PEIKKO

# WHITE PAPER

# DELTABEAM® SLIM FLOOR STRUCTURES TO LIGHTEN A BUILDING'S ENVIRONMENTAL FOOTPRINT

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## 1 INTRODUCTION

The building industry is responsible for more than 30% of global $CO_2$ emissions. Development, design, and construction phases are estimated to account for 30% of a building's emissions. Furthermore, over its entire life cycle, the building's emissions have a huge impact on the environment, and they are estimated to account for more than 70% (Fig. 1).

Future urbanization rapidly requires solutions to meet this challenge. For this reason, we in the building industry need to be innovative in creating solutions that are economical yet ecological. DELTABEAM® Slim Floor Structures greatly improve the sustainability of buildings in both the construction and the operational phases. Building height is decreased, total material consumption can be reduced, and recyclable materials and processes can be used. Bu choosing products that are manufactured by using recycled raw materials with lower $CO_2$ emissions in the process, even challenging environmental targets can be achieved sooner than expected.

Peikko promises to change the building industry to be faster, safer, and more efficient and to lighten its environmental footprint. By using DELTABEAM® Slim Floor Structures, the environmental impact of buildings can be decreased in many ways. In this White Paper, three ways of achieving this goal are presented along with recent case studies and a new, recently launched and innovative product called DELTABEAM® Green. This product is made from recycled steel using renewable energy and delivered with low-emission logistics. And eventually sustainable promises have to be proofed with certified Environmental Product Declarations, EPDs, enabling reliable, comprehensive building life cycle assessments, LCAs.

## 2. REDUCTION IN BUILDING HEIGHT

By reducing building height while retaining the same number of floors, significant environmental and economical savings can be made. In a six-storey building, for example (Fig. 2), has a height of 27.8 meters, and the surface area of one floor with a conventional structure is 20,000 $m^2$ (550,000 $m^3$).

The same building designed with a Slim Floor Structure has a height of 25.4 meters, a reduction in hight of 2.4 meters and reduction in volume of approximately 50,000 $m^3$ which is 10% less. Less cladding and lower columns, walls, elevator and stair shafts, pipes and ducts all lead to savings and a more sustainable structure. As the building envelope is smaller, energy consumption for heating and cooling is lower throughout the lifespan of the building. A slim floor structure can also save significantly on person-hours during construction, and HVAC installation is also easier in a ceiling with no obstructions.

