Low carbon bridge engineering: from life extension of existing structures to new stone arch bridges

ERMABI workshop, September 2023

Brian Duguid, Chair, Net Zero Bridges Group

AECOM
Amey
ARCADIS
Arup
Atkins
BEAM Architects
BG&E
Buro Happold
Cake Industries
Cass Hayward
COWI
Expedition
Format Engineers
GHD
Hewson
Jacobs
Kier Consulting
Knight Architects
Mott MacDonald
Moxon Architects
Nuttall Bowser
Ramboll
Robert Bird Group
RPS
SWECO
Tony Gee
Useful Studio
Waterman
Weston Williamson
Wilkinson Eyre
WSP

Net Zero Bridges Group

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UK Architects Declare Climate and Biodiversity Emergency

UK Civil Engineers Declare Climate & Biodiversity Emergency

UK Structural Engineers Declare Climate & Biodiversity Emergency

Net Zero Bridges Group

To accelerate progress towards Net Zero carbon bridges by sharing knowledge and ideas, and shaping best practice

Our objective

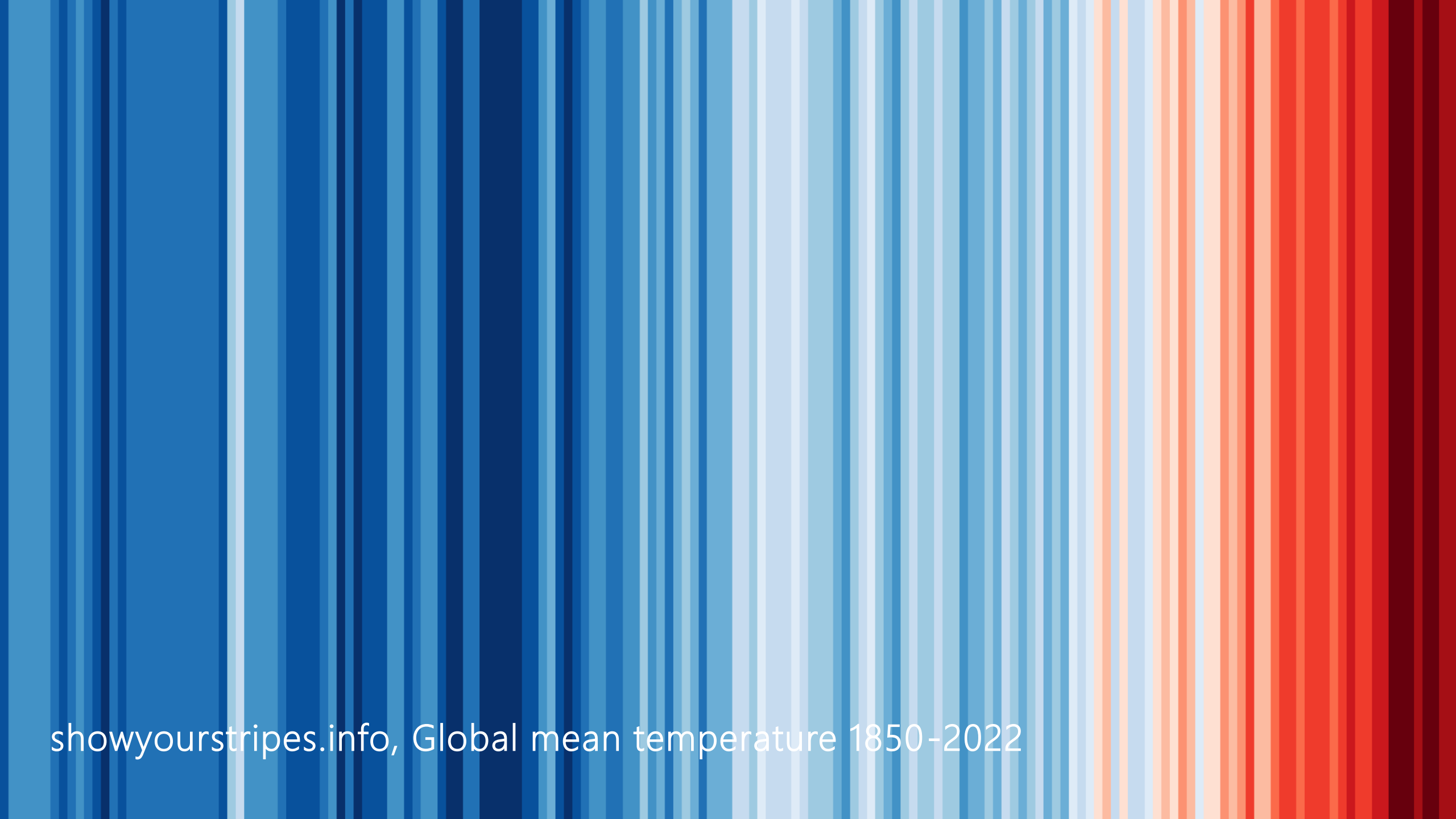
Just Bridges

Just Net Zero

What about climate resilience?

