Supporting information for the paper:

"The Lightest Beam Method - a methodology to find ultimate steel savings and reduce embodied carbon in steel framed buildings"

Buildings Embodied Carbon Assessment – MEICON project

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1. Introduction

This document is an integral part of the Buildings Embodied Carbon Assessment (BECA), developed in the MEICON project at the University of Cambridge as well as a Supporting Information for the paper: "The Lightest Beam Method - a methodology to find ultimate steel savings and reduce embodied carbon in steel framed buildings"

It is not surprising that environmental impact (embodied energy / embodied carbon) of different structural materials used in buildings differs. This is due to the fact that energy intensity to produce these materials varies, i.e. there is significant difference between
energy used to produce 1 tone of steel and 1 tone of concrete. What is more,
environmental calculations can be different as well for the same element made from the same material, used in the same building, in the same location. The variations are usually due to the use of different carbon data sources, carbon deductions and future credits, different calculation boundaries, etc. Different buildings can be compared only under the same data assumptions, within the same boundaries. Comparison is then based on materials quality and quantity and specific location. Nevertheless, finding this level of information might be very time consuming, and in many cases, impossible as many of materials used in buildings are not assessed yet form environmental point of view.
The environmental impact of the buildings depends on the materials and processes related to produce the building (embodied carboy/energy to practical completion), operational energy that is needed during the service life (e.g. for lighting heating, cooling) and embodied carbon/energy over the building life, connected to materials and processes related to maintenance, repair, replacement, refurbishment, as well as connected to the building end-of-life (e.g. demolition, materials disposal etc.).
Embodied carbon in use is can represent approximately 20-32% of whole-life carbon emissions for 60-year building life cycle but due to lack of detailed information, is not included in the environmental calculations.

This report provides an information about initial embodied carbon values for different building life cycle stages, that were agreed for further calculations. Neither operational nor embodied carbon was included in the report, nevertheless the next steps of this work is to find complete environmental impact of buildings over the time.

2. Methods

To eliminate the barriers to trade, the framework standards of environmental impacts was developed under the Technical Committee 350 "Sustainability of construction works" CEN/TC350[1]. Integration of all three sustainability aspects (economic, social and environmental) were included in BS EN 15643-1:2010 "Sustainability of construction works. Sustainability assessment of buildings. General framework". CEN/TC350 has developed standards for the sustainability assessment of buildings (EN 15978:2011) as well as for relevant

[1] European Committee for Standardisation, https://standards.cen.eu/

for products (EN 15804:2014). The methods include the assessment of the sustainability aspects of new and existing construction works (buildings and civil engineering works) and materials from the cradle to the grave (from raw materials to after-production-stage). Both represent the modular approach, within the system boundary presented on Figure 1.