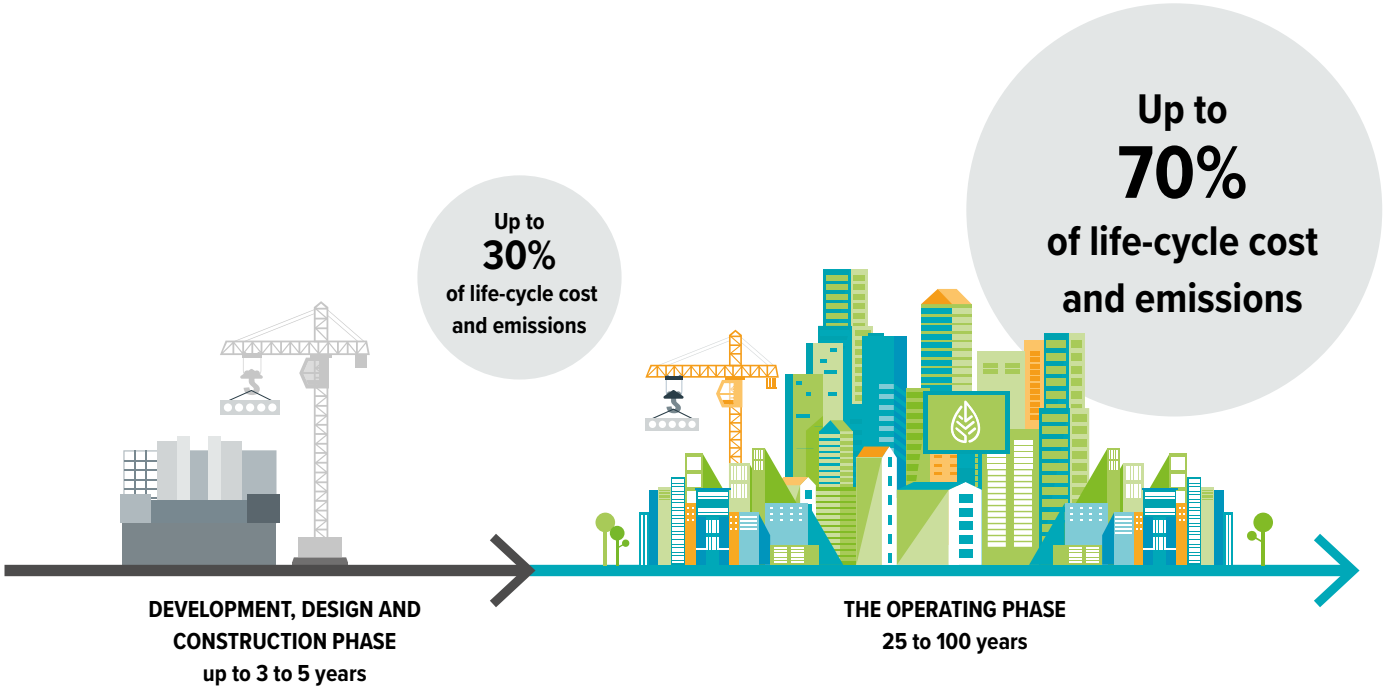



FIG. 1 A BUILDING'S ECONOMIC AND ECOLOGICAL FOOTPRINTS OVER ITS ENTIRE LIFE CYCLE

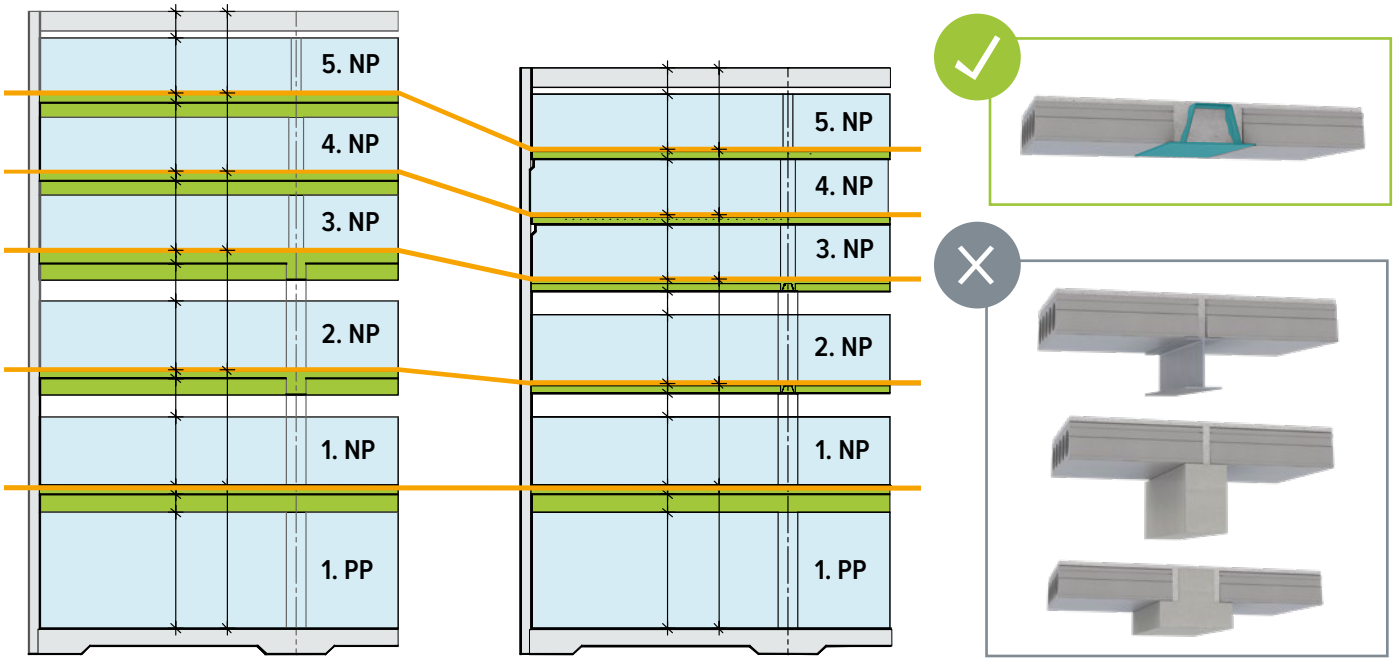



FIG. 2 DIFFERENCE IN HEIGHT AND BUILDING ENVELOPE BETWEEN A SLIM FLOOR STRUCTURE AND CONVENTIONAL STRUCTURE

### 3. REDUCTION IN SITE LOGISTICS AND USE OF BUILDING MATERIALS

In another building example, the initial design resulted in an overall floor depth of 700 mm using a traditional solution. However, it was quickly realized that a traditional fully cast-in-situ solution presented significant difficulties due to a shortage of local ready-mixed concrete supply, the number of construction workers required, and the lack of construction site area required. The large number of vehicle deliveries would have resulted in serious disruption and emissions in the already congested construction site area. A solution was needed that would result in a faster construction schedule and reduced on-site activities, create less need for in-situ concrete works, and be more eco-friendly in particular.

Initial calculations were carried out with various combinations of DELTABEAM® composite beams, hollow-core slabs, and topping depths. The calculations indicated that it was possible to find a structural solution that meets the stringent specification requirements with the required construction advantages. Finally, a detailed FEM analysis revealed that the required low response factors would be achieved with D32-500 DELTABEAM® beams, 300 mm-deep hollow-core slabs, and 200 mm of structural concrete topping. The designed result was a hybrid frame combining the benefits of both precast and cast-in-situ techniques. The use of DELTABEAM® facilitated a 200 mm-slimmer floor compared to an in-situ-casted floor (Fig. 3). According to the main contractor's estimation, the engineered hybrid solution reduced the number of truck deliveries to the site by over 500 and the dead weight of the building by more than 3,000 tons compared to the original in-situ frame solution. The onsite construction program was 20 weeks faster and saved over 2,500 person-weeks in comparison to the envisaged in-situ solution. Moreover, the overall carbon footprint was significantly reduced, with fewer truck deliveries and high-quality offsite production of the DELTABEAM® and precast concrete units.

