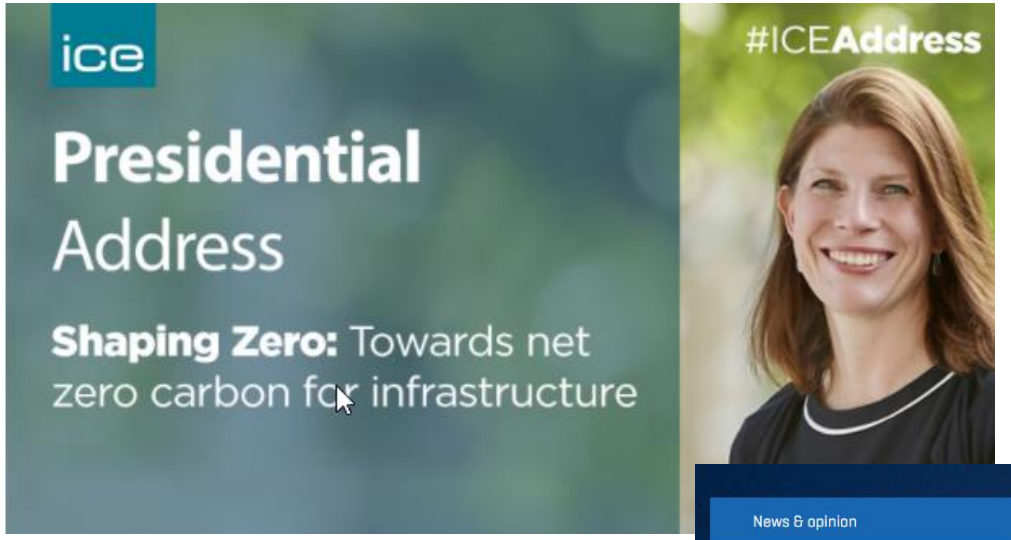
Gross Replacement Carbon footprint (GRCf) Toolkit

Nick Trump

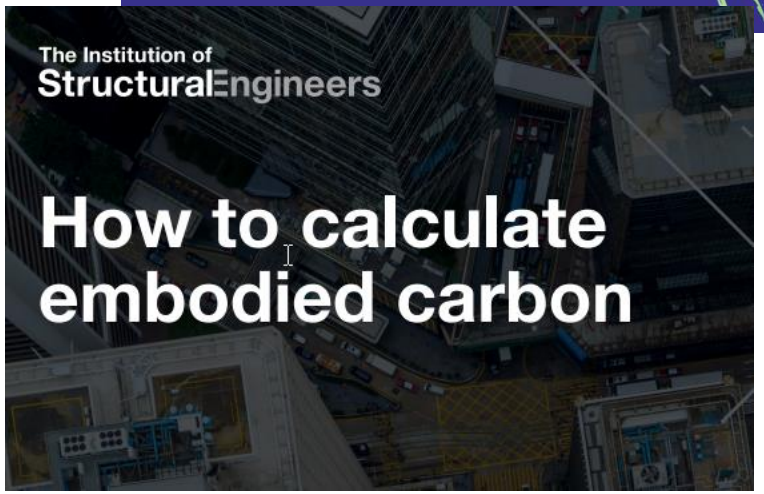
Agenda

1. Introduction
2. Approach
3. Details of work
4. Future work

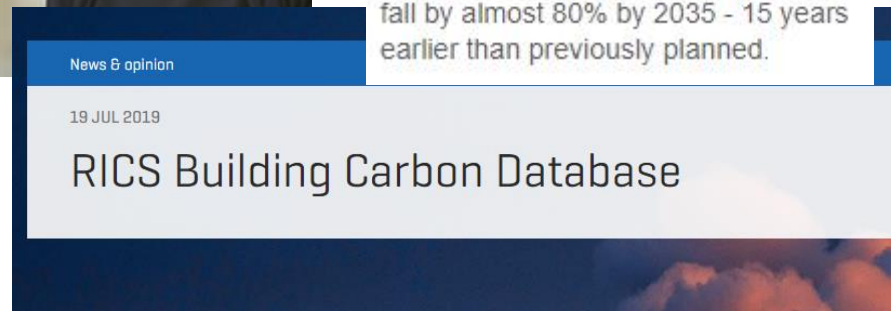


Government to speed up UK climate change target

The PM says carbon emissions must fall by almost 80% by 2035 - 15 years earlier than previously planned.



Net Zero



News story

UK becomes first major economy to pass net zero emissions law

New target will require the UK to bring all greenhouse gas emissions to net zero by 2050.

NetworkRail

What are our sustainability targets?

We commit to:

- Reduce absolute scope one and two greenhouse gas emission (those within our control) by 46% by 2029.
- Reduce absolute scope three (indirect) emissions by 28% by 2029.
- Ensure 75% of our suppliers by emissions covering purchased goods and services and capital goods (those used in the production of other goods) have science-based targets by 2025.

Rail Carbon Tool

15/02/2021

SHARE THIS

The Rail Carbon Tool is here to assist the UK rail industry with understanding what its carbon footprint is so it can go on and reduce it throughout its supply chain.