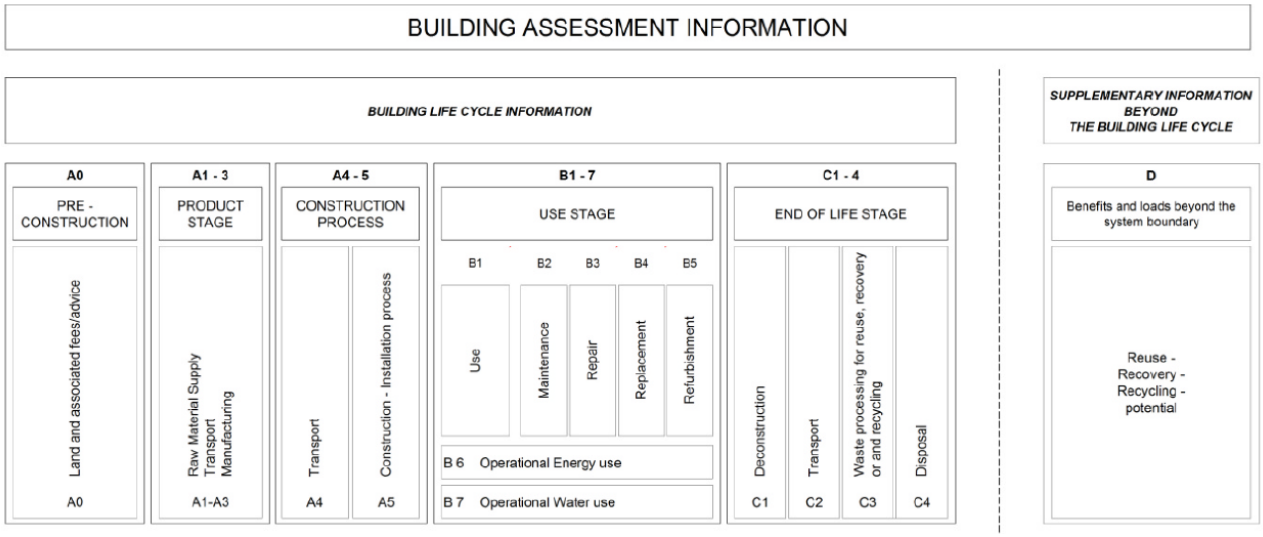

Figure 1 Scope of building assessment information

3. Environmental impact of used materials

The purpose of this section was to find environmental impact of structural materials. The scope was to find complete information regarding the impact of materials across the building life, including all life cycle stages. Nevertheless, due to lack of information regarding use stage (Module B), this report was limited to modules A, C and D. Module B1 was included only for concrete, as this data was available.
Inventory of Carbon & Energy (ICE V3.0)[2] was the main data source for modules A1-A3. For the rest, producers EPD's was used. Detailed information how values were calculated are presented in further sections.

3.1. Concrete

In this study 11 different EPD's for ready mix concrete was collected and analysed. Analysis was also based on values included in ICE v3.0 data base.

3.1.1. Module A1 – raw material supply, including processing of secondary material input

According to ICE v3.0 data base general embodied carbon for concrete varies between 0.104 kg CO2e/kg for C16/20 (with assumed 240 kg cementitious content per m^3) up to 0.138 kg CO2e/kg for 32/40 (with assumed 360 kg cementitious content per m^3). For more specific use and with increasing cement replacement by fly ash embodied carbon decreases from 0.113 (no replacement, only CEM I) to 0.081 kg CO2e/kg (40% replacement) for C16/20 and 0.149 (no replacement, only CEM I) to 0.109 kg CO2e/kg (30% replacement) for C32/40.

[2]Available on http://bit.ly/2nGp3h2

The average value of combined Module A1-A3 from EPD's was found **0.140 kg CO2e/kg** with standard deviation of 0.047 kg CO2e/kg.

For further calculations it was assumed concrete class C32/40 with general ICE v3.0 value of 0.138 kg CO2e/kg (with assumed 360 kg cementitious content per m^3), that was very close to found in EPD's, and reduced by an average values of modules A2 and A3 found in EPD's (described below), giving **0.129 kg CO2e/kg.**

3.1.2. Module A2 – transport of raw materials and secondary material to the manufacturer

This impact is clearly location specific, i.e. the location of the cement and concrete plant. ICE v3.0 data base does not include this value as separate module.
The average value of all found A2 modules was used A2 modules was used as **0.0057 kg CO2e/kg** with a standard deviation of 0.0005 CO2e/kg.

3.1.3. Module A3 – manufacture of the construction products

In case of ready-mix concrete this module includes making the concrete in the batch plant. ICE v3.0 data base does not include this module separately.

The average value of all found A3 modules was used as **0.0028 kg CO2e/kg** with a standard deviation of 0.0016 kg CO2e/kg.

3.1.4. Module A4 – transport to site

This impact is clearly location specific, i.e. the location of the construction site and the concrete factory / concrete pre-cast factory.

In this study 11 different EPD's for ready mix concrete was collected and analysed.
The average value of all found A4 modules was used as **0.0027 kg CO2e/kg** with a standard deviation of 0.0016 kg CO2e/kg.

3.1.5. Module A5 – fabrication

This impact is clearly design dependent, i.e. type of the structure, elements and high of the structure. Includes mainly casting.

Only two EPD's with included Module A5 was found.
The average value was used as **0.0006 kg CO2e/kg** with a standard deviation of 0.0002 kg CO2e/kg.

3.1.6. Module B1 – B7 – use stage

For this exercise it is assumed no maintenance, repair, refurbishment or replacement requirements of the structure during the building lifetime.