1. Climate context
2. What about construction?
3. Climate action
4. Masonry arch bridges
5. A future for stone?

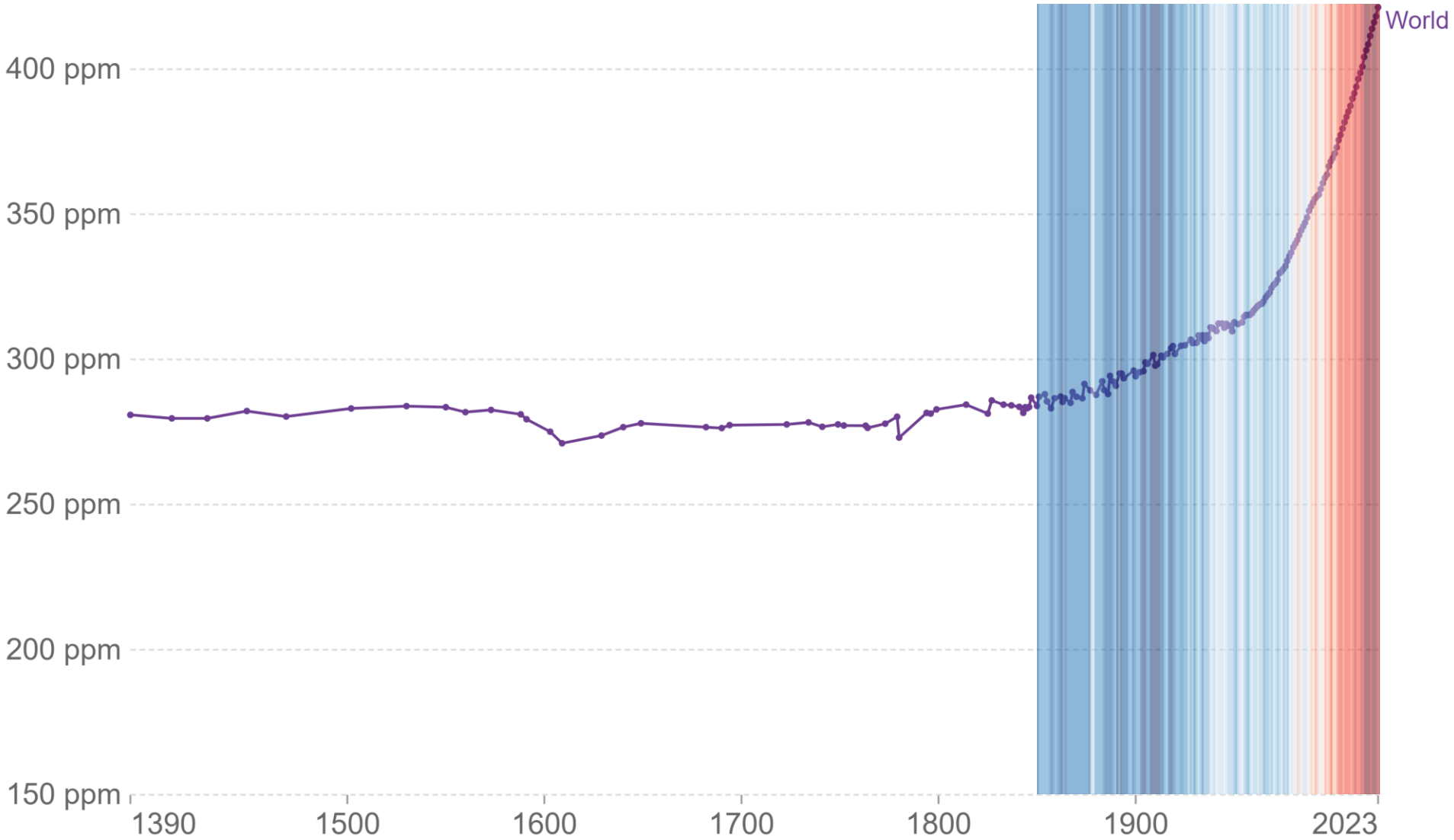
1. Climate context


showyourstripes.info, Global mean temperature 1850-2022

Global atmospheric CO_2 concentration

Atmospheric carbon dioxide (CO_2) concentration is measured in parts per million (ppm). Long-term trends in CO_2 concentrations can be measured at high-resolution using preserved air samples from ice cores.

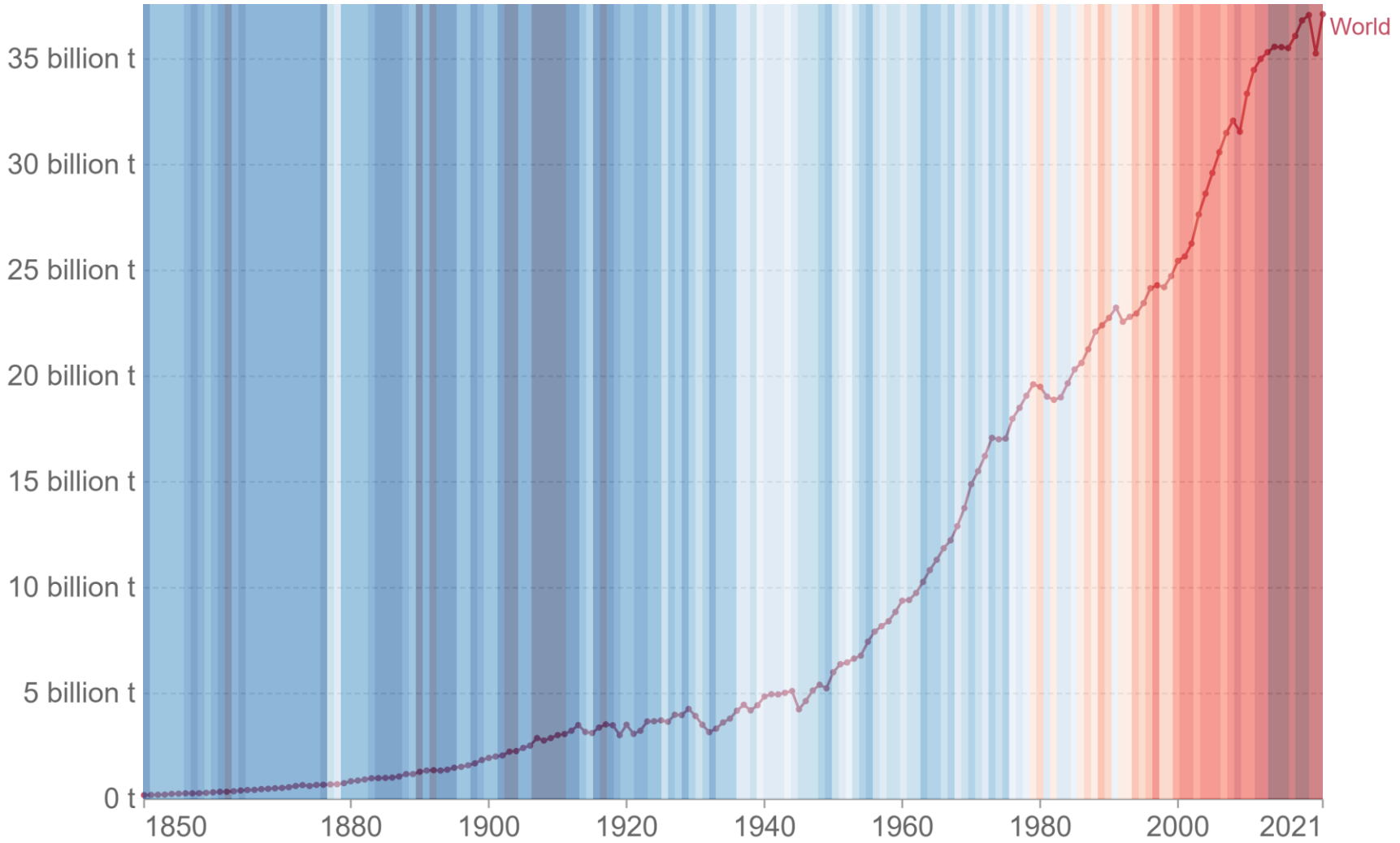
Our World in Data



Source: National Oceanic and Atmospheric Administration (NOAA)

Annual CO_2 emissions

Carbon dioxide (CO_2) emissions from fossil fuels and industry[1] . Land use change is not included.



