Temporary Works forum

Low carbon temporary works

Guidance - January 2023

TW22.106

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Low carbon temporary works

BUILD NOTHING
BUILD LESS
BUILD CLEVER
BUILD EFFICIENTLY
MINIMISE WASTE
SPECIFY LOW-CARBON
OFFSET

USE LESS STUFF

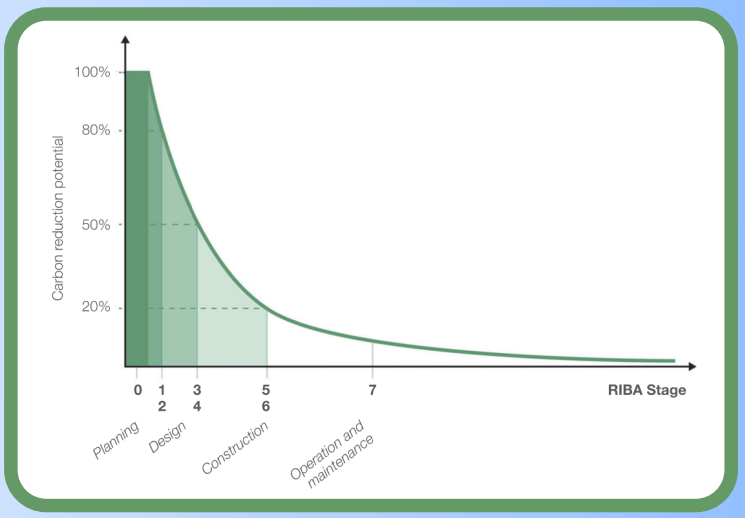
Your early decision matter...

Combine permanent and temporary works, e.g. sheet pile basement wall.

Recycled materials are in demand far above supply. Specify flexibility but, more importantly, use less stuff.

Importing Ground Granulated Blast-furnace Slag (GGBS) from China may be worse than using British clinker.

We may be waiting a long time for clean raw materials. Hydrogen is required and there is a queue.



Sources:
PAS 2080, Carbon management in infrastructure verification GHG Management Hierarchy 2020, IEMA Climate emergency, IStructE (https://www.istructe.org/resources/climate-emergency/)

Repurposing infrastructure through sophisticated structural engineering

After challenging the brief, the best design reuses...

Advice in upgrading existing infrastructure reduced the number of railway gentries deemed in need of replacement from over 400 to fewer than ten.

The client benefitted from substantial savings in terms of direct project cost, risk allowance and the associated programme.

The advanced approach taken decreased the amount of steel required by an estimated 3,054 tonnes.

Case Study:
https://www.istructe.org/resources/news/winners-of-the-2021-structural-awards-announced/

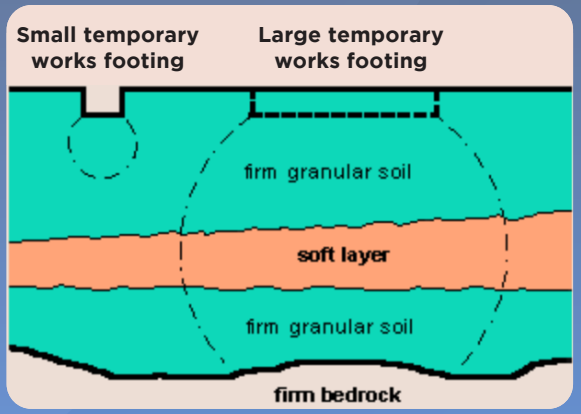
Then we build clever ....

Good inputs

Ground investigation (GI) specified for permanent works (deep foundations).

But rarely relevant for shallow temporary works footings, leading to over conservative design.

Educate others for better GI. Trial pits with dynamic cone penetrometer and hand shear vane generally give much better parameters.



Rethink > Refuse > Reduce > Repurpose > Reuse > Recycle > Rot

Combine permanent and temporary works, e.g. sheet pile basement wall.

Good design

Compare options by measuring 'A5a' (emissions due to general construction activity) and 'A5w' (waste on site).

Examples:

- Justify existing structures through analysis and surveying
- Aim for 100% utilisation and take advantage of partial factors and use the full codes
- Consider exposure class for temporary works and specify using a performance-based recipe
- Reach out to concrete supplier over durability; give freedom over recycled concrete aggregate (RCA) and mix design
- Use load testing to justify existing structures
- Compare the best method – finite element vs. beam strips – peak moments at face vs. at node
- Specify the correct strength at 56 days
- Prioritise proprietary equipment and off site manufacture
- Allow for re-use of steel beams (NSSS, Annex J)

Boundaries: Carbon lifecycle modules

Total carbon is equal to 'A5w' (material wasted) + 'A5a' (site emissions)
NOTE: 'A4' is included in TWf 'A5w' calculation

PAS 2080:2016
Carbon Management in Infrastructure.

