smithandwallwork engineers

Annual materials and carbon report 2023

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Introduction

Smith and Wallwork is a civil and structural engineering design company based in Cambridge. We carry out the structural design of buildings and the civil engineering aspects associated with those buildings. Our projects range from small private houses through to large building projects, the largest completed construction project to date is £40m.

Founded in 2012, we started recording the quantities of structural materials used in our projects from day one. This is our fourth annual report on the materials and carbon used in our projects – more specifically structural materials installed on sites in 2023 and the CO2 emissions associated with the production, fabrication, transport and installation on site of those materials (i.e. lifecycle stages A1-A5). The methodology used to apportion materials to a date range and the figures used to calculate carbon are explained in this report.

2023 Materials and Carbon

In 2023, Smith and Wallwork had six live construction projects. The four projects for which carbon data is available total 14,781m^2 of floor area (of which 6,058m^2 is assumed to have been completed during the period). Of the six projects, one was a refurbishment project involving minimal material additions, two were conservation projects (excluded from reporting), and the remaining were new build. Three of the six building projects were greenfield developments. Interestingly, this year we see a significant reduction in materials on site and the /m2 numbers. This is due a combination of more projects in design and a higher proportion of existing building projects.

4,382 t *(the total tonnage of structural material used on our sites in 2023)*

1,106 tCO2e *(the total emission associated with these structural materials, stages A1-A5)*

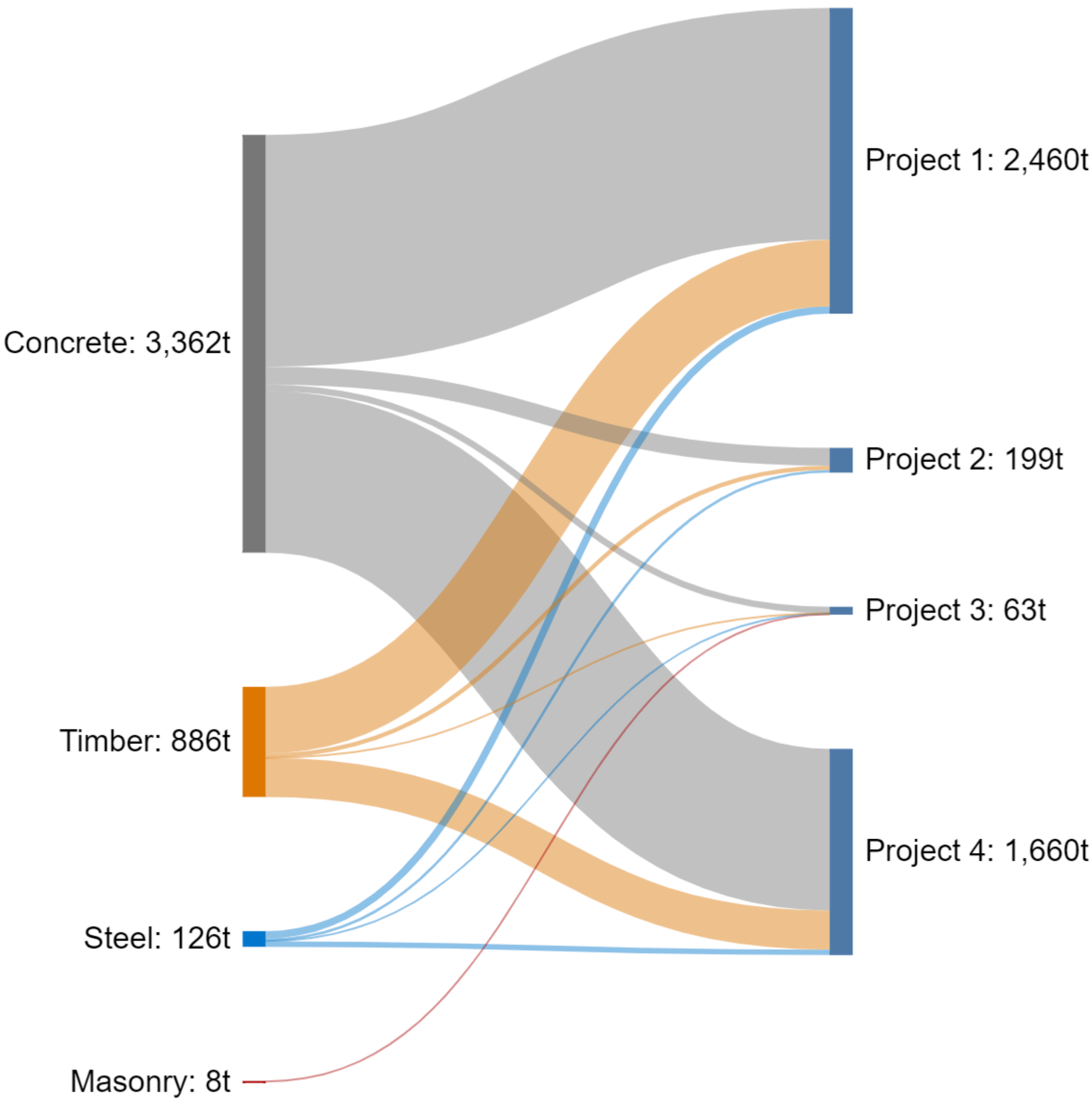
Some key statistics from the structural materials used in are provided below. These figures include sub- and super-structure data and carbon numbers are for life cycle stages A1-A5.