Source: Global Carbon Budget (2022)

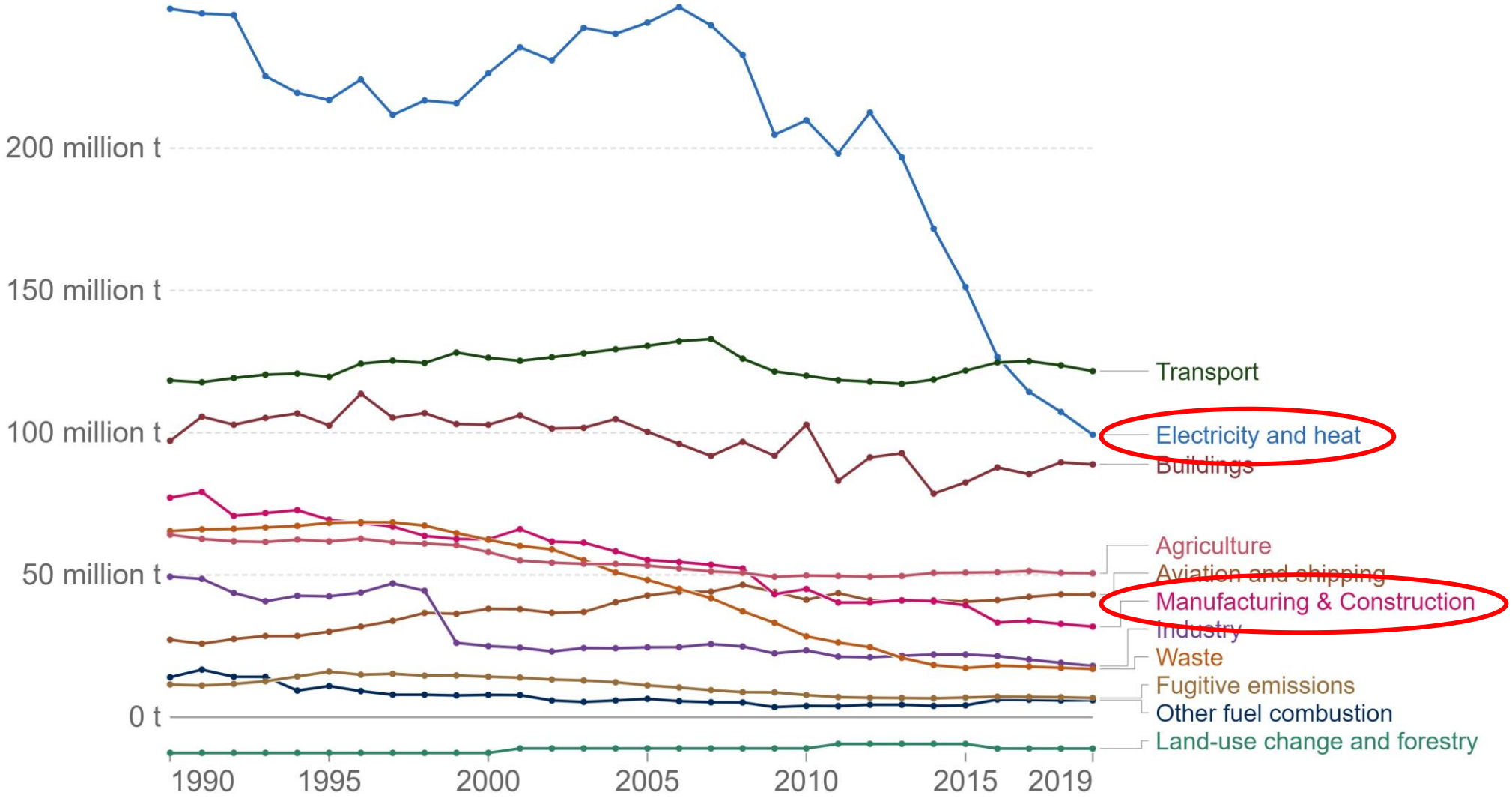
OurWorldInData.org/co2-and-greenhouse-gas-emissions • CC BY

1. Fossil emissions: Fossil emissions measure the quantity of carbon dioxide (CO_2) emitted from the burning of fossil fuels, and directly from industrial processes such as cement and steel production. Fossil CO_2 includes emissions from coal, oil, gas, flaring, cement, steel, and other industrial processes. Fossil emissions do not include land use change, deforestation, soils, or vegetation.

Greenhouse gas emissions by sector, United Kingdom

Our World in Data

Emissions are measured in carbon dioxide equivalents (CO2eq). This means non-CO2 gases are weighted by the amount of warming they cause over a 100-year timescale.



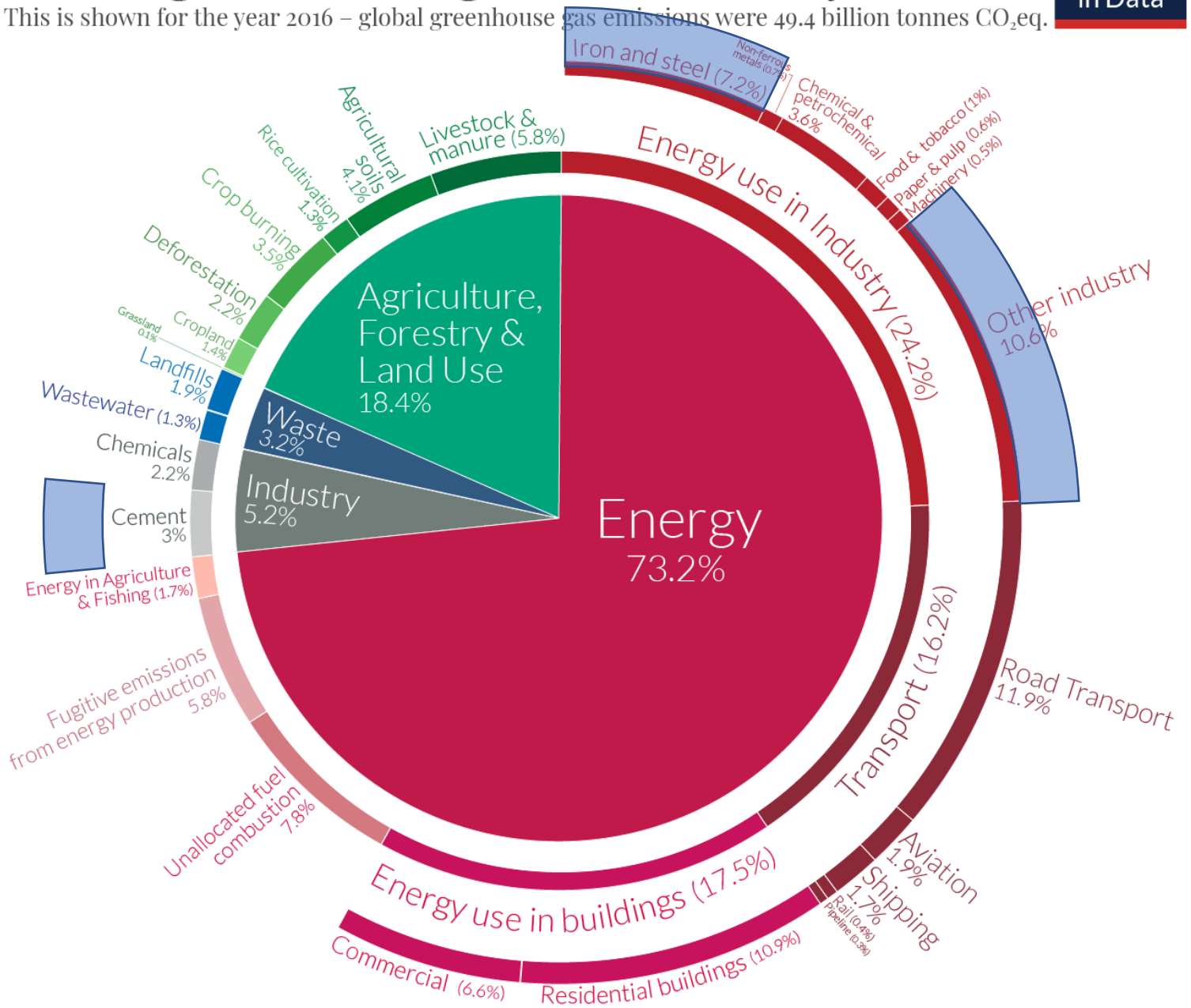
Source: Our World in Data based on Climate Analysis Indicators Tool (CAIT).
OurWorldInData.org/co2-and-greenhouse-gas-emissions • CC BY