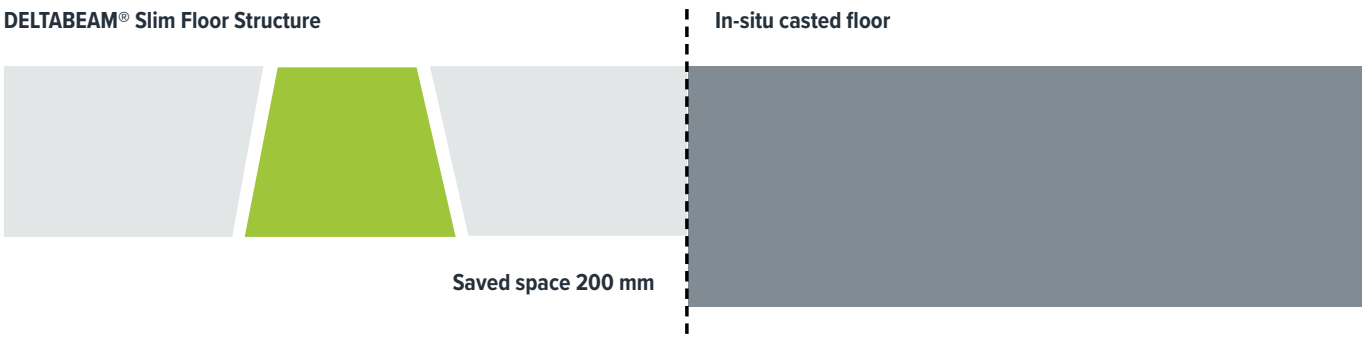
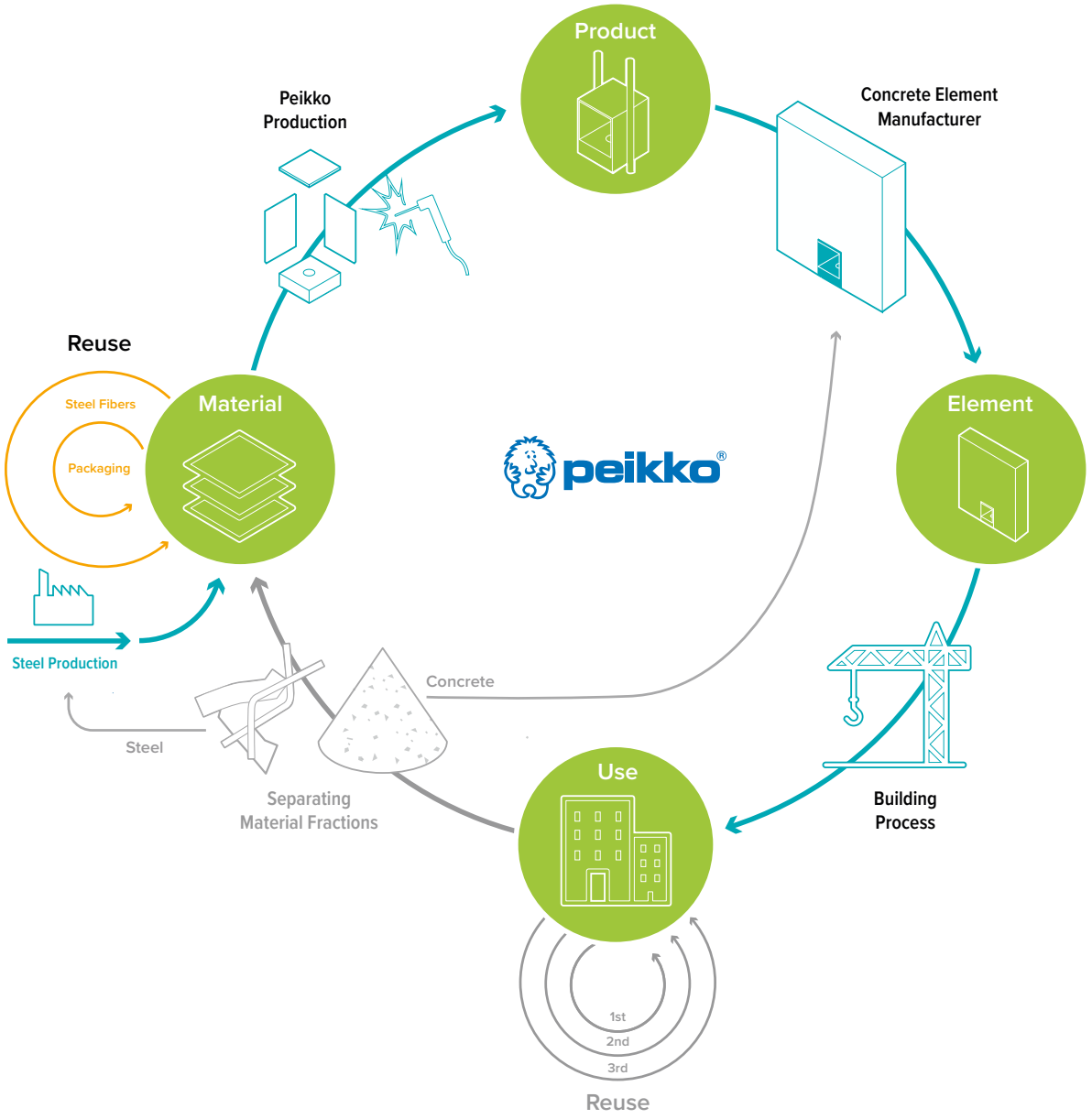



FIG. 3 THE OVERALL SLAB THICKNESS WAS REDUCED BY 200 MM AND THE DEAD WEIGHT OF THE BUILDING WAS MORE THAN 3,000 TONS LOWER COMPARED TO THE ORIGINAL IN-SITU FRAME SOLUTION.