Calculate and reduce carbon impact across structures

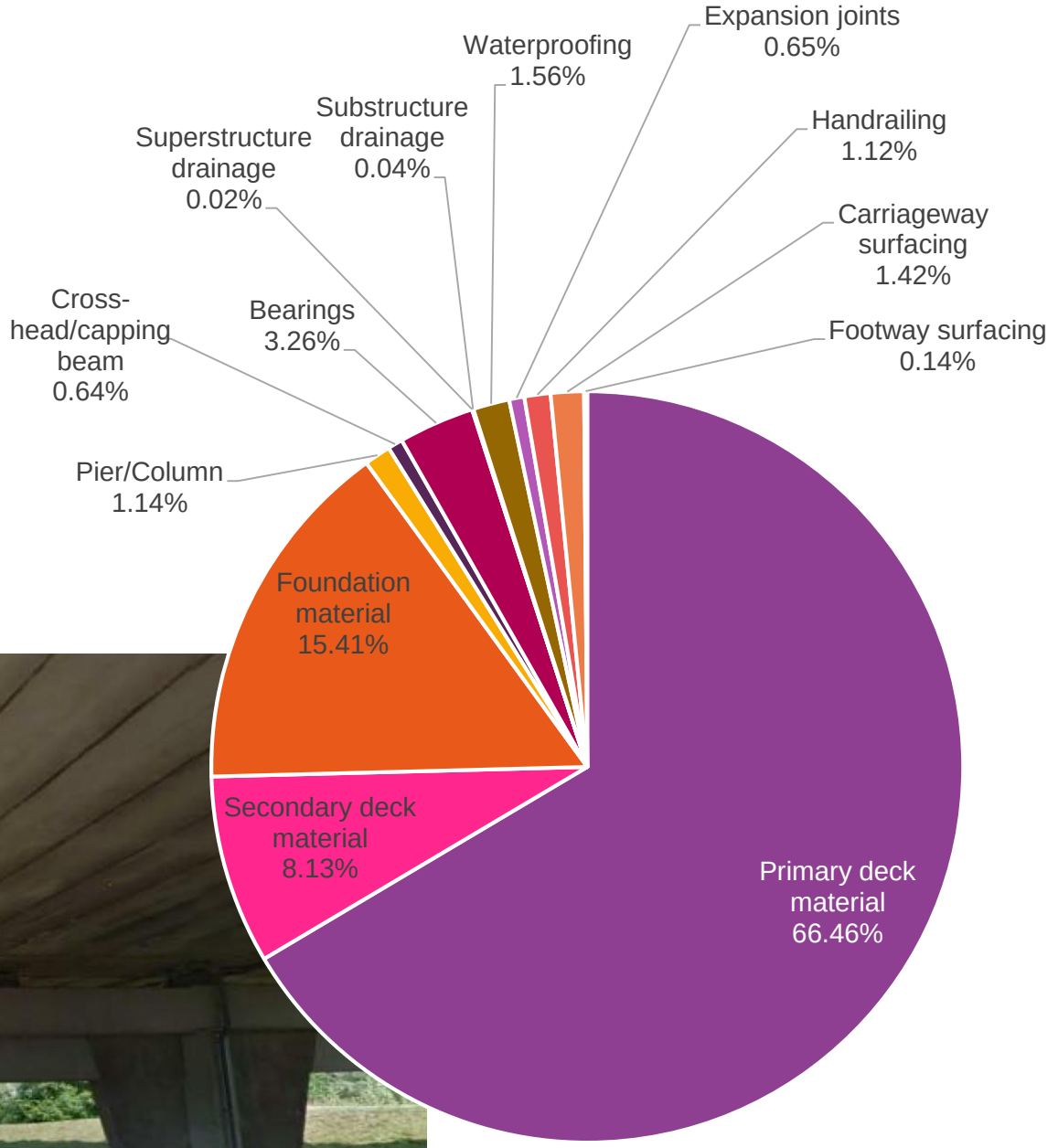
Main aims

- Create an open-source tool
- Quantify: baseline, maintenance, offsetting
- Improve awareness and understanding on carbon
- Change procurement focus to include sustainability
- Communicate and knowledge share across the sector

Why are you looking at the embodied CO2e?

Baseline approach

- Replace like-for-like, CO2e content
- **Gross Replacement Carbon footprint (GRCf)**
- Understand the embodied carbon on an element-by-element basis
- Unlocks understanding on the structure



Funding requests

Recent chloride testing has indicated a high chance of corrosion, what would be the replacement carbon cost if a CPS is not installed and the steel protected?

Asset management

How do our proactive maintenance strategies align with our known high-carbon structures?

Major intervention

How does replacement carbon compare to embodied carbon? Is strengthening really not an option?

Maintenance

The handrailing paint has flaked off. If the handrailing continues to corrode and deteriorates what would be the carbon cost of replacement?

Knowledge

How do our different construction form bridges compare?

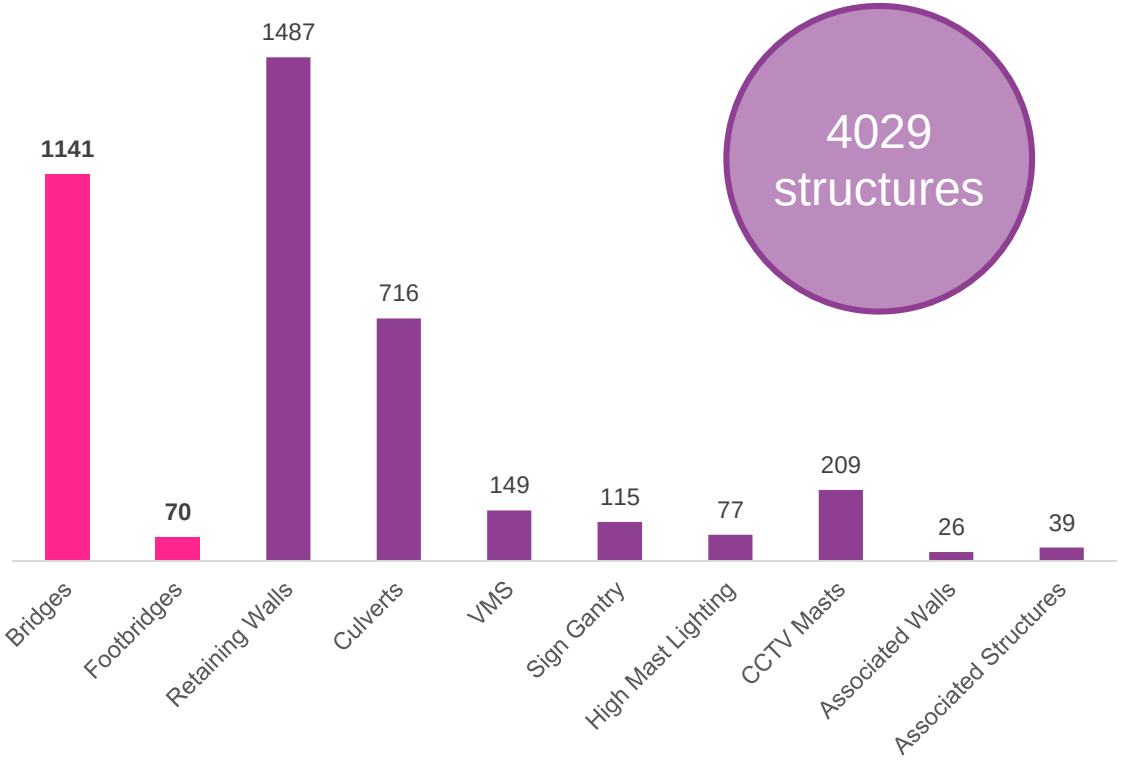
Procurement stage

How does CAPCarb compare to OPCarb? Can we plan long term?

How do you calculate GRCf?

Welsh Government network

- 1211 bridges
- ~ 60 types of construction form
- Automated approach to calculation
- Justifiable and usable by other asset owners



Workflow

Dimensions

Quantities of materials

X

Rates

Rate of each material
ICE DB V3.0
TATA guide
Etc.