2. What about construction?

Global greenhouse gas emissions by sector

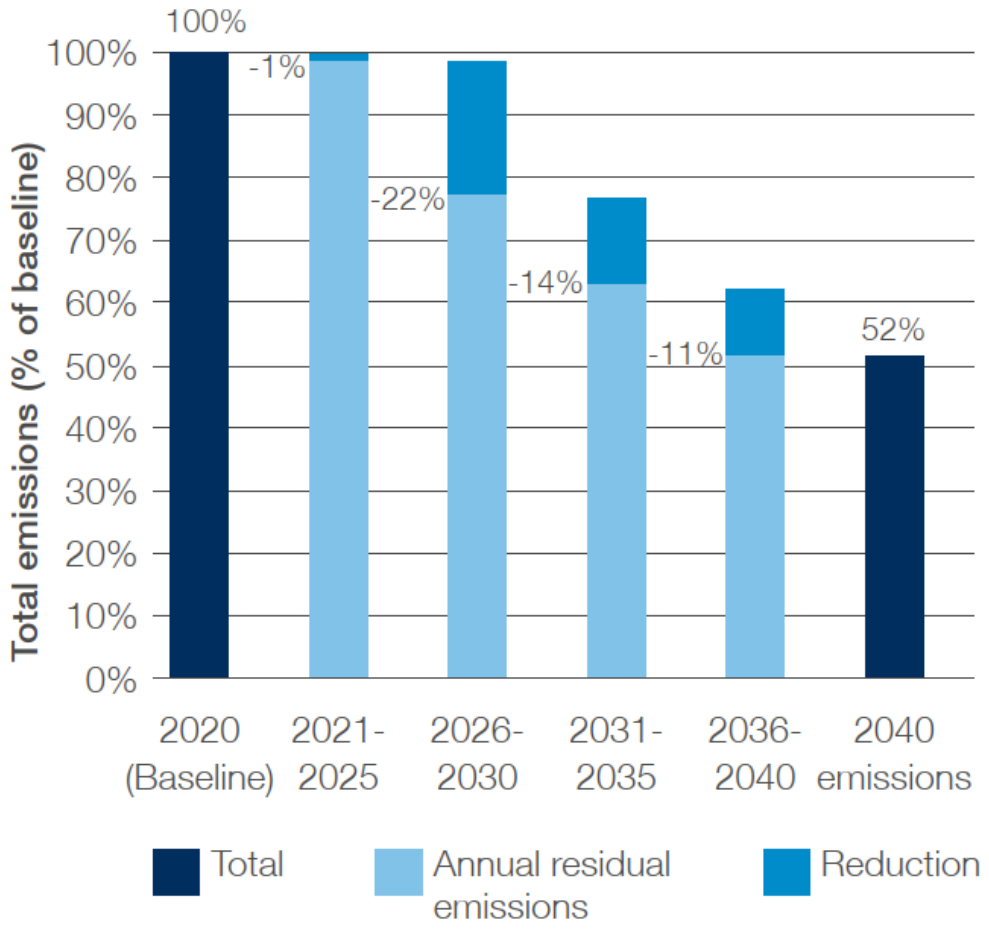
This is shown for the year 2016 – global greenhouse gas emissions were 49.4 billion tonnes CO_2eq.