## 4. LIGHTENING A BUILDING'S ENVIRONMENTAL FOOTPRINT WITH DELTABEAM® GREEN

Optimizing material usage is a step towards closed-loop economy. In frame manufacturing, it entails reducing the amount of virgin material and resources used. This can be achieved by analyzing the entire production chain presented in Fig. 4. The aim of reducing and re-using materials and components offers significant potential for cutting $CO_2$ emissions. The best-case scenario, in which all materials would be separated and reinserted into the circular process as raw materials at the end of their life cycle, is the goal that the entire industry needs to further develop.

To lighten the environmental footprint, Peikko has made significant progress by increasing the use of recycled steel in the DELTABEAM® Slim Floor Structure (Fig. 5). The result is DELTABEAM® Green, produced from 90% of recycled steel and using green energy. This new, environmentally friendly version of Peikko's Slim Floor Structure solution offers the same benefits as the standard DELTABEAM® but with a significantly reduced environmental impact compared to traditional steel structures.

DELTABEAM® Green composite beams cut $CO_2$ emissions by up to 50%. Their eco-friendly design encompasses everything from materials and production and to certifications and transport. The environmental impacts are confirmed by the third-party verified Environmental Product Declaration, EPD, and project-specific Life Cycle Assessment calculations of $CO_2$ emission can be based on this certificate. For those seeking to achieve high BREEAM or LEED standards, DELTABEAM® Green is an easy, efficient solution. Peikko's DELTABEAM® Green goes all out on sustainability, and the extra mile, too.

In the following chapter, a comparative calculation explains how much DELTABEAM® Green can reduce the $CO_2$ emissions of an office building in practice.

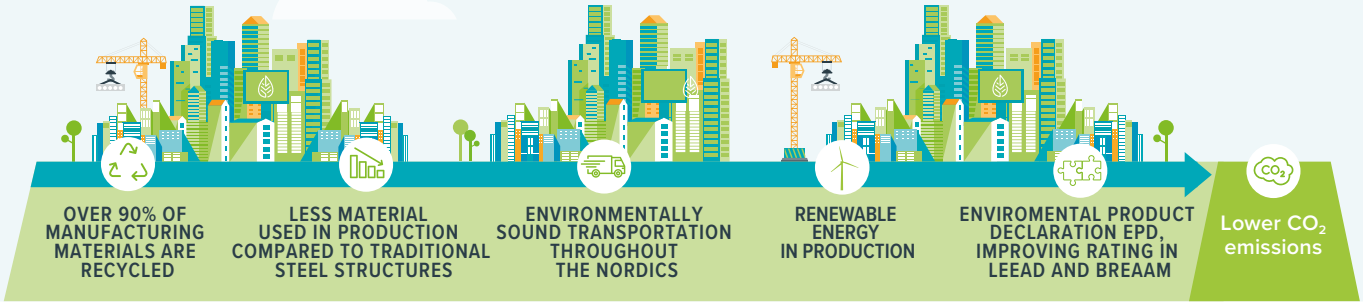



FIG. 5 DELTABEAM® GREEN LIGHTENS THE ENVIRONMENTAL FOOTPRINT OF BUILDINGS IN MULTIPLE WAYS

### 4.1 COMPARISON OF THE ENVIRONMENTAL FOOTPRINTS OF DIFFERENT BEAM TYPES IN A TYPICAL OFFICE BUILDING

Based on available official EPD data, Peikko has made sample calculations for a real office building that has been built. The project involves 10 floors, a floor space of roughly 20,000 $m^2$, and over 500 beams delivered. In this comparison, one floor with 41 beams was used to calculate the amount of $CO_2$ emissions. The building frame is of beam-column type with precast staircases and sandwich walls. The compared beams are steel box beam (WQ), pre-stressed concrete beam, standard DELTABEAM® and DELTABEAM® Green. Examples of cross-sections of the different beams are shown in Fig. 6.

Based on these beam types, Fig. 7 shows the equivalent amount of $CO_2$ emissions in kg per square meter of floor in the building. Total $CO_2$ emissions are divided into $CO_2$ emissions caused by raw material used in the production of the beam ($kgCO_2/m^2$), emissions caused by fire protection paint in the WQ beam and infill concrete used in DELTABEAM®, and emissions caused by higher walls needed because of the height of the bottom flanges of beams. Wall areas are calculated from the actual project.