	2023	2022	2021	2020	
Concrete	3,362	9,781	13,368	8,250	t
Steel (incl. rebar)	125	741	899	460	t
Timber	887	1,142	1,130	914	t
Masonry	9	93	104	31	t
Average building mass	607	911	1,029	1,249	kg/m2
Max building mass	1051	1,610	1,610	2,195	kg/m2
Min building mass	145	309	309	472	kg/m2
Average CO2	164	231	249	287	kgCO2e/m2
Max CO2	258	347	347	514	kgCO2e/m2
Min CO2	30	54	54	161	kgCO2e/m2

Sankey Diagram of 2023 Materials Use

The diagram below is to scale and represents the flow of structural materials to our sites in 2023. The units used are tonnes of structural material. The steel tonnage includes both structural steel and rebar.

The two projects not reported here are the conservation projects where limited new materials are used and building GIA areas are not relevant.



Methodology and Data

This section describes the extent of structural materials recording, the assumptions made on when materials are installed on site and finally the dataset used in calculating CO2 emissions associated with structural materials.

Structural Materials Recorded

Smith and Wallwork records structural materials for sub-structure and super-structure as set out below. For the annual figures reported these are either RIBA stage 4 information or where a building has been completed a mix of Smith and Wallwork figures are used in combination with as-built figures given by the various sub-contractors.

	recorded	Not recorded
Concrete	• Insitu structural concrete • Precast structural concrete	• Blinding concrete • Screeds
Steel	• Primary structural steelwork • Structural steel decking • Reinforcing bar in concrete • Steel sheet piling	• Secondary steelwork • Cold-formed steelwork • Steel cladding
Timber	• Primary timbers and decking/sheeting • Glulam • CLT	• Secondary timber and decking/sheeting
Masonry	• Structural load bearing masonry only	• Masonry cladding • Internal non-loadbearing masonry partitions

It should be noted that RIBA stage 4 information for projects that have just started on site within the annual reporting year may include some estimates for structural materials such as rebar quantities, concrete and sheet pile quantities etc.

Installation of Structural Materials

Each project at Smith and Wallwork is recorded with a start on site date and a completion date. These dates are used to apportion the installation of structural materials on site.

Smith and Wallwork has chosen to apportion the installation of structural materials on a project over the entire construction period. Furthermore, structural materials are assumed to be installed at a consistent rate throughout the construction period. Strictly speaking this assumption is incorrect as typically on a building project, most of the construction materials will have been installed within the first half of the overall construction period.