Our World in Data

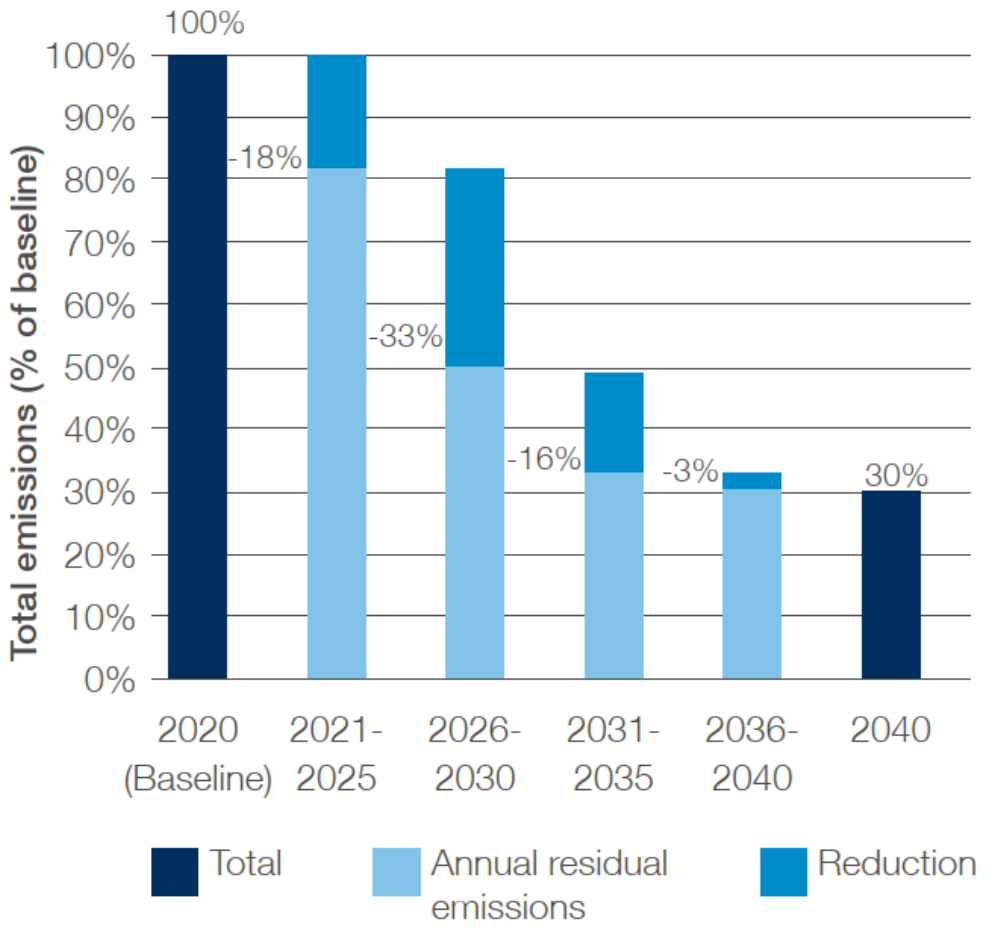


Source: Climate Watch, the World Resources Institute (2020).

Embodied carbon = Quantity x Carbon factor



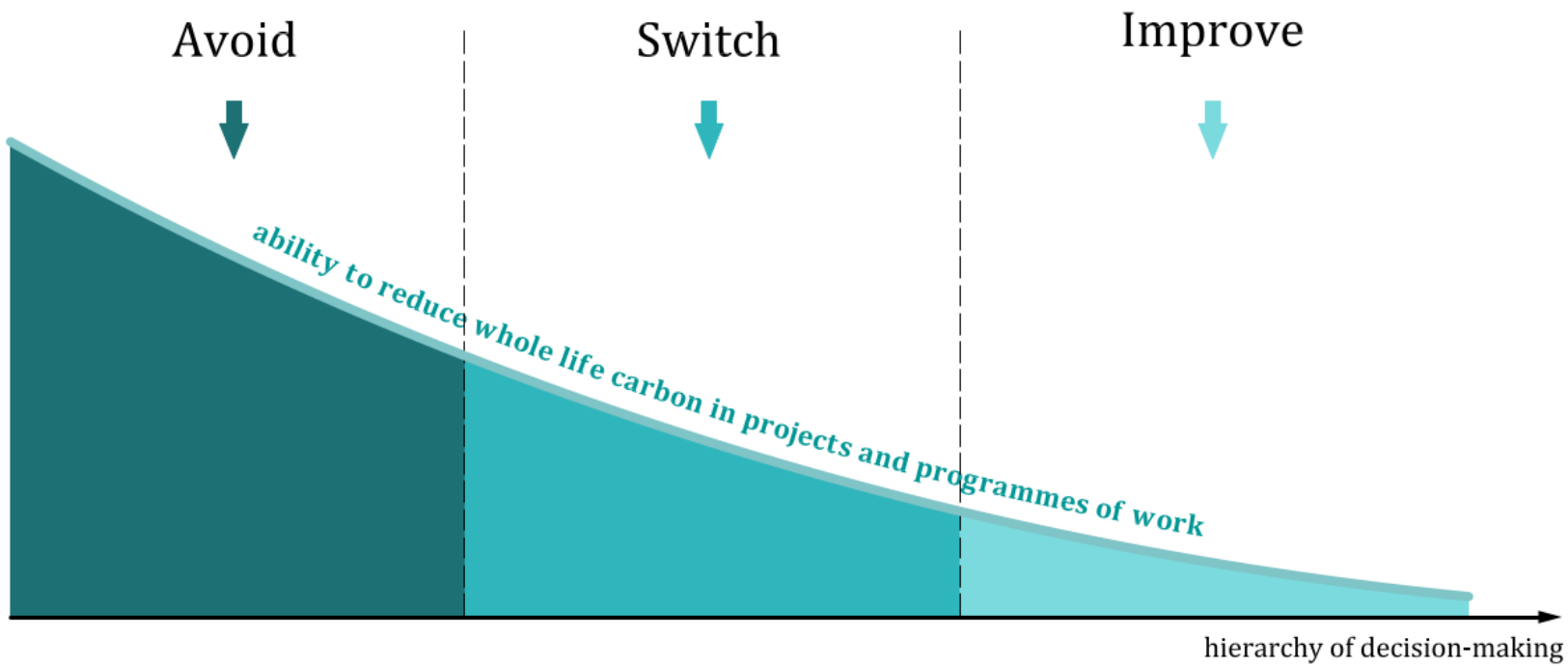
Current concrete decarbonisation trajectory