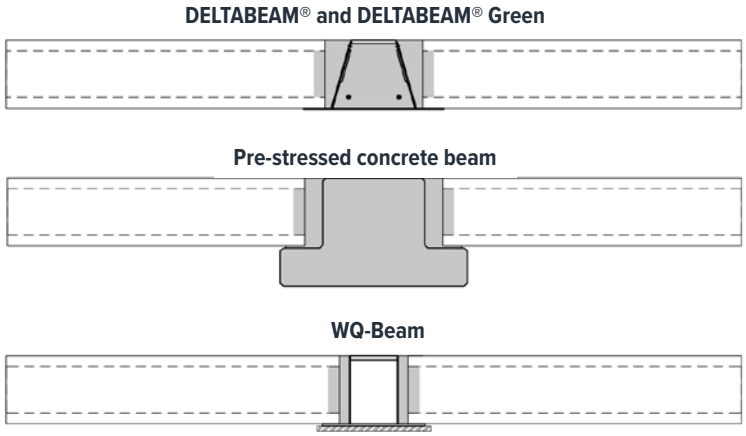
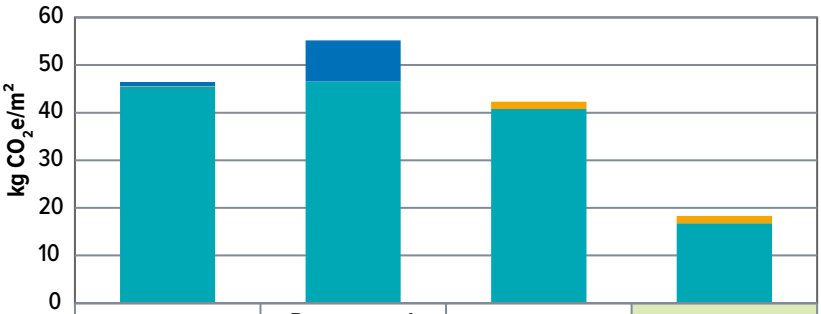



FIG. 6 BEAM TYPES USED IN THE COMPARISON




| | WQ | Pre-stressed concrete beam | DELTABEAM® | DELTABEAM® Green |
|---|---|---|---|---|
| % of max value | 98% | 100% | 88% | **36%** |
| $CO_2$ kg from higher walls | 0,9 | 8,6 | 0,0 | 0,0 |
| Fire protection paint or infill concrete | 0,1 | 0,0 | 1,5 | 1,5 |
| kg $CO_2/m^2$ | 45,4 | 46,6 | 40,8 | **16,8** |

FIG 7. COMPARISON OF $CO_2$ EMISSIONS IN OFFICE BUILDING

### 4.2 STRUCTURAL COMPARISONS AND $CO_2$ CALCULATION METHOD

WQ beam steel kilograms are optimized by manual calculations in the structure while also making the WQ beams as effective as possible. This led to multiple different cross-sections for the beams, but the result can be considered conservative in a comparison of $CO_2$ emission. It can be assumed that in reality the project would have had a bit more steel kilograms in WQ beams, as the profiles would have been combined into a lower number of different beam profiles. Beam weights per meter vary from 51 kg/m to 213 kg/m. Some of the beams require downstands and the highest beam used was 400 mm high, with several 370 mm high beams also needed. In the $CO_2$ emission calculation, it is assumed that 50 mm-higher walls are needed because of the use of downstands in the beam. The global warming potential of steel in WQ beams in the $CO_2$ emission calculation is 2.72 $kgCO_2e/kg$.

Pre-stressed concrete beams are dimensioned by means of table dimensioning used in pre-design to determine the required profile. Using the profile, the total mass of concrete is calculated. The highest beams used are 800 mm high, and it is assumed that 470 mm-higher walls are needed because of the height of the ledge. The global warming potential of concrete in pre-stressed beams in the $CO_2$ emission calculation is 0.265 $kgCO_2e/kg$. For higher walls the figure is 0.196 $kgCO_2e/kg$. Pre-stressed beams have a higher impact because of the use of high-strength concrete.