The total excluded input or output flows per module shall be a maximum of 5% of energy usage and mass; Expert judgement by the practitioner shall be used to determine compliance with these criteria

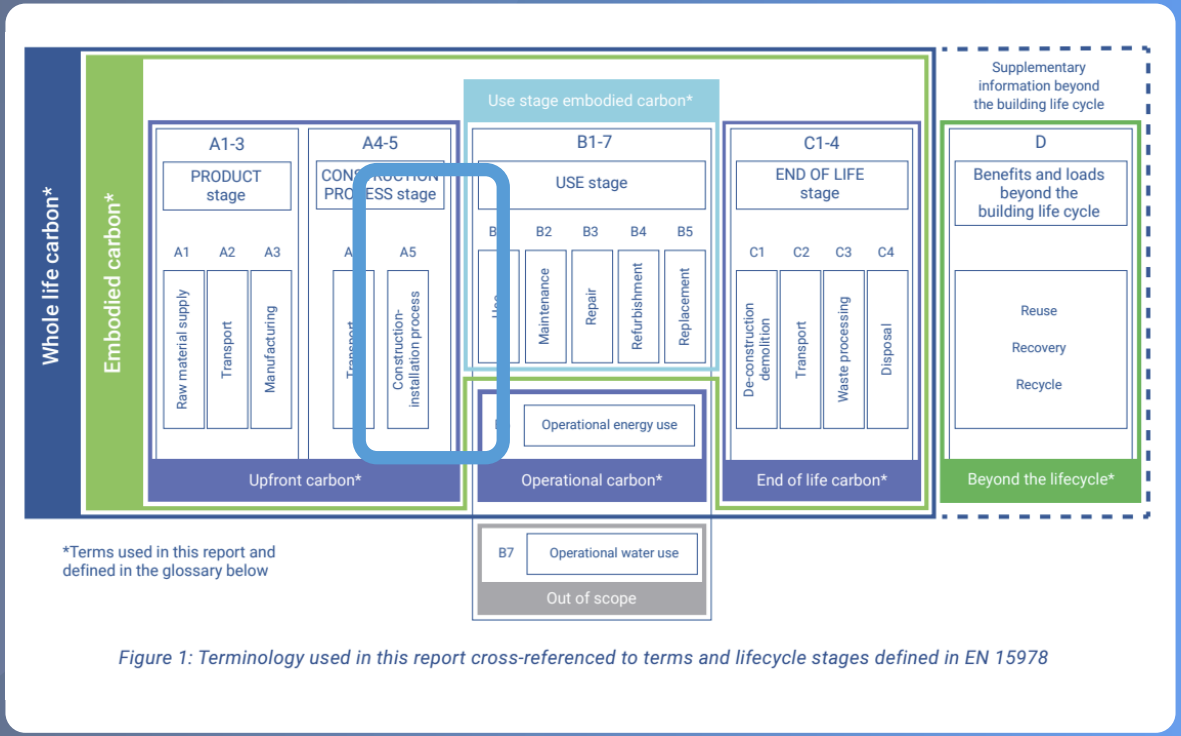


Figure 1: Terminology used in this report cross-referenced to terms and lifecycle stages defined in EN 15978

Source: World Green Building Council, Bringing embodied carbon upfront (https://www.worldgbc.org/bringing-embodied-carbon-upfront-report-download)

Modelling Carbon ‘A5a’

Consider replacement and maintenance emissions; scraping haul road, etc.

Greenhouse gas reporting: conversion factors; https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2022

Drain/sewers (small bore)
1.0m³ hydraulic backacter
2t dumper - 30% of time
2.80m³/min compressor, 2 tool - 30% of time
disc saw - 30% of time
extra 50ft/15m hose - 30% of time
small pump - 30% of time
sundry tools - 30% of time
Total Rate/Hour

Drainage/pipework gang (small bore)
1 ganger/chargehand (skill rate 4) - 50% of time
1 skilled operative (skill rate 4)
2 unskilled operatives (general)
1 plant operator (skill rate 3)
1 plant operator (skill rate 3) - 50% of time
Total Gang Rate/Hour

Multiplier Table for labour and plant for various site conditions for working:

- out of sequence x 2.75 (minimum)
- in hard clay x 1.75 to 2.00
- in running sand x 2.75 (minimum)
- in broken rock x 2.75 to 3.50
- below water table x 2.00 (minimum)

Activity	Excavation of firm sand and gravel for maximum depth of 2–5m
Typical plant gang working time per unit	0.1hr/m³ excavated
Diesel consumption for utilised plant	12.9l/hr
Effective diesel consumption	0.1 × 12.9 = 1.29l/m³
Embodied carbon factor per m³ excavation	1.29 × 2.71[a] = 3.50kgCO_2e/m³
Note: [a] The UK emissions factor for diesel	

Plant	Plant type	Fuel type	Utlilisation	Consumption l/hr	Actual l/hr
Excavators	Hydraulic Crawler Ba	HVO [average]	75%	14.25	10.69
Asphalt Paver	24KW Engine	HVO [average]	65%	4.03	2.62
Mixer	Truck Mixer 6m3	HVO [average]	100%	14.00	14.00
Crane	Crawler - 30 - 50t	HVO [average]	25%	0.88	0.22
Piling Plant	Pilling Hammer - 5,0	HVO [average]	65%	10.40	6.76
Rollers	BW 120 AD	HVO [average]	75%	3.30	2.48
Access Platforms	Telescopic 14m	HVO [average]	100%	2.00	2.00
Dumpers	Volvo A25D	HVO [average]	80%	13.60	10.88

Sources:
Spon’s Civil Engineering Highways Estimating Handbook 2012 https://www.istructe.org/resources/guidance/the-structural-carbon-tool/
https://steelconstruction.org/resources/sustainability/bridges-carbon-calculator/

Modelling Carbon A5w

See TWf Guidance in TWF2023:01.