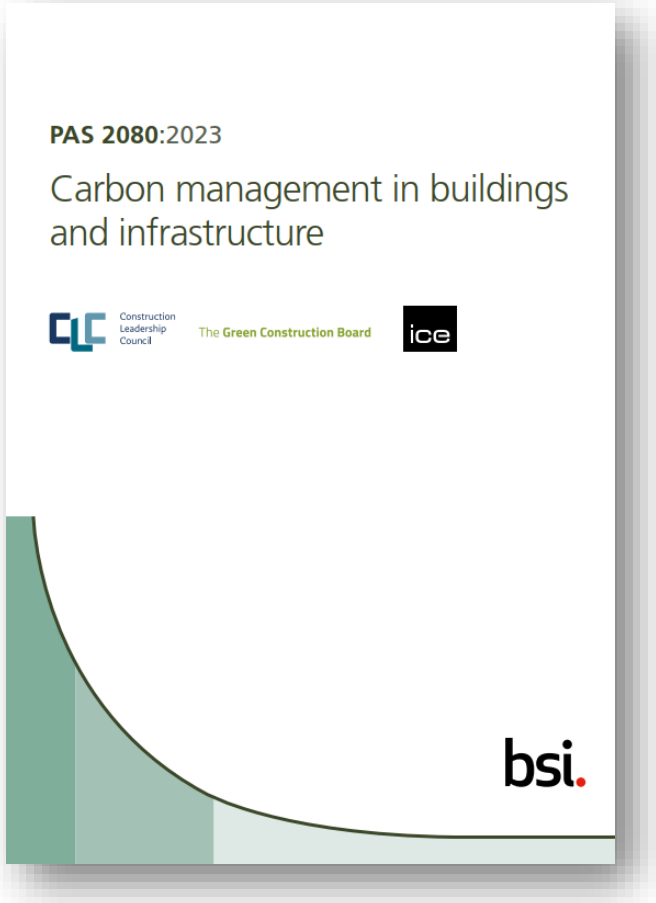


Current steel decarbonisation trajectory

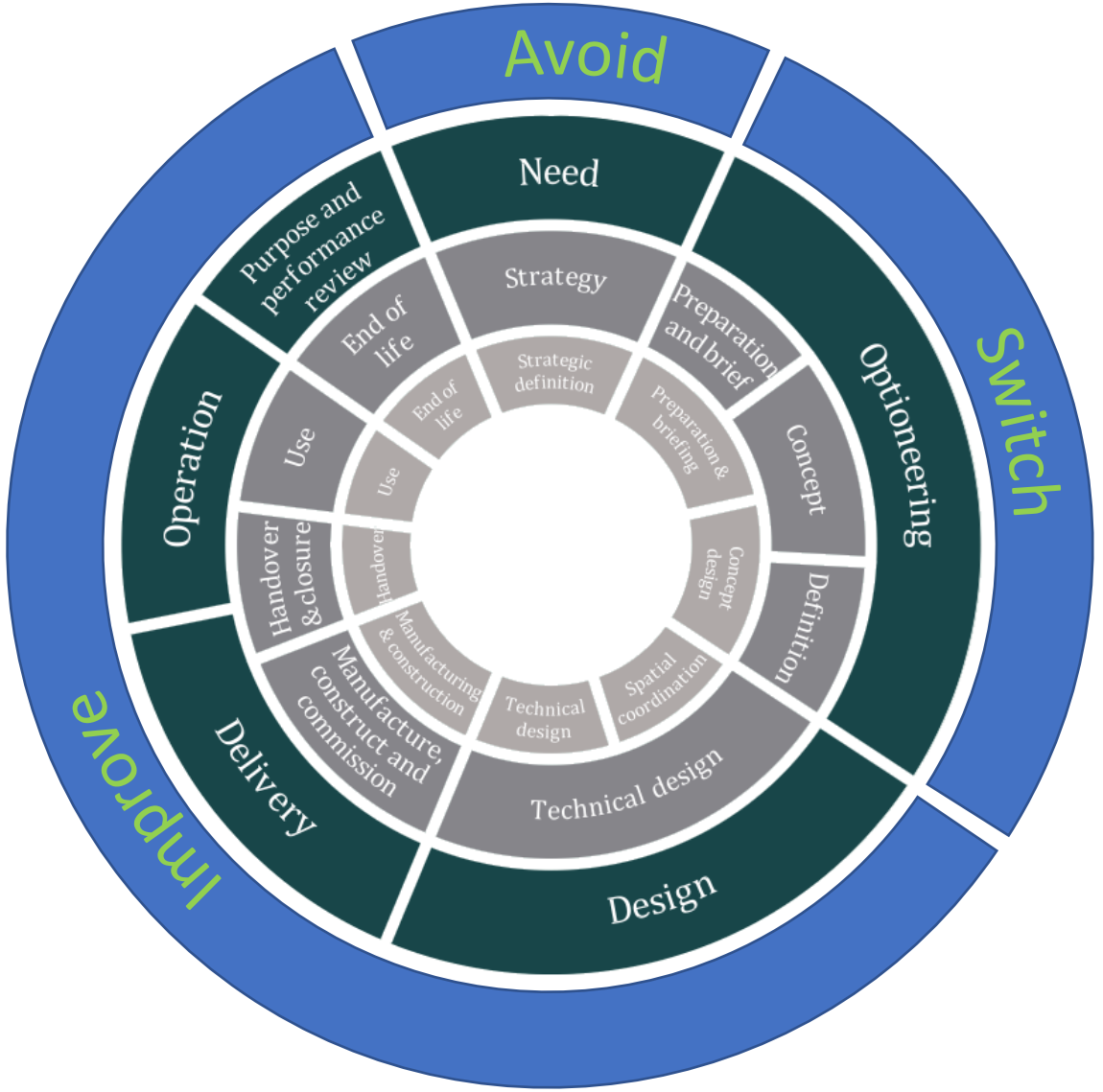
Source: Our zero carbon roadmap for concrete, steel and asphalt, National Highways, 2022