Only two found EPD's included Module B1.

The average value was used as **-0.0094 kg CO2e/kg** with a standard deviation of 0.0074 kg CO2e/kg.

3.1.7. Module C1 – deconstruction / demolition

Only two found EPD's included Module C1.
The average value was used as **0.0039 kg CO2e/kg** with a standard deviation of 0.0037 kg CO2e/kg.

3.1.8. Module C2 – transport

This impact is clearly location specific, i.e. the location of the construction site and the recycling factory or landfill facility.

Only two found EPD's included Module C2.
The average value was used as **0.0027 kg CO2e/kg** with a standard deviation of 0.0032 kg CO2e/kg.

3.1.9. Module C3 – waste processing

Only two found EPD's included Module C3.
The average value was used as **0.0031 kg CO2e/kg** with a standard deviation of 0.0009 kg CO2e/kg.

3.1.10. Module C4 – disposal

Only one found EPD's included Module C4.
The value was used as -**0.0002 kg CO2e/kg.**

3.1.11. Module D – reuse / recovery / recycling potential

Only three found EPD's included Module C3.
The average value was used as **-0.0065 kg CO2e/kg** with a standard deviation of 0.0034 kg CO2e/kg.

3.2. Steel reinforcement

In this study 13 different EPD's for steel reinforcement was collected and analysed. The average values for all modules were found.

3.2.1. Module A1 – raw material supply, including processing of secondary material input

According to ICE v3.0 data base World average embodied carbon for rebar is 1.99 kg CO2e/kg. For effective recycled content of 70%, embodied carbon for rebar can be found as 1.45 kg CO2e/kg. Value similar to similar to UK typical cradle-to-gate for bar & rod included in ICE v2.0 (1.46 kg CO2e/kg).

I this study, the average integrated A1-A3 values included in EPD's for 13 reinforcing steel producers was found 0.890 kg CO2e/kg with standard deviation of 0.175 kg CO2e/kg.

For a half of these producers' modules A2 and A3 was also calculated.

For the purpose of this work Module A1 was assumed as an integrated A1-A3 taken from ICE v3.0 (for effective recycled content of 70%) reduced by values of modules A2 and A3 found below.

1.45 - 0.047 - 0.021 = 1.38 kg CO2e/kg

3.2.2. Module A2 – transport of raw materials and secondary material to the man

This impact is clearly location specific, i.e. the location of the construction site, the steel mill, the stockholder and the fabricator.

Six producers declared EPD's Module A2.
The average value was used as **0.047 kg CO2e/kg** with a standard deviation of 0.021 kg CO2e/kg.

3.2.3. Module A3 – manufacture of the construction products

This impact is clearly design dependent, i.e. type of the structure, the element.

Six producers declared EPD's Module A3.
Nevertheless for 6 reinforcing steel producers, calculations of module A2 was found with an average of 0.057 kg CO2e/kg with median of 0.019 kg CO2e/kg and standard deviation 0.09 kg CO2e/kg. Because Module A3 from one EPD was outstanding, it was omitted.

The average value from 5 EPD's was used, **0.021 kg CO2e/kg** with a standard deviation of 0.018 kg CO2e/kg.

3.2.4. Module A4 – transport to site

This impact is clearly location specific, i.e. the location of the construction site and the steelwork contractor.

Six producers declared EPD's Module A4.
The average value was used as **0.018 kg CO2e/kg** with a standard deviation of 0.0048 kg CO2e/kg.

3.2.5. Module A5 – fabrication

This impact is clearly design dependent, i.e. type of the structure, elements and high of the structure.

Four producers declared EPD's Module A5.
The average value was used as **0.102 kg CO2e/kg** with a standard deviation of 0.011 kg CO2e/kg.

3.2.6. Module B1 – B7 – use stage

Modules B1 to B7 are not taken into consideration. For this exercise it is assumed that there is no maintenance, repair, refurbishment or replacement requirements of the structure during the building lifetime.

3.2.7. Module C1 – deconstruction / Demolition

This impact is clearly design dependent, i.e. type of the structure, elements and high of the structure.

Four producers declared EPD's Module C1.
The same value in all four EPD's was found. For calculations value **0.002 kg CO2e/kg** was used.