Wastage due to damage on site for products (e.g. fencing, ground support equipment, etc.) or wastage due to site manufactured products.

N comes from contractor knowledge or Table 3 in the TWf Guidance.

Site fabrication wastage. Effectively the over-order of materials due to over dig, cutting down timber elements, etc. Not relevant for items that are hired or manufactured off site.

WF comes from WRAP Net Waste Tool in the IStructE Guide.
https://www.istructe.org/resources/blog/how-to-calculate-embodied-carbon-guide-2nd-edi/

$$ECF_{A5w,i} = \left(\frac{ECF_{A13,i}+ECF_{C34,i}+ECF_{Di}}{N} + ECF_{A4,i} + ECF_{C2,i}\right) + WF_i(ECF_{A13,i} + ECF_{A4,i} + ECF_{C2,i} + ECF_{C34,i}$$

IStructE Structural Carbon Tool embodied carbon factors (ECF) for concrete shown here;

Material - Type - Specification	Density [tonnes/m^3]	ECF A1-A3 [kgCO_2e/kg] (Product stage (Cradle to gate))	ECF A4 [kgCO_2e/kg] (Transport To Site)	WRAP WF (Waste Factor)	ECF C2 [kgCO_2e/kg] (Transport To Waste Processor)	ECF C3,4 [kgCO_2e/kg] (Waste processing for reuse, recovery or recycling)
Concrete - Insitu - UK C16/20 (0% SCM)	2.40	0.113	0.005	0.053	0.005	0.013

https://www.istructe.org/resources/guidance/the-structural-carbon-tool/

Build efficient.

Brief considers; site skills, end-of-life, strength, minimum in-service strength for striking, build quality assurance, fire, durability, workability, mix grade simplification, post-tension stress loss

Provide good GI - Client GI is rarely if ever relevant for temporary works
Measure and report on waste generated from temporary works and waste streams

Engage suppliers early – They are the designers – Can items be returned for reuse? Is there an Environmental Product Declaration (EPD)?

Engage sub contractors early – They are the builders
Engage designers early for standard solutions and the best available options

Develop a list of items where there is the most potential for reuse or exchange

Provide space to store reusable temporary work items and a management system to track status

Write up case studies, demonstrating the environmental and economic benefits of reusing temporary works items

Early, good brief

Engage supply chain

Query designer; build trust

Reduce wastage

Encourage innovation.

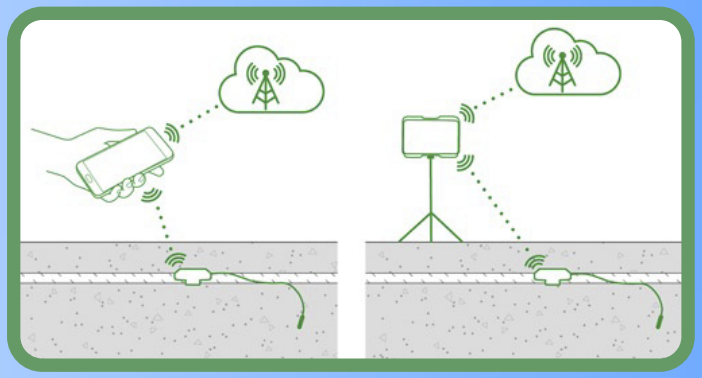
There is a heap of innovation waiting to be used. Typically, items take 18 years to market. We don't have that time and permanent works designers (PWDs) don't have the freedom and flexibility to trial innovative materials. Therefore, temporary works designers (TWDs) can really lead the way in sustainable infrastructure.

There are more novel materials and techniques than just AACMs;

Alkali Activated Cementitious Materials
Tailored concrete gives more durable or stronger concrete in different parts of a structural element. Maybe slip-form.

Shear behaviour testing by removing zones not utilised, potentially with lightweight concrete or void formers.

Embedded cables and sensors give real-time feedback on not just temperature but strain, carbonation, porosity, and many other aspects.



Question the blockers

"There are no design codes"
Cross-laminated timber (CLT) is uncodified. CLT isn't in Eurocode 5 but it is used because everybody uses it.

"We can't calculate its effectiveness"
Why do we need to back calculate a tested product? Have you ever back calculated a proprietary fixing?

"There is no funding pots"
Many organisations, including most large contractors and clients, have large research funds. Most innovations save time and money so this isn't always an issue.

https://www.cirg.eng.cam.ac.uk/

Use best practice – Adopt low carbon waste initiatives,
https://www.twforum.org.uk/resources/low-carbon-temporary-works