This simplification in reporting the installation of materials on construction sites provides a smoothing-out of the reported material use on Smith and Wallwork construction sites. Some projects will be under-reported and some over-reported.

CO2 Emissions of Structural Materials

Background Information

The lifecycle stages in BS EN 15978 and BS EN 15804 are used to define the amount of carbon released at the different stages of a material or products life.

- A1-A3: Product stage
- A4-A5: Construction process
- B1-B6: Use stage
- C1-C4: End of life stage
- D: Beyond end of life

Some studies have shown that stages A1-A3 and B1-B6 together account for more than 90% of the life cycle of a building's carbon emissions with a balanced distribution of emissions between the two.

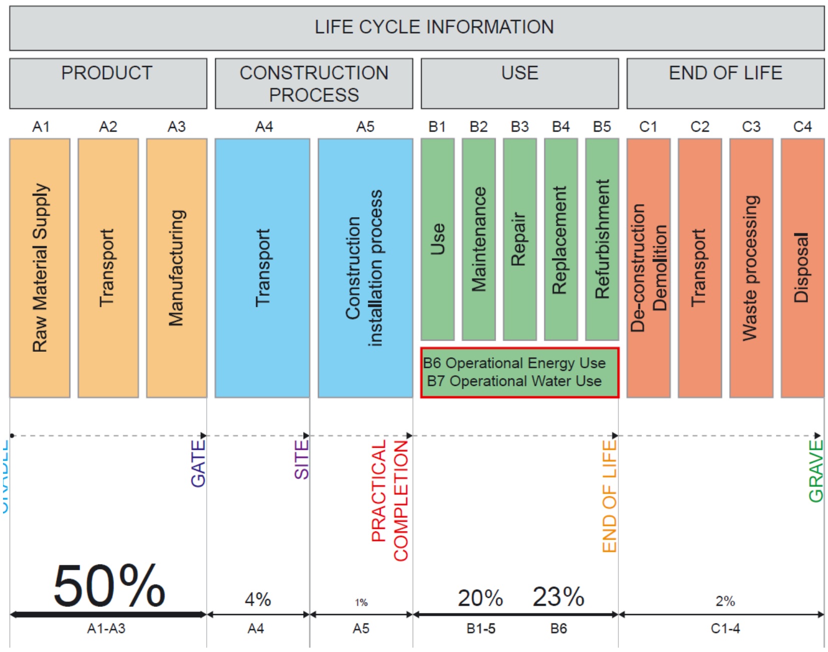


Figure: Lifecycle stages (ref.: The Structural Engineer July 2020)

It should be noted that the calculation of the CO2 emissions associated with structural materials is a new area of research and implementation. The available pool of datasheets is relatively small and as such it can be difficult to justify data. As the dataset of materials and products gets larger the reliability of data is likely to increase. In this respect, care should be taken when comparing historic carbon data as each year our carbon data is reviewed and updated.

Also of note is the origin of structural materials used on site. A change in location of manufacture can significantly alter the CO2 figures.

Whilst the foundations and structure are likely to form the largest component of CO2 emissions in stage A it is worth noting that different structural solutions can have impacts of finishes applied as well as operational energy (and hence CO2 emissions).

Smith and Wallwork Dataset

Several assumptions have been made in order to establish a set of embodied carbon data for structural engineering materials and products. A summary of the various figures and factors used are presented below. The source of data is The Institution of Structural Engineer's 'How to calculate embodied carbon' guide (second edition, published 2022).