3.2.8. Module C2 – transport

This impact is clearly location specific, i.e. the location of the construction site and the recycling facility / landfill.

Four producers declared EPD's Module C2.
The same value in all four EPD's was found. For calculations value **0.039 kg CO2e/kg** was used.

3.2.9. Module C3 – waste processing

Only one produced declared Module C3.
For calculations value **0.0043 kg CO2e/kg** was assumed.

3.2.10. Module C4 – disposal

Disposal module was introduced by 4 producers with an average of 0.0014 kg CO2e/kg and standard deviation 0.00026 kg CO2e/kg.

Value **0.0014 kg CO2e/kg** was assumed for further calculations.

3.2.11. Module D – reuse / recovery / recycling potential

Reuse potential was declared by 6 producers with an average -0.258 kg CO2e/kg and standard deviation 0.155 kg CO2e/kg.

One EPDs' module was outstanding (-0.0178 kg CO2e/kg) so was omitted.
An average of 5 values **of -0.306 kg CO2e/kg** with standard deviation of 0.112 kg CO2e/kg was taken for further calculations.

3.3. Reinforced concrete

Reinforced concrete carbon assessment was conducted by a combination of corresponding cement and reinforced steel modules under the assumptions:

Steel density: 7850 kg/m^3
Concrete density: 2400 kg/m^3
Concrete class: C32/40
Reinforcement ratio: 1.0% of cross section (88.5 kg reinforcement / m^2).

3.4. Precast slabs

In this study 10 different EPD's for precast slabs was collected and analysed. The average values for all modules were found.

3.4.1. Module A1 – raw material supply, including processing of secondary material input

ICE v3.0 include precast hollowcore concrete flooring, 150 mm, prestressed steel reinforced with world steel average steel, included reinforcement (2.77 kg rebar per 1m2 od 150mm slab), and it was estimated from ICE cement, mortar and concrete model. Modules A1-A3 in ICE v3.0 was found as 0.184 kgCO2e/kg.

Average value for combined Modules A1-A3 from EPD's was found **0.218 kg CO2e/kg** with a standard deviation of 0.056 kg CO2e/kg.

For further calculations ICE v3.0 value of 0.184 kg CO2e/kg reduced by an average values of modules A2 and A3 found in EPD's (described below), giving **0.147 kg CO2e/kg.**

3.4.2. Module A2 – transport of raw materials and secondary material to the manufacturer

This impact is clearly location specific, i.e. materials suppliers' location and precast concrete producer. ICE v3.0 data base does not include this module.

Five producers declared EPD's Module A2.
The average value was used as **0.01 kg CO2e/kg** with a standard deviation of 0.004 kg CO2e/kg.

3.4.3. Module A3 – manufacture of the construction products

This impact is product and production type specific.

Four producers declared EPD's Module A3.
The average value was used as **0.027 kg CO2e/kg** with a standard deviation of 0.027 kg CO2e/kg.

3.4.4. Module A4 – transport to site

This impact is clearly location specific, i.e. precast concrete supplier and construction site.

Six producers declared EPD's Module A4.
The average value was used as **0.032 kg CO2e/kg** with a standard deviation of 0.032 kg CO2e/kg.

3.4.5. Module A5 – fabrication

This Module include construction an installation. It depends mainly on the type of element.

Five producers declared EPD's Module A5.
The average value was used as **0.005 kg CO2e/kg** with a standard deviation of 0.033 kg CO2e/kg.

3.4.6. Module B1 – B7 – use stage

Modules B2 to B7 are not taken into consideration. For this exercise it is assumed that is no maintenance, repair, refurbishment or replacement requirements of the structure during the building lifetime.

Only one producer declared Module B1 – Use, **-0.006 kg CO2e/kg.** This value was taken for further calculations.

3.4.7. Module C1 – deconstruction / Demolition

Four producers declared EPD's Module C1.
The average value was used as **0.005 kg CO2e/kg** with a standard deviation of 0.0041 kg CO2e/kg.

3.4.8. Module C2 – transport

Four producers declared EPD's Module C2
The average value was used as **0.003 kg CO2e/kg** with a standard deviation of 0.0005 kg CO2e/kg.

