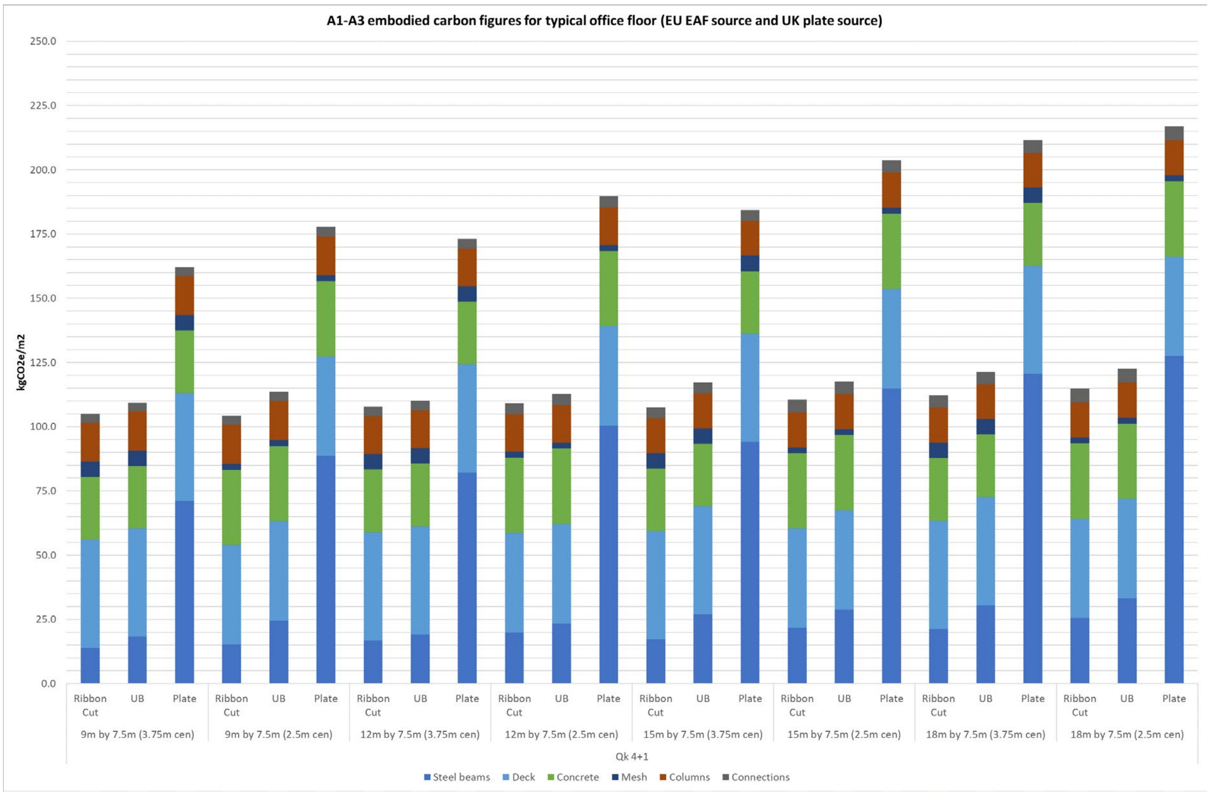

Figure 9 Westok ribbon cut, Westok UB & Westok plate beams based on EAF manufacture: qk = 4 + 1kN/m2

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