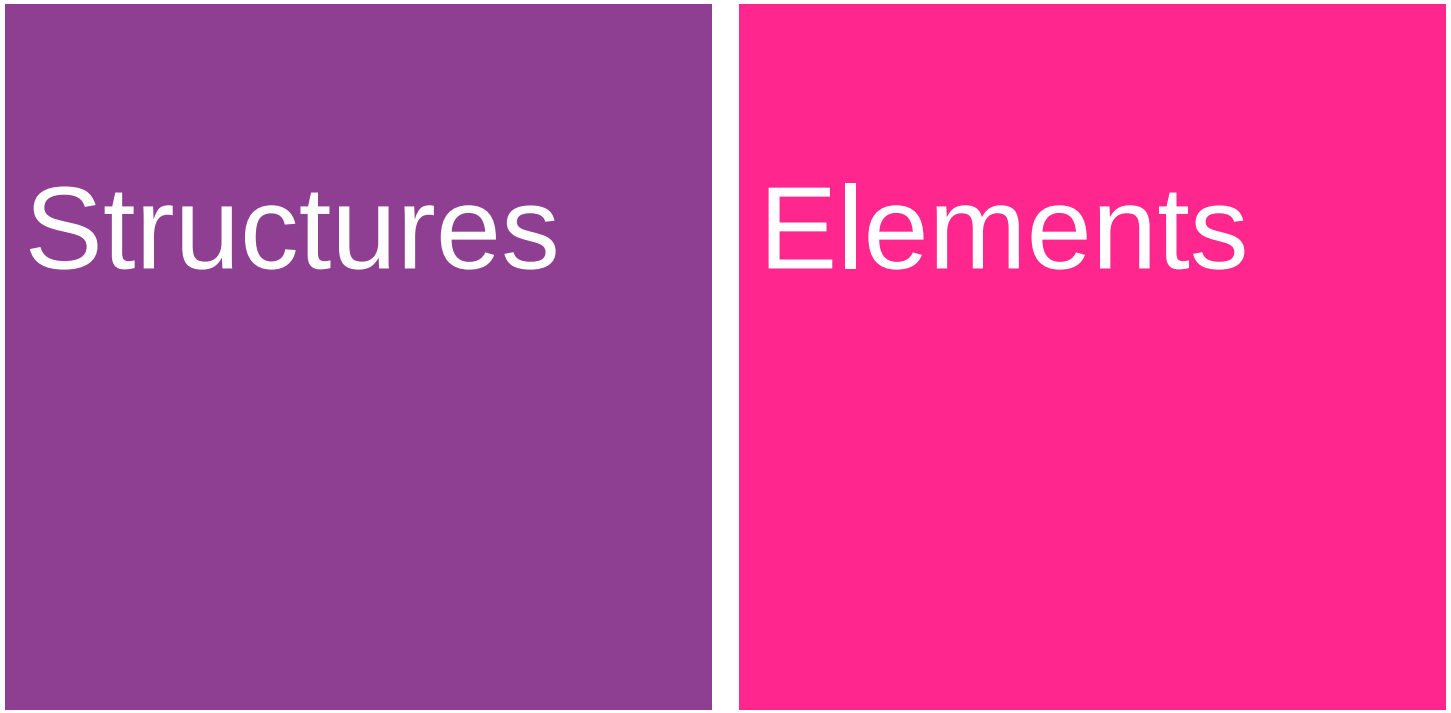
=

CO2e

Equivalent CO2 of each element

Dimensions

Existing data



Structures

Name of Structure	Structure Type	Structure type	Span construction type	Fixity	Length (m) of Structure	Average Width (m) of Structure	Average Critical Headroom (m) of Structure OR Average Height (m) of Structure
A40 660 - PONT LLANWRDA - SPAN2	Bridge: Vehicular (2 or 3 spans)	SLAB			5.6	17.8	5.03
A40 670 - PONT MARLAIS - SPAN1	Bridge: Vehicular (single span)	SLAB			7.3	13.2	5.03
A40 680 - PONT DULAIS - SPAN1	Bridge: Vehicular (single span)	SLAB	PRECAST PRETEN, INV 'T' BEAMS, IN SITU CONC INFILL (COMPOSITE)	SIMPLY SUPPORTED	9.5	16	5.03
A40 70 - LONGSTONE BRIDGE - SPAN1	Bridge: Vehicular (single span)	PORTAL	£	?	15.2	26.5	5.03
A40 700 - PONT MYDDFI - SPAN1	Bridge: Vehicular (2 or 3 spans)	ARCH, FILLED SPANDREL	MASONRY CONCRETE BLOCKS	MORTAR JOINTED	2.66666667	12.5	5.03
A40 700 - PONT MYDDFI - SPAN2	Bridge: Vehicular (2 or 3 spans)	ARCH, FILLED SPANDREL	MASONRY CONCRETE BLOCKS	-	2.66666667	12.5	5.03
A40 700 - PONT MYDDFI - SPAN3	Bridge: Vehicular (2 or 3 spans)	ARCH, FILLED SPANDREL	MASONRY CONCRETE BLOCKS	-	2.66666667	12.5	5.03
A40 710 - NANT STEPHANAU - SPAN1	Bridge: Vehicular (single span)	ARCH, FILLED SPANDREL	MASONRY CONCRETE BLOCKS	MORTAR JOINTED	3.68	8.3	5.03
A55 0730 - DINERTH RD U/BRIDGE - SPAN1	Bridge: Vehicular (single span)	BOX TYPE STRUCTURE	RC, SLAB	FIXED	9.91	25.3	4.2
A40 730 - PONT DULAS (DRYSLWYN) - SPAN1	Bridge: Vehicular (single span)	BEAM AND SLAB	PRECAST PRETEN, INV 'T' BEAMS, IN SITU CONC INFILL (COMPOSITE)	SIMPLY SUPPORTED	12.75	12.36	3.3
A40 739 - PONT AR GOTHI RD BR - SPAN1	Bridge: Vehicular (2 or 3 spans)	ARCH, THROUGH (UNTIED)	MASONRY STONE	FIXED	10.65	7.8	5.03
A40 739 - PONT AR GOTHI RD BR - SPAN2	Bridge: Vehicular (2 or 3 spans)	ARCH, THROUGH (UNTIED)	MASONRY STONE	FIXED	10.65	7.8	5.03
A40 739 - PONT AR GOTHI RD BR - SPAN3	Bridge: Vehicular (2 or 3 spans)	ARCH, THROUGH (UNTIED)	MASONRY STONE	FIXED	10.65	7.8	5.03
A40 750 - FELIN WEN WHITEMILL - SPAN1	Bridge: Vehicular (single span)	SLAB	RC, SLAB	SIMPLY SUPPORTED	4.35	12.1	5.03
A40 1155 - Maesgwynne Road Bridge - SPAN1	Bridge: Vehicular (single span)	BOX TYPE STRUCTURE	RC	NOT APPLICABLE	9.66	37	5.85
A40 755 - Bat Roost - SPAN2	Bridge: Vehicular (2 or 3 spans)	BOX TYPE STRUCTURE	RC	NOT APPLICABLE	1.5	26	5.03
A40 762 - Bishops Mill Culvert - SPAN1	Bridge: Vehicular (single span)	BOX TYPE STRUCTURE	IN SITU RC, BARREL	FIXED	4.8	16.45	2.8
A40 765 - Gwili River Bridge - SPAN1	Bridge: Vehicular (2 or 3 spans)	SLAB (WITH EDGE CANTILEVERS)	RC, SLAB	FIXED	15	13.4	3.75
A40 765 - Gwili River Bridge - SPAN2	Bridge: Vehicular (2 or 3 spans)	SLAB (WITH EDGE CANTILEVERS)	RC, SLAB	FIXED	15	13.4	3.75
A40 765 - Gwili River Bridge - SPAN3	Bridge: Vehicular (2 or 3 spans)	SLAB (WITH EDGE CANTILEVERS)	RC, SLAB	FIXED	15	13.4	3.75
A40 768 - Green Meadow Overbridge - SPAN1	Bridge: Vehicular (4 or more spans)	SLAB (WITH EDGE CANTILEVERS)	RC, SLAB	CONTINUOUS	17.75	11.4	6.2
A40 768 - Green Meadow Overbridge - SPAN2	Bridge: Vehicular (4 or more spans)	SLAB (WITH EDGE CANTILEVERS)	RC, SLAB	CONTINUO		11.4	6.2
A40 768 - Green Meadow Overbridge - SPAN3	Bridge: Vehicular (4 or more spans)	SLAB (WITH EDGE CANTILEVERS)	RC, SLAB	CONTINUO		11.4	6.2
A40 768 - Green Meadow Overbridge - SPAN4	Bridge: Vehicular (4 or more spans)	SLAB (WITH EDGE CANTILEVERS)	RC, SLAB	CONTINUOUS		11.4	6.2
M4 39-40 7 - BROMBIL LANE UPASS - SPAN1	Bridge: Vehicular (single span)	BOX TYPE STRUCTURE	RC	FIXED	9.5	75.7	5.03

