WESTOK CELLULAR BEAM GRID STUDY

FOR COMMERCIAL OFFICE BUILDINGS (Nov 2021)

At ASD, we are driven by our passion for contributing to a sustainable future and reducing our environmental footprint. With ASD Westok leading the charge, we offer a complimentary advisory design service, where our dedicated structural engineers strive to deliver lean and carbon-friendly designs. In line with our commitment to sustainable practices, we are proud to unveil a comprehensive grid study tailored for commercial office developments.

Our work confirms that the Westok cellular beam, is the lightest weight, lowest embodied carbon cellular beam in the market.

Grid Study

The gird study compares the impact of beam type, loading, beam spacing and bay size on the floor-plate steel kg/m² and embodied carbon $kgCO_2e/m^2$ for the different forms of cellular beam manufactured by ASD Westok.

The design philosophy is based on Westok's experience assisting with the design of hundreds of commercial office developments across the UK and Ireland using the material efficient long-span secondary beam approach to the grid.

The parameters of the grid study are:

- Westok cellular beams compared: ribbon-cut, UB, plate
- Office loading: Super G_k = 1.0kN/m² ; Q_k = 2.5 + 1kN/m² and 4 + 1kN/m²
- 140mm metal deck slab
- Primary beam span: 7.5m
- Secondary beam spans: 9m, 12m, 15m & 18m
- Secondary beam spacing: 2.5m and 3.75m c/c
- Standard office service requirements: regularly spaced 400mm diameter cells

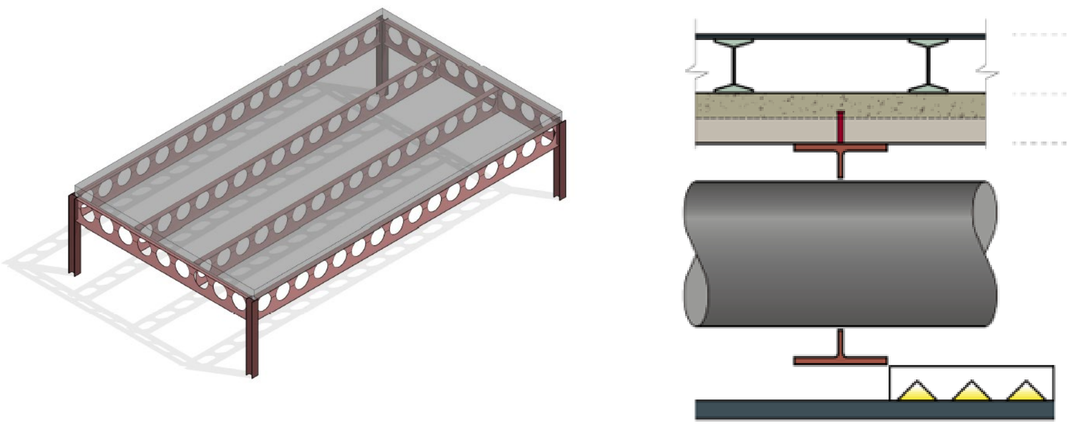

Figure 1 Typical grid layout & floor cross-section

Discussion: Cellular Beam Characteristics

The material efficient Westok ribbon-cut manufacturing process typically involves expanding hot-rolled stock sections to significantly increase the beam section properties beyond the parent sections. The profiled tees are welded back together to form the Westok beam with a full portfolio of cells across the beam. This is the ideal service integration approach; a highly flexible solution which delivers a significant degree of future proofing.

The flexible profiling process allows beams to be manufactured in depths of +/- 1mm. Asymmetric design and cost-free in-house pre-cambering are available to ensure the design of each Westok ribbon-cut beam is optimised in every instance.

Westok plate beams comprise individual plated webs and flanges welded to form the I-shaped cellular beam using an automated submerged arc welding process. Westok plate beams can also benefit from both asymmetric design and pre-cambering, whereas asymmetry is not available for Westok UB sections. Westok UBs are limited to the available stock sections and tend to be heavier than alternatives to facilitate the profiling of cells, with a knock-on increase in transportation costs.