DELTABEAM® profiles for the project had already been designed by a structural engineer, and the final design for the beams had already been prepared by Peikko. The DELTABEAM® weight from the Peikko design is used in the $CO_2$ emission calculation. DELTABEAM® weights per meter vary from 61 kg/m to 169 kg/m, so it appears that, especially in longer beams, DELTABEAM® beams are significantly lighter than steel box beams. The global warming potential of DELTABEAM® used in the $CO_2$ emission calculation according to DELTABEAM® EPD is 2.94 $kgCO_2e/kg$. For DELTABEAM® Green, the EPD figure is 1.21 kgCOe/kg. For infill concrete, the figure used is 0.146 kgCOe/kg, which is lower than the figure used for concrete walls as no reinforcement is needed.

### 4.3 RESULTS OF THE OFFICE BUILDING COMPARATIVE CALCULATIONS

As a conclusion from this study based on one office building considering only $CO_2$ emissions from building materials, it appears that all three basic solutions are equal when compared. Significantly lower $CO_2$ emissions can be achieved by choosing recycled material for beams such as DELTABEAM® Green. In this comparison, DELTABEAM® Green causes 64% lower emissions in the comparison from pre-stressed concrete beams. Compared to traditional DELTABEAM®, the green version generates 59% lower $CO_2$ emissions.

### 4.4 DELTABEAM® AND GREEN ENVIRONMENTAL FOOTPRINT CALCULATOR

Peikko has developed a calculation tool that can estimate the $CO_2$ emissions of beams at the preliminary stage of a project, as shown in the example in Fig. 8. Only the building type, floor type, floor thickness and grid need to be defined in order to obtain estimated $CO_2$ emissions for DELTABEAM® and DELTABEAM® Green for two different profiles. More information on this tool is available from local Peikko sales offices (www.peikko.com).

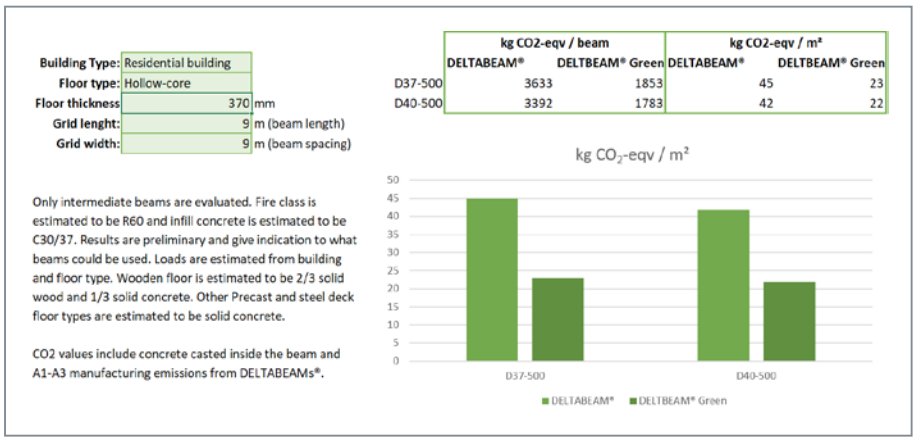



FIG. 8 CALCULATION EXCEL TOOL FOR ESTIMATING THE $CO_2$ EMISSIONS OF DELTABEAM® BEAMS AND DELTABEAM® GREEN AT THE PRELIMINARY STAGE OF A PROJECT.

## 5. CONCLUSIONS

**The main conclusions of this White Paper are as follows:**

1. Using Slim Floor Structures can significantly reduce both the constructional and the operational environmental impacts of buildings
2. Commercially available solutions can be used for both economically and ecologically sound construction
3. Tried and true building methods are already available for use in combination with low-emission materials and processes
4. Using circular economy in structural components is an effective way to lower building $CO_2$ emissions further using DELTABEAM® Green, for example


# A faster, safer, and more efficient way to design and build

Peikko is a leading global supplier of slim floor structures, wind energy applications and connection technology for precast and cast-in-situ. Peikko's innovative solutions offer a faster, safer, and more efficient way to design and build.

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