3.4.9. Module C3 – waste processing

Two producers declared EPD's Module C3. One declared the value "zero".
For next calculations the value **-0.012 kg CO2e/kg** was assumed.

3.4.10. Module C4 – disposal

Four producers declared EPD's Module C4.
The average value was used as **0.002 kg CO2e/kg** with a standard deviation of 0.0008 kg CO2e/kg.

3.4.11. Module D – reuse / recovery / recycling potential

Due to lack of information regarding the Module D for Precast elements, value for reinforced concrete was assumed, -**0.014 kg CO2e/kg**

3.5. Steel decking

In this study 9 different EPD's for steel decking / galvanised building products was found. Average values were found for A1 – A3, C4 and D. For the rest it was assumptions were made, using calculations included in section 3.6.

3.5.1. Module A1 – raw material supply, including processing of secondary material input

According to ICE v3.0, embodied carbon for finished cold-rolled coil and hot-dip galvanized steel was found as 2.73 and 2.76 kg CO2e/kg. Four steel decking producers declared EPD's integrated Modules A1-A3. The average value was **2.712 kg CO2e/kg** with a standard deviation of 0.3757 kg CO2e/kg.

For the calculations module A1 was assumed as 2.76 kg CO2e/kg (finished cold-rolled coil), found in ICE v3.0, reduced by an average values of Modules A2 and A3 from found EPD's.

Module A1 was assumed as **2.517 kg CO2e/kg.**

3.5.2. Module A2 – transport of raw materials and secondary material to the manufacturer

This impact is clearly location specific, i.e. the location of the steel mill, steel rolling mill and steel decking producer.

Five producers declared EPD's Module A2.
The average value was used as **0.061 kg CO2e/kg** with a standard deviation of 0.038 kg CO2e/kg.

3.5.3. Module A3 – manufacture of the construction products

This impact is clearly type of element specific, i.e. depth, length, shape.

Five producers declared EPD's Module A3.
The average value was found as 0.153 kg CO2e/kg with a standard deviation of 0.238kg CO2e/kg. One Module A3 was outstanding (0.57 kg CO2e/kg) and therefore was omitted.

The average value of four was used as **0.047 kg CO2e/kg** with a standard deviation of 0.039 kg CO2e/kg.

3.5.4. Module A4 – transport to site

This impact is clearly location specific, i.e. steel decking producer and construction site.

None of the producers indicated Module A4. This was assumed as an analogy to the Module A4 for structural steel – UB (see section 3.6.4) as **0.027 kg CO2e/kg.**

3.5.5. Module A5 – fabrication

This module includes installation on-site.

None of the producers indicated Module A5. This was assumed as an analogy to the Module A5 for structural steel – UB (see section 3.6.5) as **0.018 kg CO2e/kg.**

3.5.6. Module B1 – B7 – use stage

Modules B1 to B7 are not taken into consideration. For this exercise it is assumed that there is no maintenance, repair, refurbishment or replacement requirements of the structure during the building lifetime.

3.5.7. Module C1 – deconstruction / demolition

None of the producers indicated Module C1. This was assumed as an analogy to the Module C1 for structural steel – UB (see section 3.6.7) as **0.005 kg CO2e/kg.**

3.5.8. Module C2 – transport

One producer declared EPD's Module C3 as 0.0033 kg CO2e/kg

For further calculations Module C2 was assumed as **0.033 kg CO2e/kg.**

3.5.9. Module C3 – waste processing

None of the producers indicated Module C3. This was assumed as an analogy to the Module C3 for structural steel – UB (see section 3.6.9) as **0.002 kg CO2e/kg.**

3.5.10. Module C4 – disposal

Three producers declared EPD's Module C4. One declared "zero", so it was omitted.
The average value was used as **0.002 kg CO2e/kg** with a standard deviation of 0.0004 kg CO2e/kg.

3.5.11. Module D – reuse / recovery / recycling potential

Five producers declared EPD's Module D.
The average value was used as **-1.313 kg CO2e/kg** with a standard deviation of 0.302 kg CO2e/kg.

3.6. Structural steel – Universal Beams (UB)

In this study, 8 different EPD's for structural sections (UB) was found. For some calculations EPDs from FB producers were used. The average values for all modules were found.