3. Climate action



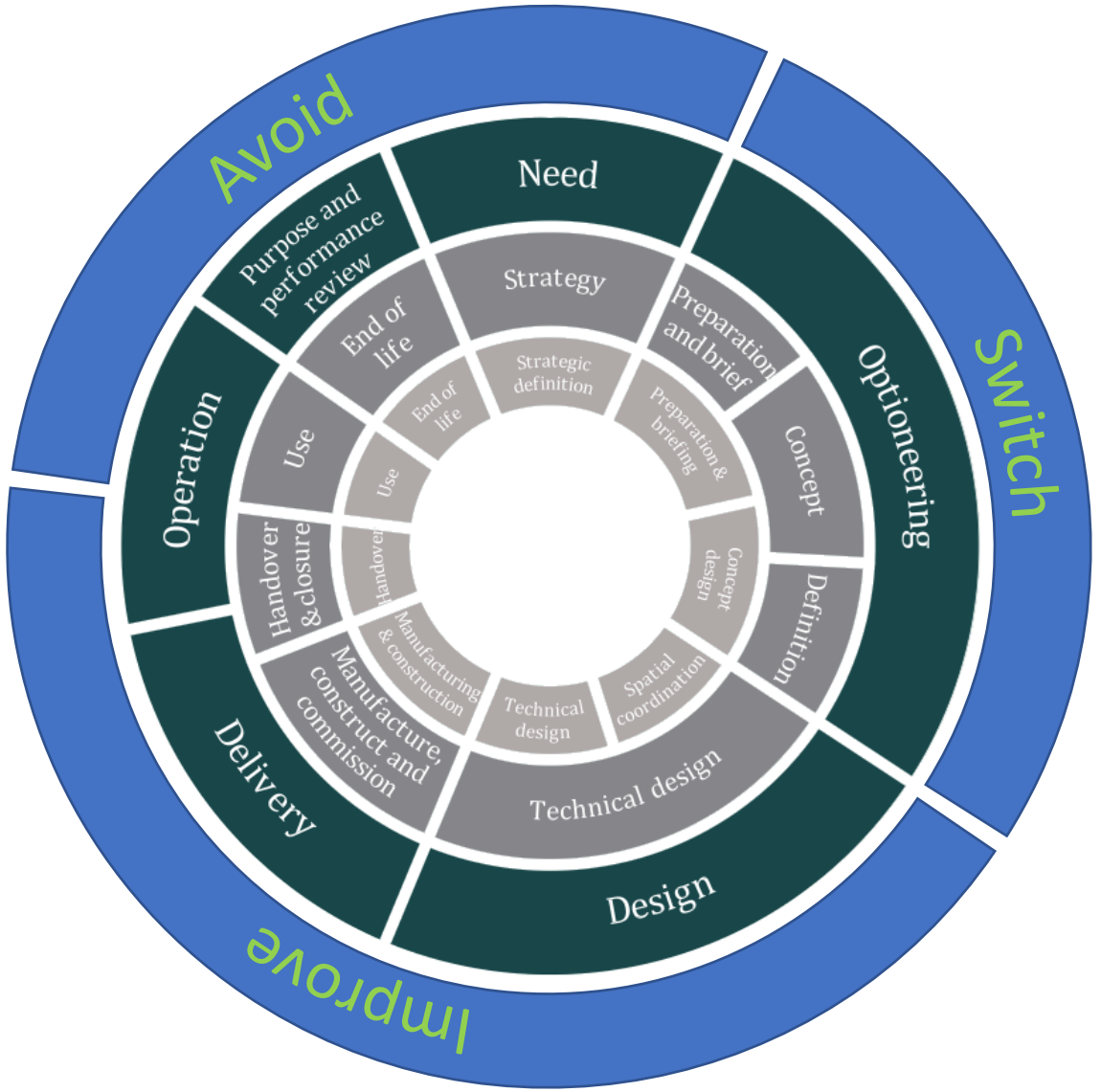


Source: PAS 2080:2023



Net Zero Bridges Group

Source: PAS 2080:2023 / Net Zero Bridges Group

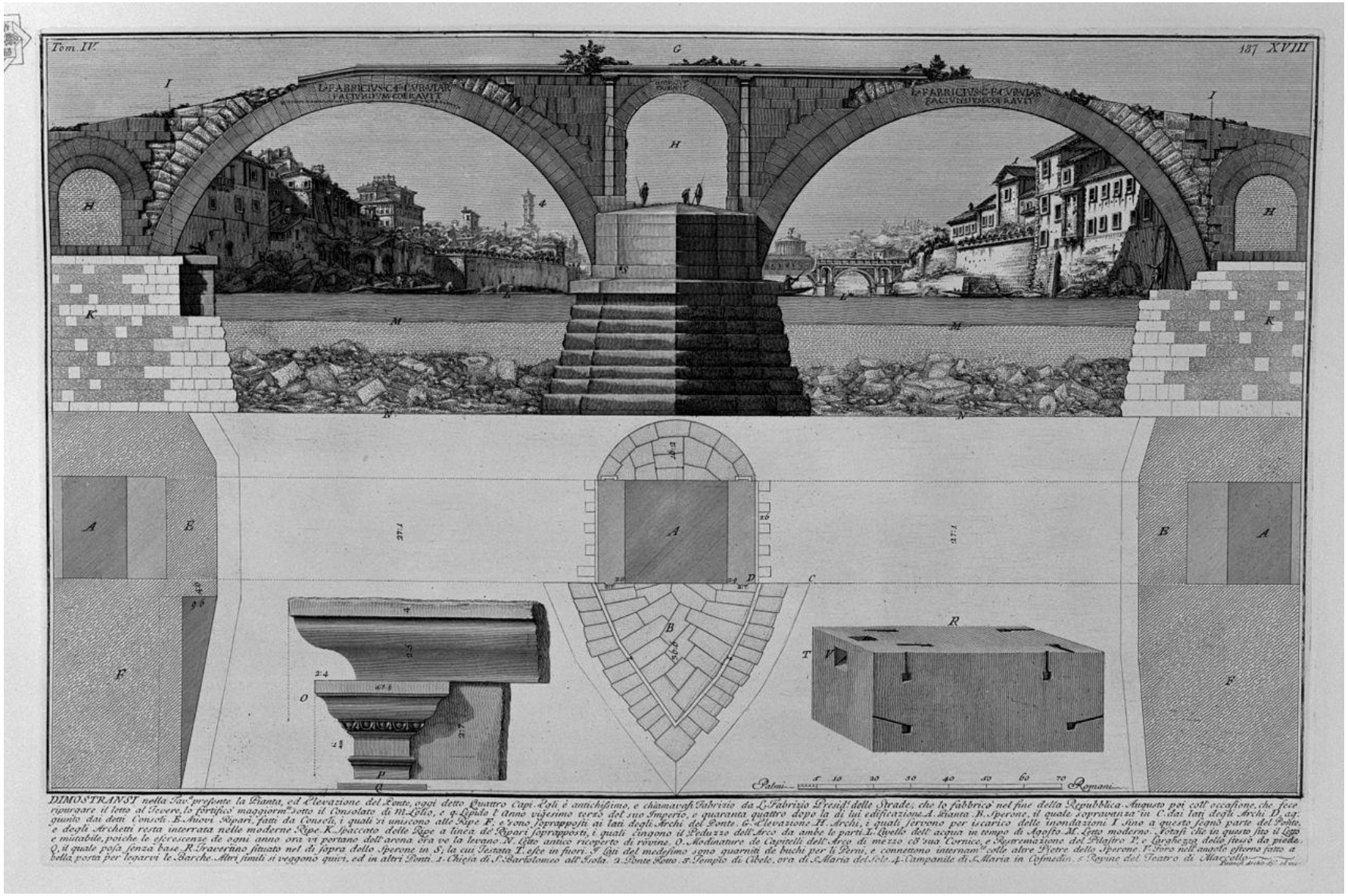


Net Zero Bridges Group

Source: PAS 2080:2023 / Net Zero Bridges Group

4. Masonry arch bridges

Arkadiko Bridge, circa 1300 BCE, source: Wikipedia



Pons Fabricius, 62 BCE, source: Wikipedia

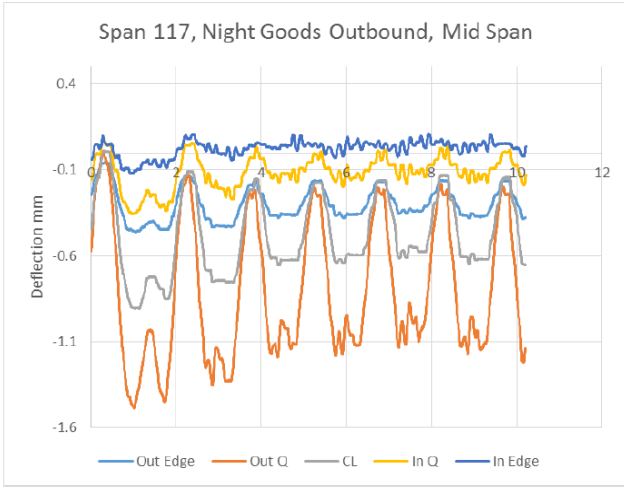
Anji / Zhaozhou Bridge, 605 CE, source: Wikipedia