The provision of regular cells in Westok plate and Westok UB cellular beams involves the wasteful profiling of cells from solid web or plate material, and this is reflected in the higher waste values evident in the results. Based on our study, the Westok ribbon-cut manufacture process generates between 1.4 to 4.7 times less scrap compared to the other cellular beam types reviewed.

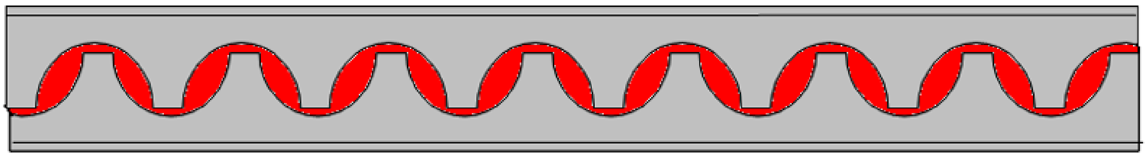

Figure 2 Westok's low waste ribbon-cut profiling process

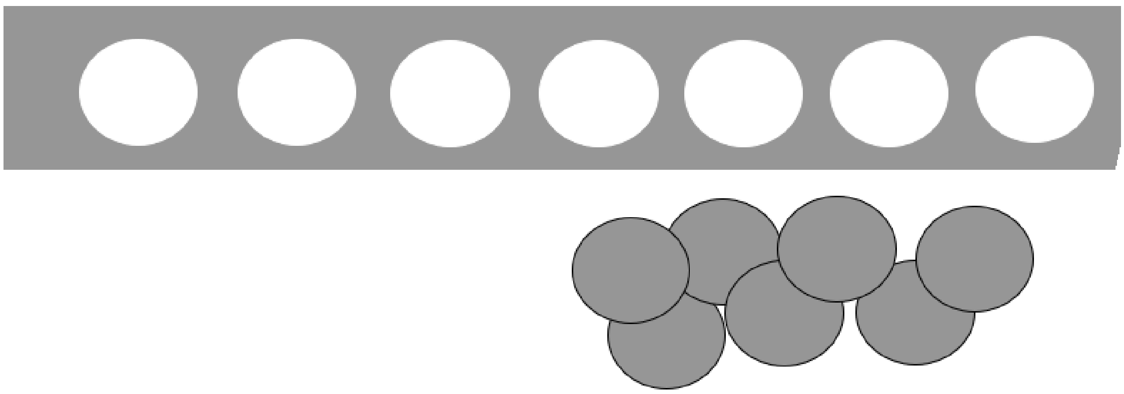

Figure 3 Profiling cells from solid web/plate material

Discussion: Steelwork Densities

Westok manufacture beams in a range of lengths, depths and weights, reflecting the needs of any given project. For the grid study, secondary beams ranging from 9m to 18m have been adopted for comparison purposes. Beam lengths below and beyond these lengths are available also.

The results illustrate the steelwork density of the combined secondary & primary beams per bay in kg/m^2. The scrap content associated with the manufacture and parent material purchase for each cellular beam type is included.

The study indicates that:

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

- Longer-spanning solutions using Westok ribbon-cut beams offer a lighter floor steelwork density than alternatives on a shorter grid

Discussion: Module A1-A3 & D Embodied Carbon

When reviewing the embodied carbon values of steelwork, there is much debate regarding which embodied carbon factors to adopt.

Hot-rolled section from the electric arc furnace (EAF) process are manufactured from scrap steelwork. Consequently the %-age recycled content is very high at 90%+ and EAF steelwork attracts a relatively low up-front product A1-A3 embodied carbon value.

Plate and section from the basic oxygen steelmaking (BOS) process result in a relatively low %-age of recycled content of ca. 20-25%, and consequently relatively high up-front A1-A3 embodied carbon values.

Module D is an important metric for quantifying the circular economy and the inherent reuse and recycling capabilities of steelwork. The embodied carbon values for BOS and EAF are re-balanced when Module D recycling is considered as part of a whole life carbon assessment.