3.6.1. Module A1 – raw material supply, including processing of secondary material input

It is more difficult to find BOF or EAF specific EPD information, however based on a range of sources held by SCI, typical values are:

BOF structural steel production 2,490 kg CO_2eq per tonne

EAF structural steel production 456 kg CO_2eq per tonne.

According to ICE v3.0, embodied carbon for steel section was found as 1.55 kg CO2e/kg

Eight producers declared EPD's integrated Module A1-A3.
The average value was found as **1.621 kg CO2e/kg** with a standard deviation of 0.96 kg CO2e/kg.

For further calculations Module A1 was used as Module A1-A3 from ICE v3.0, reduced by an average Modules A2 and A3 found in EPD's.

Module A1 was assumed as **1.304 kg CO2e/kg**.

3.6.2. Module A2 – transport of steel from steel mill to fabricator

The generic carbon footprint of UK steelwork fabrication, SCI calculated the Module A2 impact as 0.024 kgCO_2e /kg of structural steel. This impact is clearly location specific, i.e. the location of the construction site, the steel mill, the stockholder and the fabricator.

Only one producer declared Module A2. The worst scenario was taken for further calculations, **0.063 kg CO2e/kg**.

3.6.3. Module A3 – fabrication of structural steelwork

In 2013, as part of SCI study to calculate the generic carbon footprint of UK steelwork fabrication, SCI calculated the Module A3 impact as 0.247 kgCO_2e/kg of structural steel. This impact was derived based on the average annual impacts of four large UK fabricators.

In this study, only one producer declared Module A2 at the level of 0.1833 kg CO2e/kg.
For "Welded and coated sections, trusses and beams made of hot-rolled plate, sheet and coil" EPD (see section 3.7) the Module A2 was found 0.250 CO2e/kg.

Nevertheless, for further calculations Module A2 was assumed as **0.1833 kg CO2e/kg** due to the fact that in case of UB less fabrication is needed.

3.6.4. Module A4 – transport of fabricated steelwork to site

In 2013, as part of a study to calculate the generic carbon footprint of UK steelwork fabrication, SCI calculated the Module A2 impact as 14 kgCO_2e per tonne of structural steel. This impact is clearly location specific, i.e. the location of the construction site and the steelwork contractor.

In this study, three producers declared Module A4 (UB) and two for FB. Due to the fact that transport of UB fabricated structures and FB structures might be considered as similar, the average of 5 values was used as **0.027 kg CO2e/kg** with a standard deviation of 0.014 kg CO2e/kg.

3.6.5. Module A5 – erection impacts

This impact varies. In this study only two EPDs was found for UB and one for FB that include Module A5. Three values were: 0.0148 (UB), 0.0209 (FB), 0.316 (UB) kg CO2e/kg. This module depends on structure, building high, number of elements.
Module A5 was assumed as an average of two, as one was visible outstanding.

For further calculations Module A5 was assumed as **0.018 kg CO2e/kg** with a standard deviation of 0.004 kg CO2e/kg.

3.6.6. Modules B1 – B7 – use stage

Modules B1 to B7 are not taken into consideration. For this exercise it is assumed that there is no maintenance, repair, refurbishment or replacement requirements of the structure during the building lifetime.

3.6.7. Module C1 – deconstruction / demolition

Two producers declared EPD's Module C1.
The average value was used as **0.005 kg CO2e/kg** with a standard deviation of 0.0038 kg CO2e/kg.

3.6.8. Module C2 – transport

Two UB producers and one FB producer declared EPD's Module C2.
The average value was used as **0.015 kg CO2e/kg** with a standard deviation of 0.021 kg CO2e/kg.

3.6.9. Module C3 – waste processing

Five UB producers and one FB producer declared EPD's Module C3.
The average value was used as **0.021 kg CO2e/kg** with a standard deviation of 0.0003 kg CO2e/kg.

3.6.10. Module C4 – disposal

Two UB producers declared EPD's Module C4.

The average value was used as **0.003 kg CO2e/kg** with a standard deviation of 0.0031 kg CO2e/kg.