Bridges – span level

Structure type

Span length

Form of construction

Width of span

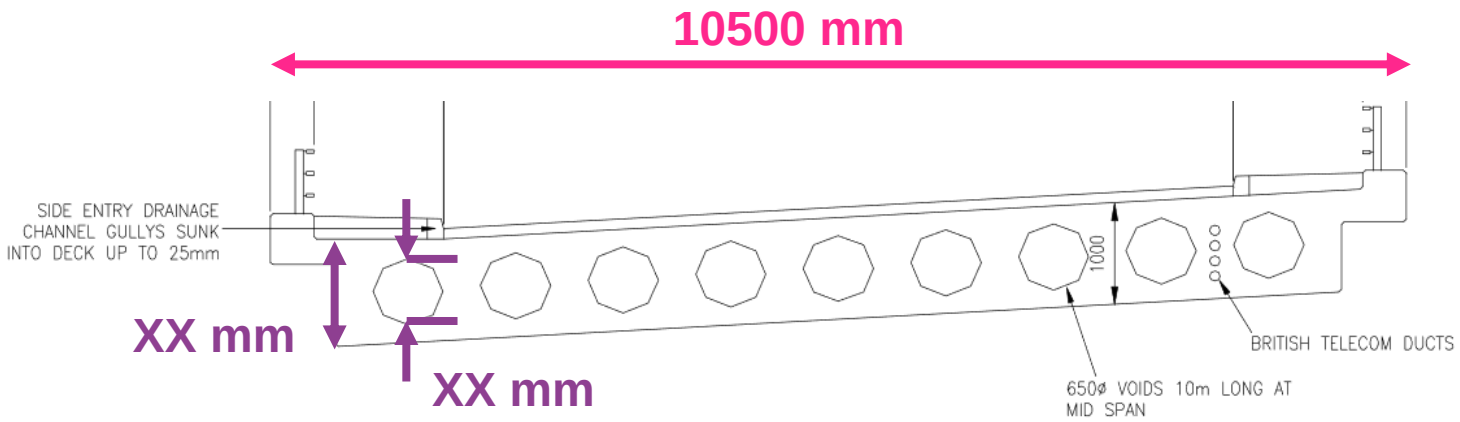
Elements

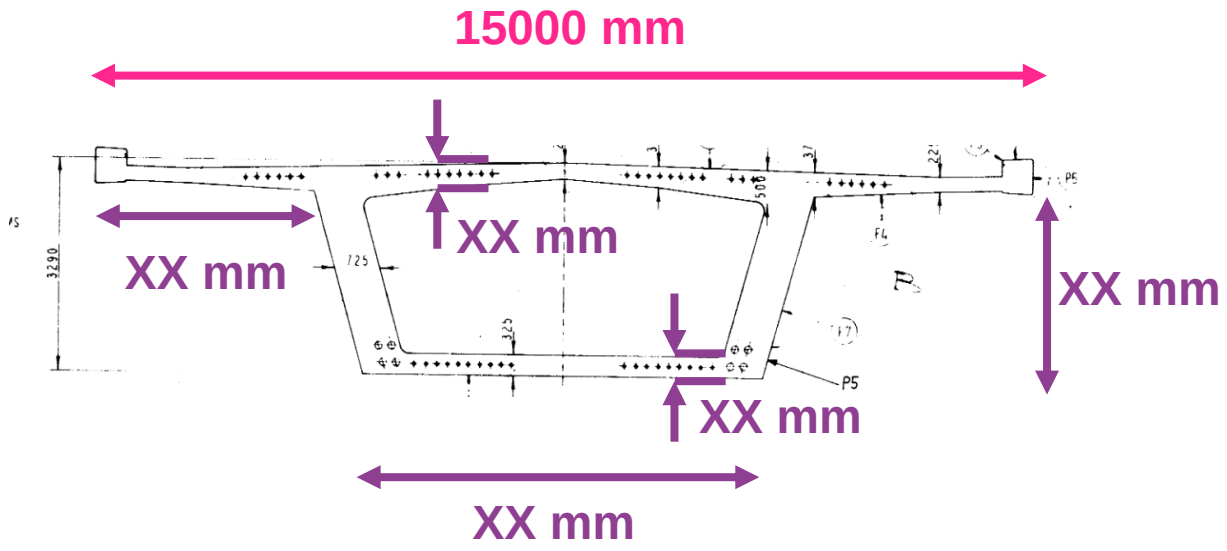
Identifier of Structure	Name of structure	Full Name of Element	Component/Material Type	Condition at last inspection	Proximity to Traffic Spray Zone
A40 10 - 1	A40 10 - CHAPEL FARM - SPAN1	Br01. Primary Deck Element	Insitu Reinforced Concrete	2B	Not within 3 metres' proximity to spray zone / Not applicable
A40 10 - 1	A40 10 - CHAPEL FARM - SPAN1	Br03. Secondary Deck Element	Insitu Reinforced Concrete	1A	Not within 3 metres' proximity to spray zone / Not applicable
A40 10 - 1	A40 10 - CHAPEL FARM - SPAN1	Br06. Parapet Beam or Cantilever	Insitu Reinforced Concrete	4C	Not within 3 metres' proximity to spray zone / Not applicable
A40 10 - 1	A40 10 - CHAPEL FARM - SPAN1	Br08. Foundations	Foundation material	1A	Not within 3 metres' proximity to spray zone / Not applicable
A40 10 - 1		Br09. Abutments (incl. Arch Springing)	Insitu Reinforced Concrete	2C	Within 3 metres' proximity to spray zone
A40 10 - 1		Br15. Superstructure Drainage	Plastic (External)	3D	Not within 3 metres' proximity to spray zone / Not applicable
A40 10 - 1		Br16. Substructure Drainage	Plastic (External)	3C	Not within 3 metres' proximity to spray zone / Not applicable
A40 10 - 1		Br17. Waterproofing	Spray Systems	1A	Not within 3 metres' proximity to spray zone / Not applicable
A40 10 - 1	A40 10 - CHAPEL FARM - SPAN1	Br18. Expansion Joints	Other/Unknown Expansion Joint	1A	Not within 3 metres' proximity to spray zone / Not applicable
A40 10 - 1	A40 10 - CHAPEL FARM - SPAN1	Br21. Finishes: Parapets/Safety Fences	Other/Unknown Finish	5E	Not within 3 metres' proximity to spray zone / Not applicable
A40 10 - 1	A40 10 - CHAPEL FARM - SPAN1	Br23. Handrail/Parapets/Safety Fences	Steel	4D	Not within 3 metres' proximity to spray zone / Not applicable
A40 10 - 1	A40 10 - CHAPEL FARM - SPAN1	Br24. Carriageway surfacing	Carriageway surfacing	3C	Not within 3 metres' proximity to spray zone / Not applicable
A40 10 - 1	A40 10 - CHAPEL FARM - SPAN1	Br25. Footway/verge/footbridge surfacing	Footway surfacing	2C	Not within 3 metres' proximity to spray zone / Not applicable
A40 10 - 1	A40 10 - CHAPEL FARM - SPAN1	Br30. Revetment/Batter Paving	Other/Unknown Revetment	2B	Not within 3 metres' proximity to spray zone / Not applicable
A40 10 - 1	A40 10 - CHAPEL FARM - SPAN1	Br31. Wing Walls	Blockwork, i.e. Masonry or Stone	2C	Within 3 metres' proximity to spray zone