(kgCO2e/kg)	A1-A3	A4	A5a	A5w	A1-A5
Steel sections	1.435	0.096	0.092	0.015	1.639
Steel sections UK	1.740	0.032	0.092	0.018	1.882
Steel section Europe	1.130	0.160	0.092	0.013	1.395
Steel section World	1.580	0.160	0.092	0.018	1.850
Steel profile decking	2.550	0.032	0.092	0.026	2.700
Rebar	1.360	0.096	0.046	0.078	1.580
Rebar UK	0.760	0.032	0.046	0.043	0.881
Rebar World	1.960	0.160	0.046	0.113	2.279
CLT	0.250	0.160	0.092	0.022	0.524
Glulam	0.280	0.160	0.185	0.022	0.647
Concrete (insitu unreinforced)	0.103	0.005	0.014	0.007	0.129
Concrete (insitu 50kg/m3 rebar)	0.130	0.007	0.015	0.008	0.161
Concrete (insitu 100kg/m3 rebar)	0.157	0.009	0.016	0.010	0.192
Concrete (insitu 150kg/m3 rebar)	0.185	0.011	0.017	0.011	0.224
Concrete (precast unreinforced)	0.178	0.032	0.014	0.002	0.227
Concrete (precast 50kg/m3 rebar)	0.189	0.033	0.015	0.003	0.239
Concrete (precast 100kg/m3 rebar)	0.232	0.036	0.016	0.005	0.290
Concrete (precast 150kg/m3 rebar)	0.260	0.038	0.017	0.007	0.322
Blockwork	0.280	0.032	0.012	0.083	0.406
Brickwork	0.213	0.032	0.019	0.066	0.330

For Smith and Wallwork standard embodied calculations the following data has been used:

- An average value for UK and European steel sections is taken for A1-A3.
- An average value for UK and global rebar is taken for A1-A3.
- An average UK concrete mix of C30/37 with 35% cement replacement material is taken for insitu concrete for A1-A3.
- An average UK mix of C40/50 is taken for precast concrete for A1-A3.

Transport carbon factors (A4) for movement of materials and products between factory and site are based on local, national and European scenarios.

A4 factor	km		
Local manufacture	50	0.005	kgCO2e/kg
National manufacture	300	0.032	kgCO2e/kg
Europe manufacture	1500	0.160	kgCO2e/kg

On site assembly carbon factors (A5a) are based on simplified data from the RICS relating construction cost to emissions. This can be related to material use through a relationship between material and construction costs based on previous SAW projects. Using data from 33 Smith and Wallwork projects at RIBA stage 4 and 5, construction cost is on average 6.6 times higher than the material cost. Using this information an A5a material factor can be found.

RICS A5a factor	700	kgCO2e/£100k Construction cost				
SAW Cost Factor	6.6	Construction Cost/Material Cost				
Material costs supply and install						
Steel	2.0	£/kg	2000	£/t	7850	kg/m3
Rebar	1.0	£/kg	1000	£/t	7850	kg/m3
Concrete	0.3	£/kg	750	£/m3	2500	kg/m3
CLT	2.0	£/kg	1000	£/m3	500	kg/m3
Glulam	4.0	£/kg	2000	£/m3	500	kg/m3
Blockwork	0.3	£/kg	500	£/m3	2000	kg/m4
Brickwork	0.4	£/kg	750	£/m3	1800	kg/m5

On site waste carbon factors (A5w) are based on simplified data from the RICS and local disposal of waste. Waste percentages range from 1% to 5% for structural materials and products but can be as high as 20% for some construction products. Timber manufacturing waste is assumed to go to landfill where the sequestered carbon in the timber is released to atmosphere.

The component of A5w = WF*(A1+A2+A3+A4+C2+C3+C4).

A5w factor		
Steel frame	0.010	
Steel rebar	0.053	
Concrete insitu	0.053	
Concrete precast	0.010	
Timber frame CLT	0.010	
Timber frame glulam	0.010	
Blockwork	0.250	
Brickwork	0.250	
C2 waste from site	0.005	kgCO2e/kg
C3-4 waste disposal (timber)	1.770	kgCO2e/kg
C3-4 waste disposal	0.013	kgCO2e/kg

Our experience at Smith and Wallwork would suggest 20% error bars are relevant for the reporting of carbon factors and actual material quantities installed on site.

Historic Data

Smith and Wallwork has been collecting data on materials use since its inception in 2012. The chart below shows the structural material used on construction sites from 2014 onwards.

The information shown on materials and carbon per engineer is derived from the total annual mass divided by the total number of technical staff (full time equivalent).