For simplicity, average A1-A3 values of 1740 kgCo_2e/t for hot rolled section, and 2230 kgCO_2e/t for plate have been used when presenting our results. For assessments involving Module D, average values of -930 kgCo_2e/t & -1260 kgCo_2e/t have been adopted for hot rolled section and plate respectively. These values are presented in graph format also.

Our work clearly demonstrates the benefit of using light-weight ribbon cut cellular beams when compared to alternative cellular beams for early carbon assessments.

Conclusion

To assist with combatting the impacts of the climate emergency, lean design is required so that material efficient building structures are constructed.

Lightweight Westok cellular beams have been successfully adopted for many years as a value-engineered design solution for commercial office developments and other sectors, across the UK, Ireland and further afield.

The use of cross-laminated timber floors has proven to offer an attractive solution in more recent times, and Westok have assisted with a number of such schemes also.

Care must be taken to ensure temporary loading, steelwork fabrication and erection concerns, fire and vibration etc are adequately catered for. ASD Westok's Technical Advisory service is available at no cost to assist with all of these topics. As part of this process, project-specific value engineering design and carbon calculations are produced.

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

Results

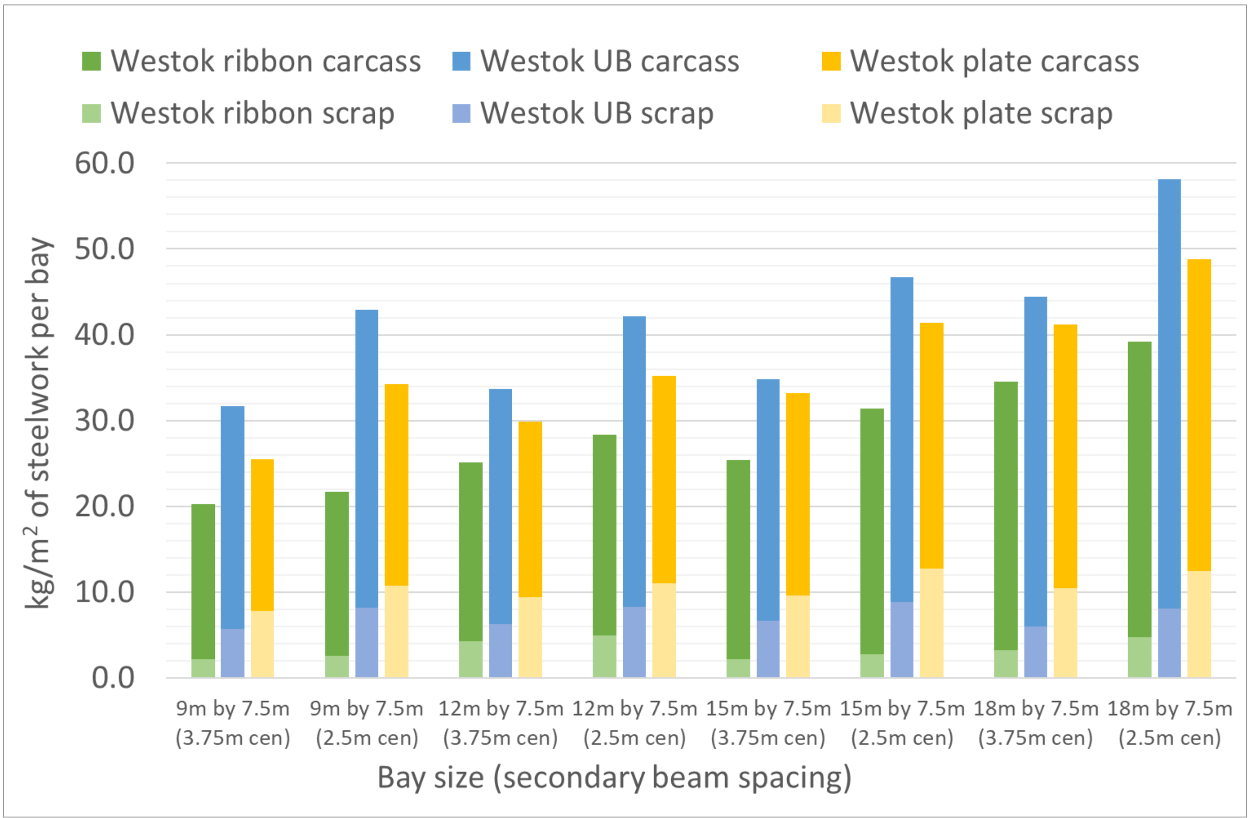

Figure 4 Bay Steelwork kg/m² (Q_k = 2.5+1kN/m²)

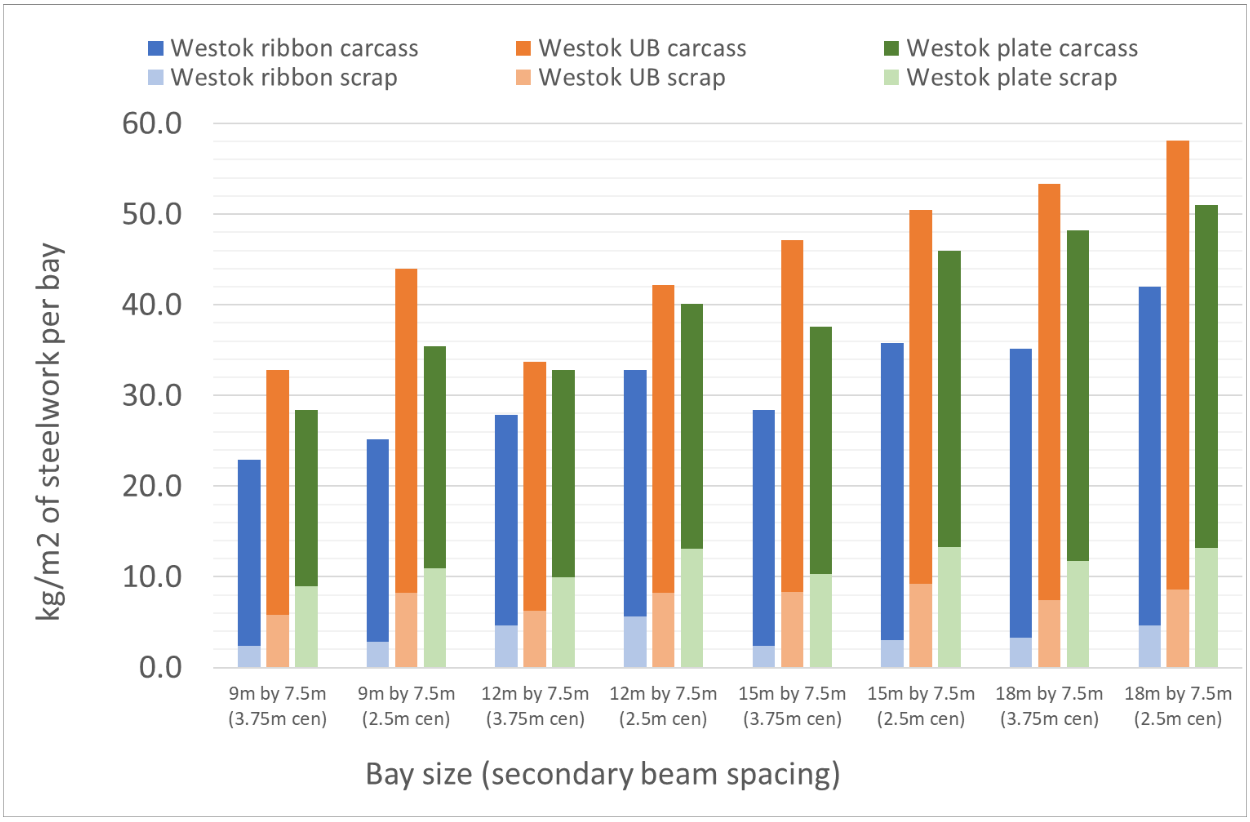

Figure 5 Bay Steelwork kg/m² (Q_k = 4 +1kN/m²)