A40 10 - 1	A40 10 - CHAPEL FARM - SPAN1	Br33. Embankments	Natural Embankment Material	1A	Not within 3 metres' proximity to spray zone / Not applicable
A40 10 - 1	A40 10 - CHAPEL FARM - SPAN1	Br35. Approach Rails/Barriers/Walls	Weathering Steel	4D	Not within 3 metres' proximity to spray zone / Not applicable
A40 10 - 1	A40 10 - CHAPEL FAR	Br36. Signs	Warning Signs	2B	Not within 3 metres' proximity to spray zone / Not applicable
A40 100 - 1	A40 100 - JINGLE STR	Br01. Primary Deck Element	Insitu Reinforced Concrete	2C	Not within 3 metres' proximity to spray zone / Not applicable
A40 100 - 1	A40 100 - JINGLE STR	Br06. Parapet Beam or Cantilever	Insitu Reinforced Concrete	3C	Not within 3 metres' proximity to spray zone / Not applicable
A40 100 - 1	A40 100 - JINGLE STR	Br08. Foundations		1A	Not within 3 metres' proximity to spray zone / Not applicable
A40 100 - 1	A40 100 - JINGLE STREET BRIDGE - SPAN1	Br09. Abutments (incl. Arch Springing)		2C	Within 3 metres' proximity to spray zone
A40 100 - 1	A40 100 - JINGLE STREET BRIDGE - SPAN1	Br11. Pier/Column		3B	Within 3 metres' proximity to spray zone
A40 100 - 1	A40 100 - JINGLE STREET BRIDGE - SPAN1	Br13. Bearings	Other/Unknown Bearing	2C	Not within 3 metres' proximity to spray zone / Not applicable
A40 100 - 1	A40 100 - JINGLE STREET BRIDGE - SPAN1	Br14. Bearing Plinth/Shelf	Insitu Reinforced Concrete	2C	Not within 3 metres' proximity to spray zone / Not applicable
A40 100 - 1	A40 100 - JINGLE STREET BRIDGE - SPAN1	Br15. Superstructure Drainage	Plastic (External)	3C	Not within 3 metres' proximity to spray zone / Not applicable
A40 100 - 1	A40 100 - JINGLE STREET BRIDGE - SPAN1	Br16. Substructure Drainage	Plastic (External)	2C	Not within 3 metres' proximity to spray zone / Not applicable
A40 100 - 1	A40 100 - JINGLE STREET BRIDGE - SPAN1	Br17. Waterproofing	Spray Systems	1A	Not within 3 metres' proximity to spray zone / Not applicable
A40 100 - 1	A40 100 - JINGLE STREET BRIDGE - SPAN1	Br18. Expansion Joints	Other/Unknown Expansion Joint	4B	Not within 3 metres' proximity to spray zone / Not applicable

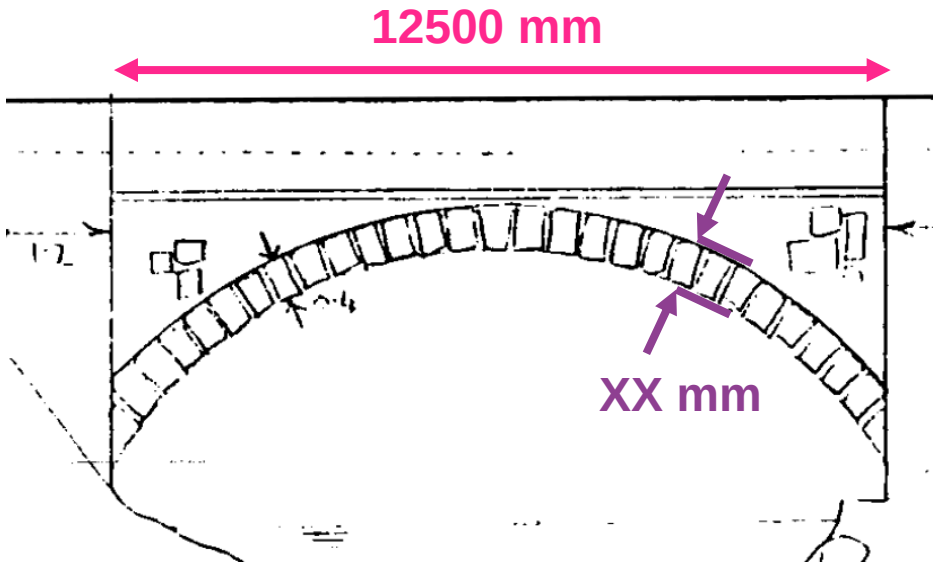
Reference to structure

Element name

Material


10500 mm
SIDE ENTRY DRAINAGE
CHANNEL GULLYS SUNK
INTO DECK UP TO 25mm
XX mm
XX mm
1000
BRITISH TELECOM DUCTS
650ø VOIDS 10m LONG AT
MID SPAN


15000 mm
XX mm
XX mm
XX mm
XX mm
XX mm


12500 mm
XX mm

How do you fill in the blanks?

