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Embodied Carbon of Natural Stone in Scotland: A Methodology

A report for Historic Environment Scotland

ADDENDUM – Embodied Carbon of Granite

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Introduction

This report is an addendum to the 2020 report on a methodology for calculating the embodied carbon (EC) of dimensional sandstone used in Scotland, and should be read alongside that report.

Extraction and Processing of Granite

The data sources and challenges associated with applying them to this topic are similar to those outlined in section 2 of the main report with respect to sandstone. Values for embodied carbon of granite recovered from relevant studies are shown in table Ad1.

Study	A1	A2	A3	Total $kgCO_2e/t$	Ref
ICE	-	-	-	700	[1]
Tennessee[1]	60.3	-	37.8	98.1	[2]
Scotland	18.5	1.9	72.5	92.9	[3,4]
Spain	16.8	-	147.5	164.3	[5]
Norway	29.18	3.01	124.91	157.1	[6]
Italy	-	-	-	230	[7]

Table Ad1. Cradle-to-gate embodied carbon, $kgCO_2e/t$, results for granite, disaggregated into stages A1 (raw material extraction), A2 (transportation), and A3 (manufacturing) where possible, either presented in or derived from published works. Notes: [1]Values presented here are calculated from embodied energy data, using the most up-to-date UK grid emission factor [8] *for electrical energy.*

The ICE value for granite references an early version of the Tennessee study, superseded by that shown in this table: as such the value shown is disregarded in the analysis in this study.

As with the case of sandstone, the values shown in the table for the Tennessee study have been re-calculated from the data in the report (which reports consumption of various fuels in units of MJ/ft^3).

The Swiss and South African studies referred to in the main report do not cover granite, so are not represented here.

Mendoza and colleagues have published two studies [5,9] relating to the life cycle assessment of granite. The earlier article concerns granite-topped sidewalks (pavements), and uses the values from the Tennessee study (recalculated as MJ/m^3) to cover the impact of the granite itself, so there is no new information for table 2. The more recent study is based on the Spanish granite industry (Spain is said to be Europe's second granite producer), but is for tiles of 2cm thickness, and therefore of limited relevance to this work because of the different processing requirements. That said, it provides useful context, and the A1 (quarrying) is still relevant (technically, to be strictly accurate, a small downwards correction would need to be applied to account for the granite dust associated with any additional sawing required, but this is assumed to be insignificant).

EPDs for granite identified are as follows:

- A Norwegian language document [6] referring to granite façade material of 3cm thickness. This, however, appears to be for granite quarried in Fujian province, China, apparently processed in Norway. The document notes the different grid emission factors applied to electricity consumed in the two countries (1155 gCO_2e in China and 31 gCO_2e in Norway), but does not appear to offer the disaggregation of data (electricity and fuel consumption) that would enable the work to be applied in other contexts, and so it is not used in this work.
- In a similar vein, an Italian EPD [7] concerns the production – in Italy – of granite quarried worldwide (from quarries in 'Italy, Africa, Europe, Asia, South and North America'). The EPD refers to 'manufactured granite' including 'massive pieces/mouldings (average thickness of 14cm), for buildings and construction works'. The cradle-to-gate emissions for this granite amount to 230 kgCO_2e/tonne: it is likely that much of this is associated with A2 (transport from the quarry to the processing site in Italy), but there is no disaggregation, so – again – this data is not used in this work.

Disaggregation

Further details of the emissions associated with the three most relevant studies are as follows. The equivalent information for sandstone is in Appendix A of the main report.

Tennessee study

The density of granite is taken to be 2650 kg/m^3.

The breakdown of non-electricity-related emissions, and electrical energy use is as follows:

A1: 43.2 kgCO_2e/t + 59.2 kWh_{el}/t

A3: 20.7 kgCO_2e/t + 59.2 kWh_{el}/t.

Scotland study

In the case of granite, there is no statement made about electricity consumption, so disaggregation of embodied carbon into electricity and fuel-related components is not possible.

A1: overall EC is 18.5 kgCO_2e/t

A3: overall EC is 72.5 kgCO_2e/t.

Spanish study

In this study, only the A1 emissions are applicable to dimensional granite (as opposed to granite tiles, which are the subject of the study).

A1: fuel-related EC is 9.9 kgCO_2e/t, and electricity consumption is 23.8 kWh/t.

Transport

The transport calculation for granite is the same as it is for sandstone, with just one exception. The emissions associated with transport from quarry to processing site require the wastage rate (or waste factor) at the processing site to be considered, and this waste factor is dependent on the properties of the stone.

The waste factor for sandstone (the mass of stone moved in A2 per mass of stone in the finished product) was calculated as 1.29, and reported in Appendix B of the main report. This was the average of the values from the Tennessee and Scotland studies, assuming – in the latter case – that half of the reported waste arises at the quarry and half at the processing site, as the split is not specified.

The equivalent value for granite, calculated on the same basis, is 1.57.

The Calculator

The calculator outlined in Appendix C of the main report has been extended to include granite. Granite is assessed in the same way as sandstone, but on granite-specific pages. A front page has been added to the calculator to help the user navigate to the version required, which will be one of the following:

- Simplified granite calculator
- Detailed granite calculator
- Simplified sandstone calculator
- Detailed sandstone calculator.

Final Remarks

Prospective stone suppliers in the future may have their own data and calculations relating to embodied carbon. In the current version of the calculator, workarounds may be possible to allow for different modes of transport (or different emission factors), as discussed in the main report. However, no such workarounds are possible in relation to quarrying and processing emissions. As such, suppliers which have assessed their own supply chains for carbon emissions may reasonably be permitted to provide their own calculations, as long as assumptions and emission factors are stated and supporting evidence is supplied in a way that would permit HES to replicate the calculations. In line with global trends, the preferred way forward is the development of environmental product declarations (EPDs) in line with appropriate international standards (e.g. EN 15804:2019) that have been developed aiming for transparency, consistency and reproducibility. The current high cost of EPDs represents a barrier to their wider uptake but the number of EPDs for construction products has grown steadily in the last 5 years (over 10 000 EPDs at the beginning of 2021 [10]) so there is hope for more and more products to be assessed through this systematic and internationally-agreed approach rather than proprietary calculations.

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