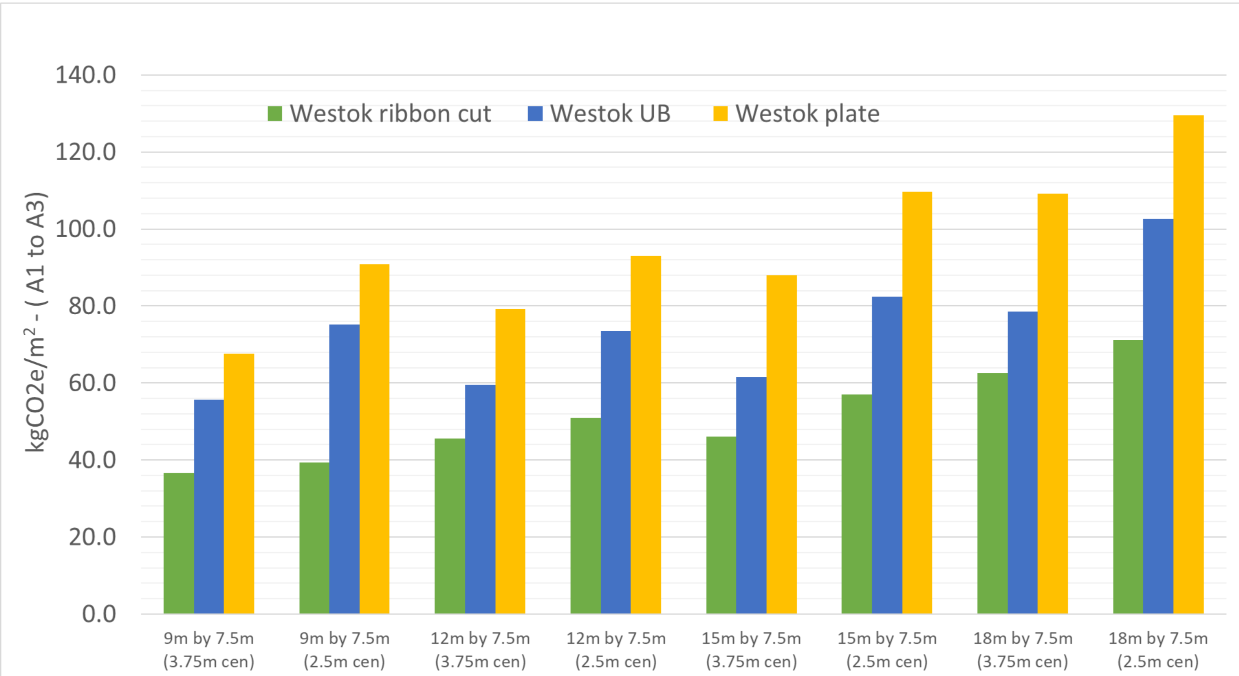

Figure 6 Embodied carbon kgCo₂e/m² for module A1-A3 (Q_k = 2.5 + 1kN/m²)