Inverted T Beams

BANAGHER PRECAST CONCRETE

Structure type

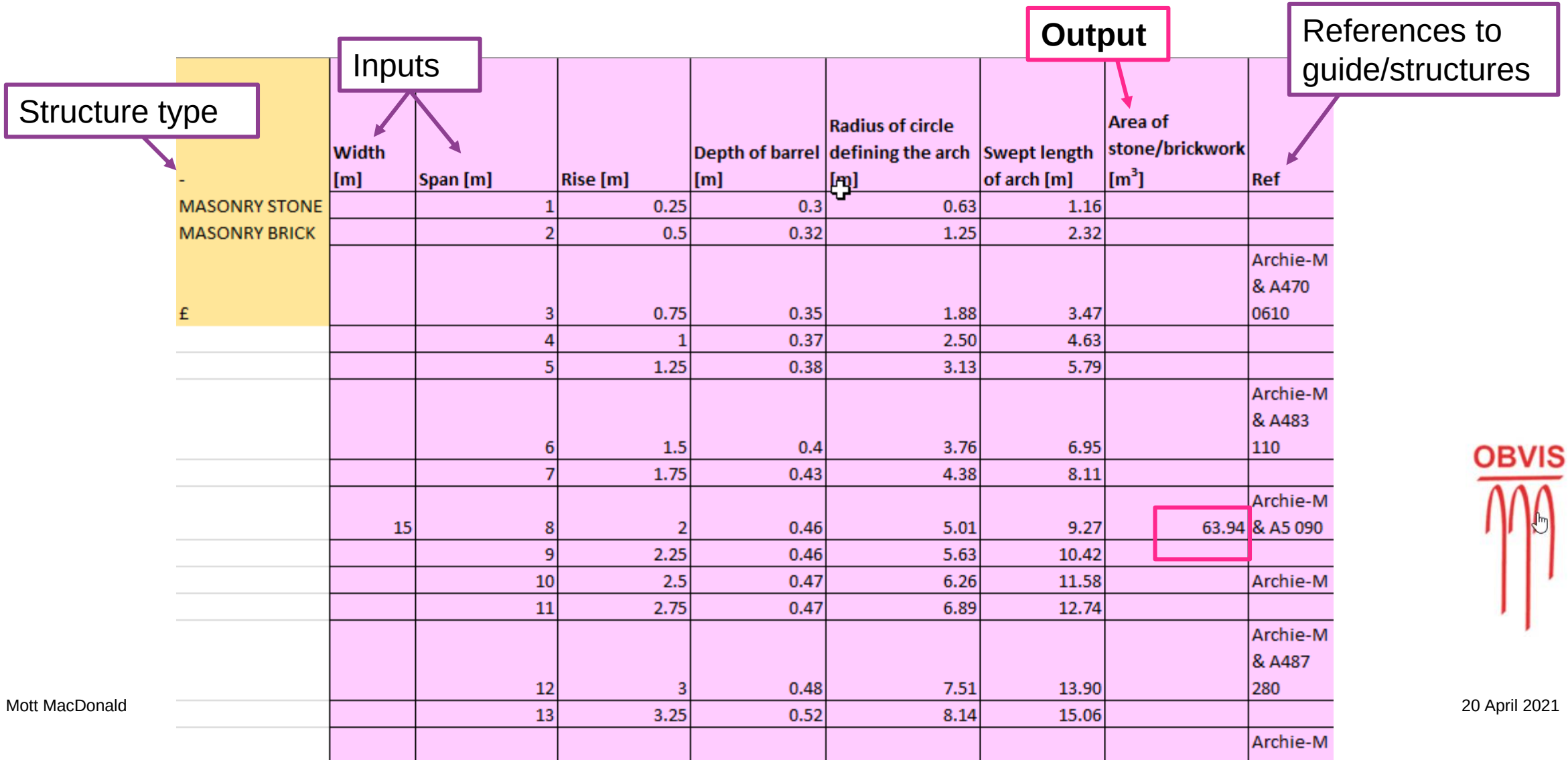
Inputs

Outputs

References to guide/structures

PRECAST REINFORCED CONCRETE	Width [m]	Span [m]	Depth [m]	Depth of slab [m]	Volume of concrete [m^3]	Volume of steel reinforcement [m^3]	Ref
PRECAST PRETEN, INV 'T' BEAMS, IN SITU CONC INFILL (COMPOSITE)		2	0.133	0.075			-
PRECAST RC, BEAMS, R.C. SLAB, (NON-COMPOSITE)		3	0.133	0.075			A470 1090 (Pierhead 5 1/4" beams)
IN SITU RC, BEAMS, R.C. SLAB, (COMPOSITE)		4	0.38	0.075			T1
PRECAST PRETEN, INV 'T' BEAMS, IN SITU CONC INFILL (COMPOSITE + TRANSVERSE)		5	0.38	0.075			T1
IN SITU RC, BEAMS, R.C. SLAB, (NON-COMPOSITE)		6	0.38	0.075			T1
PRECAST RC, BEAMS, R.C. SLAB, (COMPOSITE)		7	0.38	0.075			T1
PRECAST PRETEN, 'I' BEAMS, R.C. SLAB, (COMPOSITE)		8	0.42	0.075			A470 0730 (T2)
PRECAST PRETEN, 'I' BEAMS, IN SITU CONC INFILL, (COMPOSITE)		9	0.5	0.075			A40 955 (TY3)
PRECAST PRETEN, NON STD BEAM, IN SITU CONC INFILL, (COMPOSITE)	12	10	0.535	0.075	73.2	2.562	A40 460 (T3)
?		11	0.575	0.075			A40 840 (T4)
-		12	0.615	0.075			T5
		13	0.655	0.075			T6
		14	0.655	0.1			T6
		15	0.695	0.1			T7

Filled spandrel arches



-	Width [m]	Span [m]	Rise [m]	Depth of barrel [m]	Radius of circle defining the arch [m]	Swept length of arch [m]	Area of stone/brickwork [m^3]	Ref
MASONRY STONE		1	0.25	0.3	0.63	1.16		
MASONRY BRICK		2	0.5	0.32	1.25	2.32		
£		3	0.75	0.35	1.88	3.47		Archie-M & A470 0610
		4	1	0.37	2.50	4.63		
		5	1.25	0.38	3.13	5.79		
		6	1.5	0.4	3.76	6.95		Archie-M & A483 110
		7	1.75	0.43	4.38	8.11		
	15	8	2	0.46	5.01	9.27	63.94	Archie-M & A5 090
		9	2.25	0.46	5.63	10.42		
		10	2.5	0.47	6.26	11.58		Archie-M
		11	2.75	0.47	6.89	12.74		
		12	3	0.48	7.51	13.90		Archie-M & A487 280
		13	3.25	0.52	8.14	15.06		
								Archie-M

OBVIS

What did you use to do this?