3.6.11. Module D – reuse / recovery / recycling potential

Seven UB producers and three FB producers declared EPD's Module D.
The average value was used as **-0.802 kg CO2e/kg** with a standard deviation of 0.637 kg CO2e/kg.

3.7. Structural steel – Fabricated Beams (FB)

In this study 4 different EPD's for fabricated steel sections (FB) was found.

3.7.1. Module A1 – raw material supply, including processing of secondary material input

According to ICE v3.0, embodied carbon for steel plate was found as 2.46 kg CO2e/kg.

In this study 4 producers declared EPD's integrated Module A1-A3.
The average value was found as **2.388 kg CO2e/kg** with a standard deviation of 0.540 kg CO2e/kg.

For further calculations Module A1 was used as Module A1-A3 from ICE v3.0 reduced by an average Modules A2 and A3 found in EPD's.

Module A1 was assumed as **1.977 kg CO2e/kg**.

3.7.2. Module A2 – transport of steel from steel mill to fabricator

The generic carbon footprint of UK steelwork fabrication, SCI calculated the Module A2 impact as 0.024 kgCO_2e /kg of structural steel. This impact is clearly location specific, i.e. the location of the construction site, the steel mill, the stockholder and the fabricator.

Two FB producers declared EPD's Module A2.
The average value was used as **0.052 kg CO2e/kg** with a standard deviation of 0.006 kg CO2e/kg.

3.7.3. Module A3 – fabrication of structural steelwork

In 2013, as part of SCI study to calculate the generic carbon footprint of UK steelwork fabrication, SCI calculated the Module A3 impact as 0.247 kgCO_2e/kg of structural steel. This impact was derived based on the average annual impacts of four large UK fabricators.

In this study, two FB producers declared EPD's Module A3.
The average value was used as **0.432 kg CO2e/kg** with a standard deviation of 0.256 kg CO2e/kg.

3.7.4. Module A4 – transport of fabricated steelwork to site

In 2013, as part of a study to calculate the generic carbon footprint of UK steelwork fabrication, SCI calculated the Module A2 impact as 14 kgCO_2e per tonne of structural steel. This impact is clearly location specific, i.e. the location of the construction site and the steelwork contractor.

In this study, three producers declared Module A4 (UB) and two for FB. Due to the fact that transport of UB fabricated structures and FB structures might be considered as similar,
the average of 5 values was used as **0.027 kg CO2e/kg** with a standard deviation of 0.014 kg CO2e/kg.

3.7.5. Module A5 – erection impacts

This impact varies. In this study only two EPDs was found for UB and one for FB that include Module A5. Three values were: 0.0148 (UB), 0.0209 (FB), 0.316 (UB) kg CO2e/kg. This module depends on structure, building high, number of elements.
Module A5 was assumed as an average of two, as one was visible outstanding.

For further calculations Module A5 was assumed as **0.018 kg CO2e/kg** with a standard deviation of 0.004 kg CO2e/kg.

3.7.6. Modules B1 – B7 – use stage

Modules B1 to B7 are not taken into consideration. For this exercise it is assumed that there is no maintenance, repair, refurbishment or replacement requirements of the structure during the building lifetime.

3.7.7. Module C1 – deconstruction / Demolition

One producer declared EPD's Module C1.
The value that was used for further calculations was **0.099 kg CO2e/kg**.

3.7.8. Module C2 – transport

Two UB producers and one FB producer declared EPD's Module C2.
The average value was used as **0.015 kg CO2e/kg** with a standard deviation of 0.021 kg CO2e/kg.

3.7.9. Module C3 – waste processing

Five UB producers and one FB producer declared EPD's Module C3.
The average value was used as **0.021 kg CO2e/kg** with a standard deviation of 0.0003 kg CO2e/kg.

3.7.10. Module C4 – disposal

Module C4 was used from section 3.6.10, Module C4 for structural steel used UB.
The value used was **0.003 kg CO2e/kg** with a standard deviation of 0.0031 kg CO2e/kg.

3.7.11. Module D – reuse / recovery / recycling potential

Seven UB producers and three FB producers declared EPD's Module D.
The average value was used as **-0.802 kg CO2e/kg** with a standard deviation of 0.637 kg CO2e/kg.