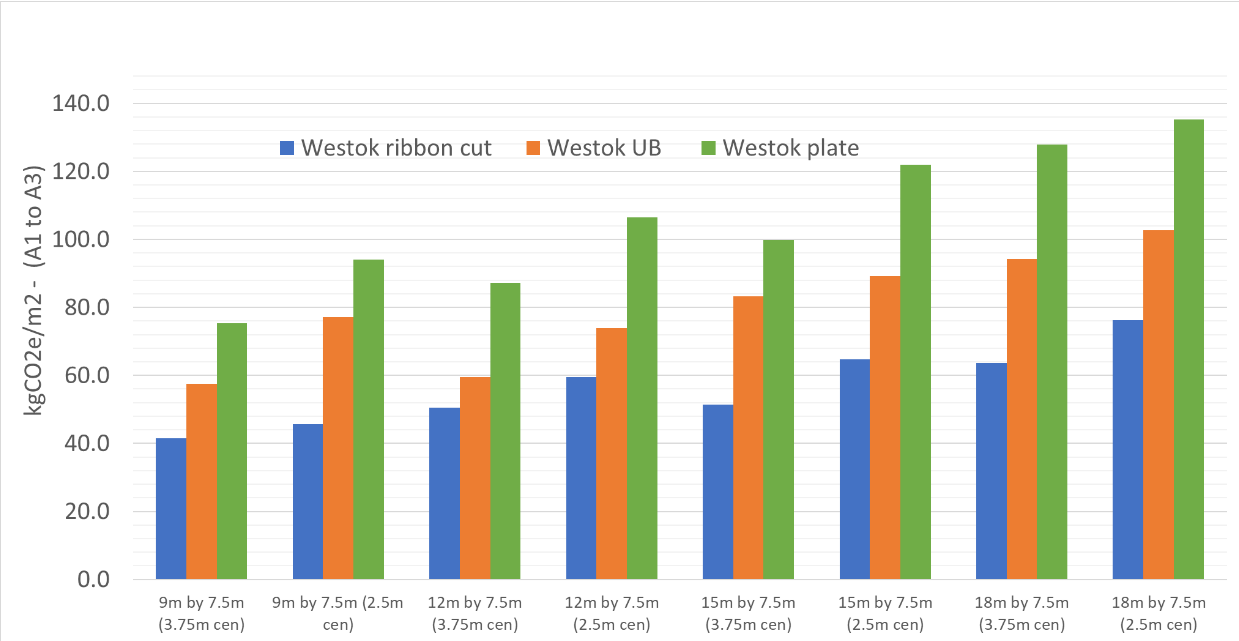

Figure 7 Embodied carbon kgCo₂e/m² for module A1-A3 (Q_k = 4 + 1kN/m²)