Covered structure forms

- RC solid slabs (+ with edge cantilevers)
- Post tensioned (PT) slabs (+ with edge cantilevers)
- Voided slabs (+ with edge cantilevers)
- Ribbed RC
- Composite steel/concrete (+ with edge cantilevers)
- Encased steel beams
- Steel box girders (+ with edge cantilevers)
- PT voided boxes (+ with edge cantilevers)
- PT I beams
- T, Y, U, M beams (+ with edge cantilevers)
- Single & multi cell box culverts (+ with edge cantilevers)
- Masonry, brickwork, concrete arches
- Steel ribbed arches
- RC single & multi cell concrete box spine beams
- PT spine beams
- Encased steel spine beams
- Pre-stressed box spine beams

~60 structure forms

References

OBVIS

Archie-M - filled spandrel arches

BCSA

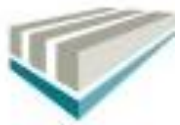
TATA STEEL

ATKINS

Eurocode Preliminary Steel Composite Highway Bridge Design

composite bridges

BANAGHER PRECAST CONCRETE



T,Y,M, etc. beams

SHAY MURTAGH

box culverts

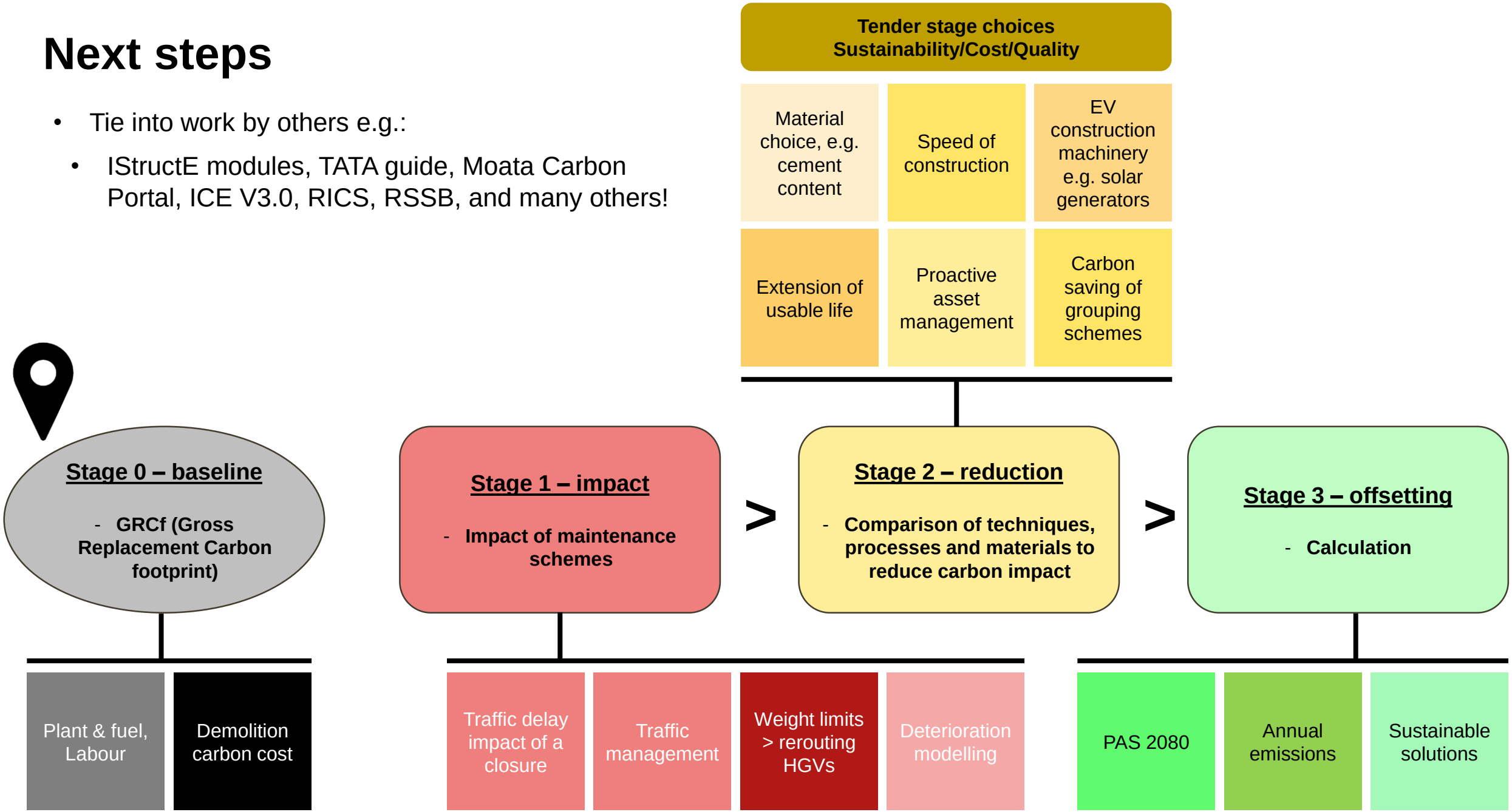
Llywodraeth Cymru
Welsh Government

Empirical - Existing structure data

What next?

Next steps

- Tie into work by others e.g.:
  - IStructE modules, TATA guide, Moata Carbon Portal, ICE V3.0, RICS, RSSB, and many others!