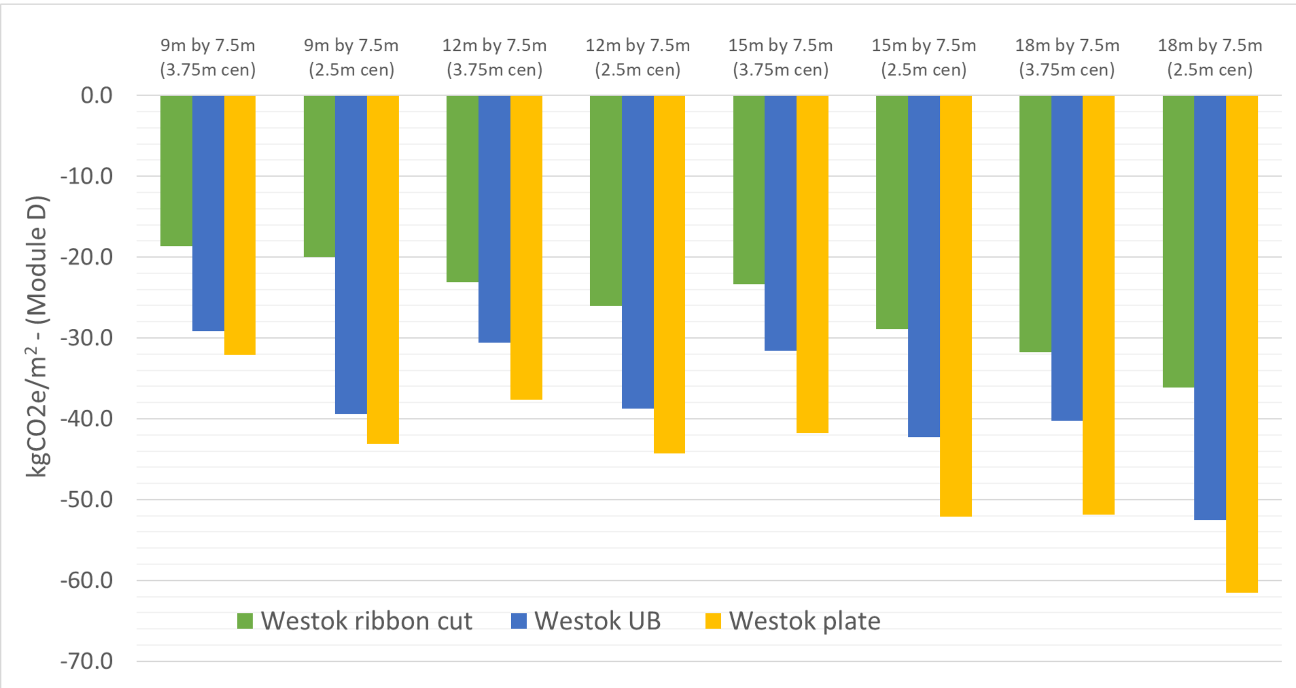

Figure 8 Embodied carbon kgCo₂e/m² for module D (Q_k = 2.5 + 1kN/m²) (Reported as negative to highlight benefit beyond the system boundary)

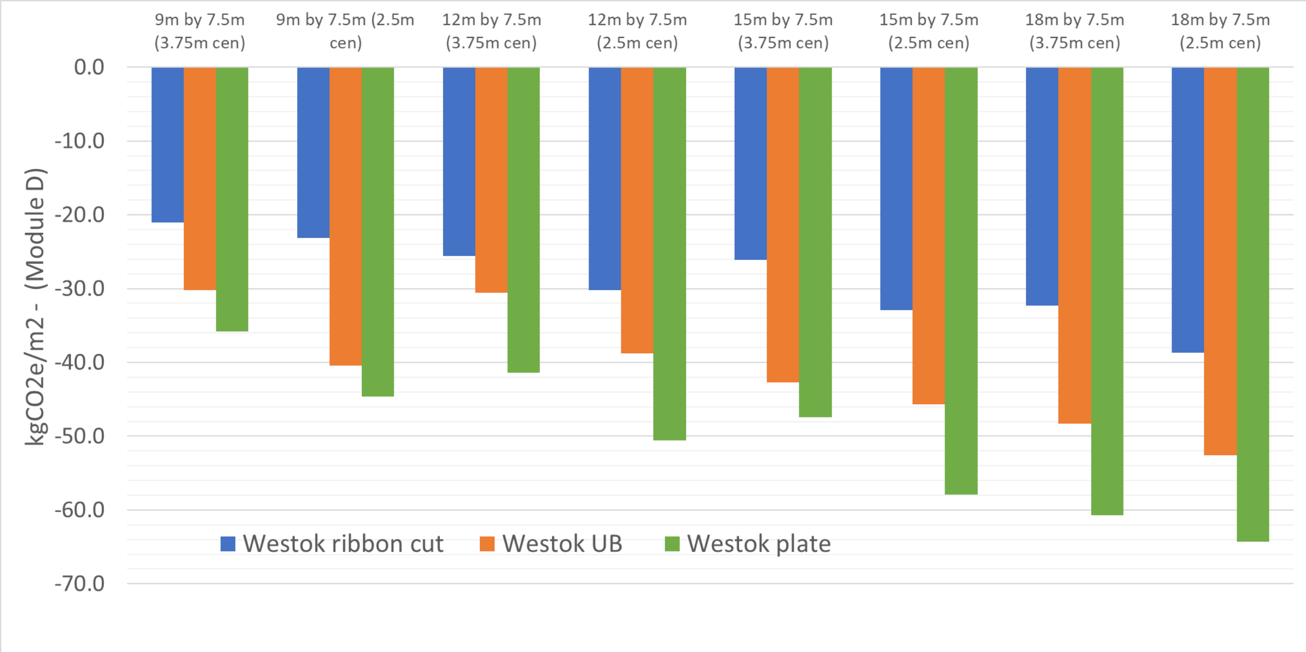

Figure 9 Embodied carbon kgCo2e/m2 for module D (Qk = 4 + 1kN/m²) (Reported as negative to highlight benefit beyond the system boundary)