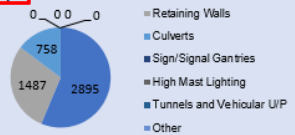


Carbon Management Plan Dashboard

DRAFT

Organisation: Welsh Government
Authority type: Overseeing (Trunk Road) Authority
Date of run: 15/04/2021

No. of Structures: 5140
No. of Elements: 60241



Gross Replacement Carbon footprint (GRCf):

1362.30 kT of CO2e

Annual budget:	**£**	**25,000,000.00**
2021 Planned Maint. (OPCarb):		**60.68 kT of CO2e**
2021 Offsetting cost:		**£526,078.26**

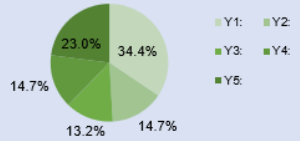
Carbon Rating (/5):

Areas for improvement:
- lower cement content repairs
- using a more local workforce
- increase zero emissions construction vehicles
- proactive maintenance: Finishes: Deck Elements

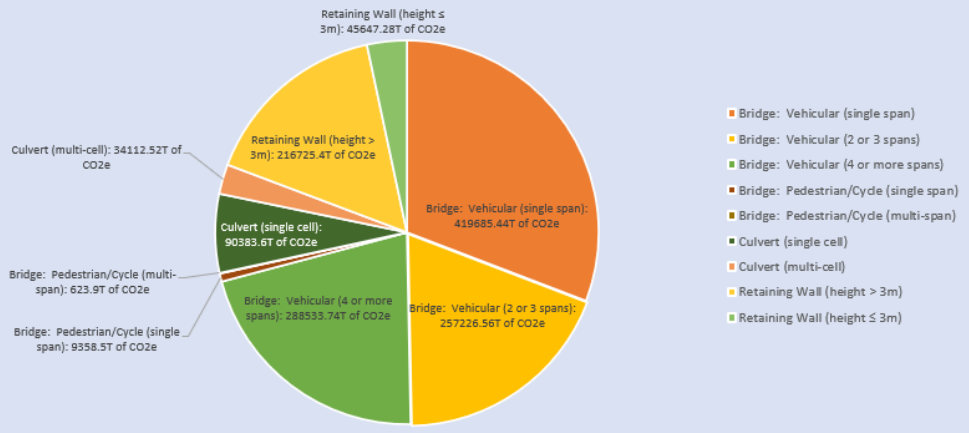
£3.78m annual budget needed to increase to a 4.1 rating.
27% reduction in annual carbon emissions.

Identified Carbon Savings (kT of CO2e)

Y1 to Y5:
60.976 kT of CO2e



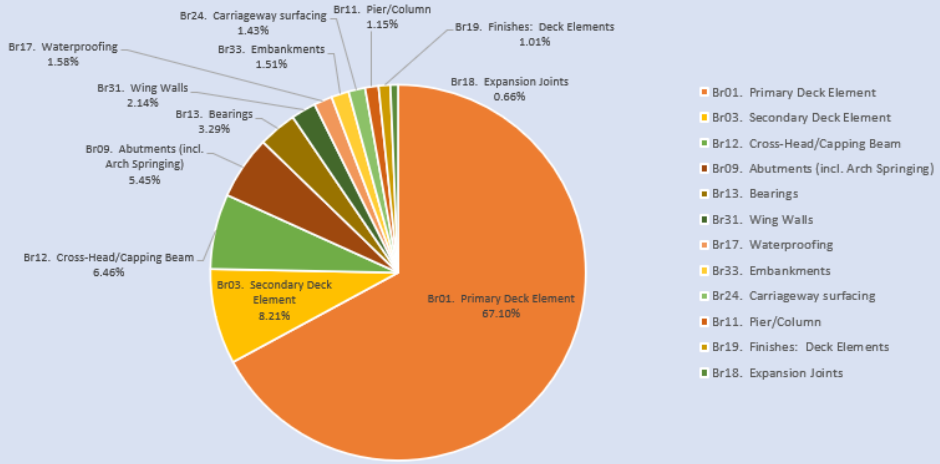
Gross Replacement Carbon footprint, by structure type



To view the prioritised maintenance list, per structure (i.e. the proposed list of individual projects), click here:

View Project List

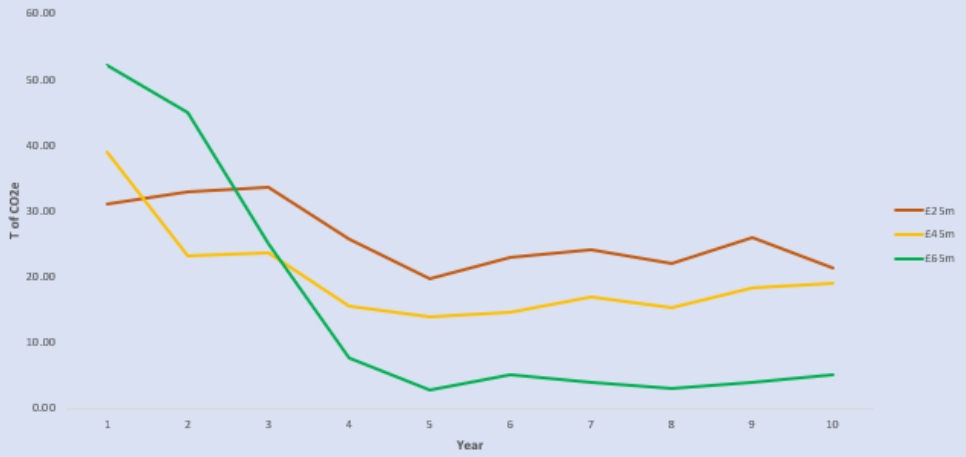
Gross Replacement Carbon footprint, by element



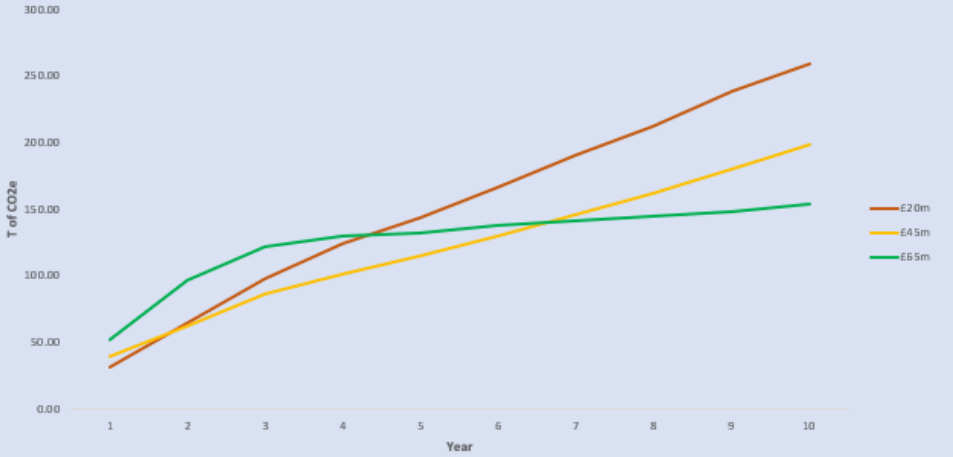
To view the prioritised maintenance list, per element, click here:

View Element List

Annual investment analysis



Cumulative investment analysis



Thank you.
Any questions?