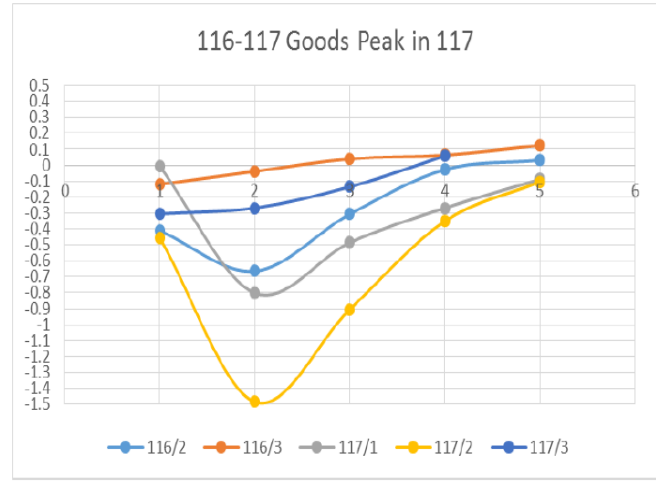
Stephenson’s Bridge, AECOM Mott MacDonald JV / BB Heritage Studio / BDP

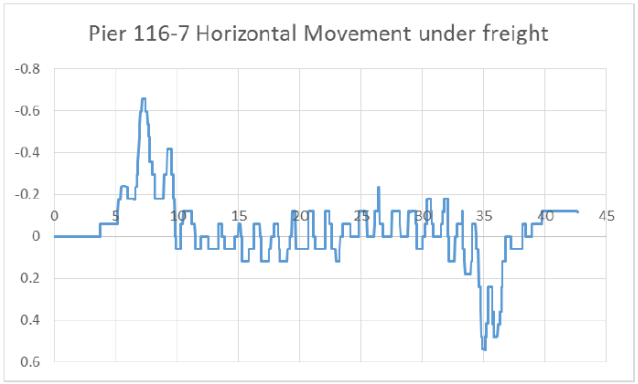

ICTS
Driven by Trailers

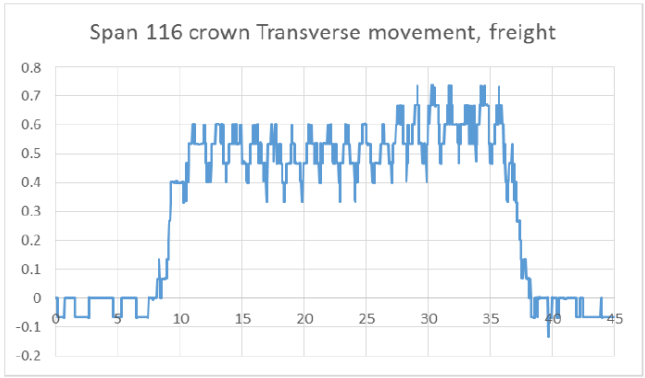

WELDEX
0114 272 1595
CW79066

COL viaduct monitoring, AECOM Mott MacDonald JV / Bill Harvey Associates

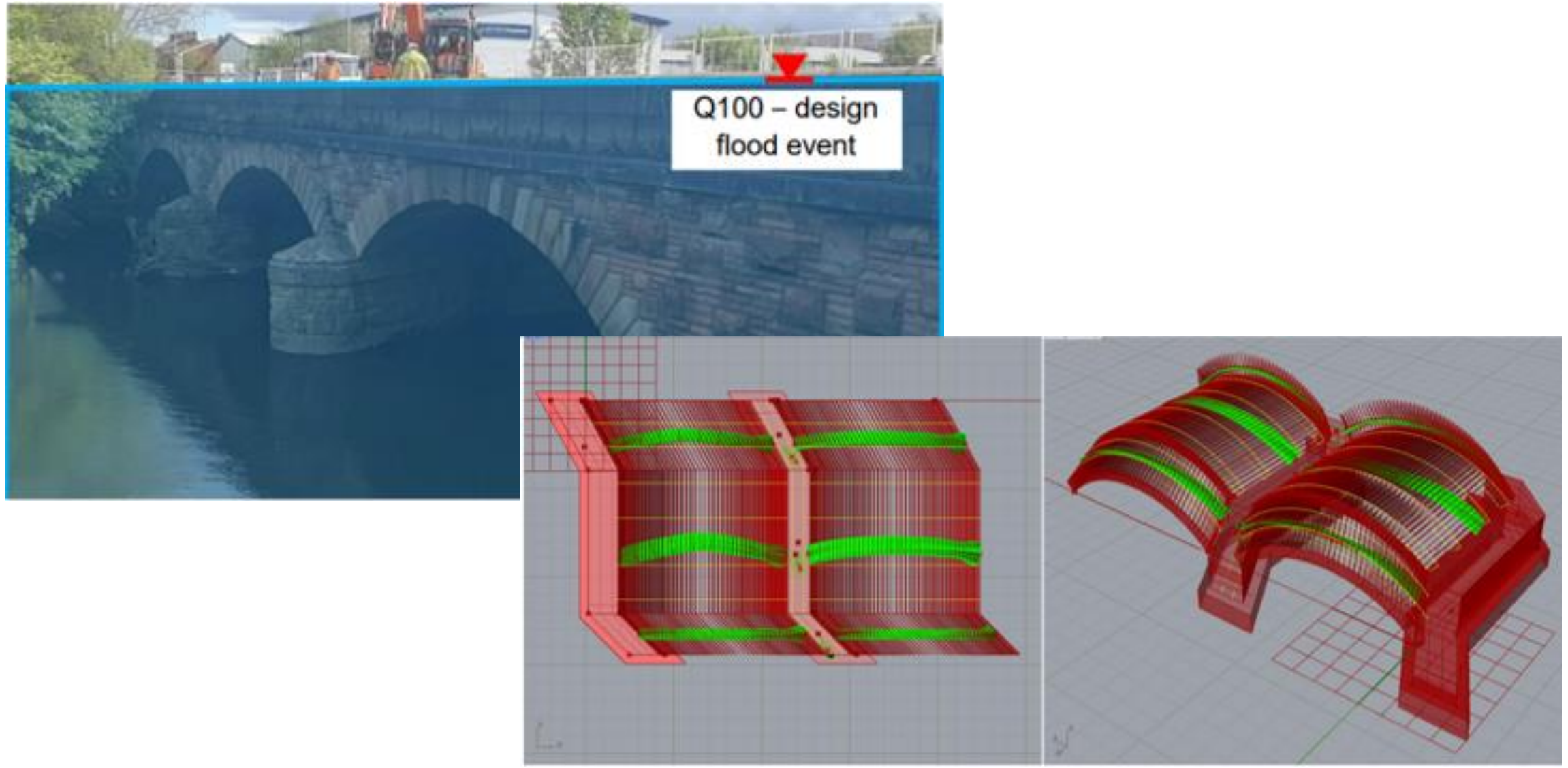








Linton Bridge stabilisation and strengthening, Mott MacDonald



Hardys Gate Bridge, Mott MacDonald

5. A future for stone?

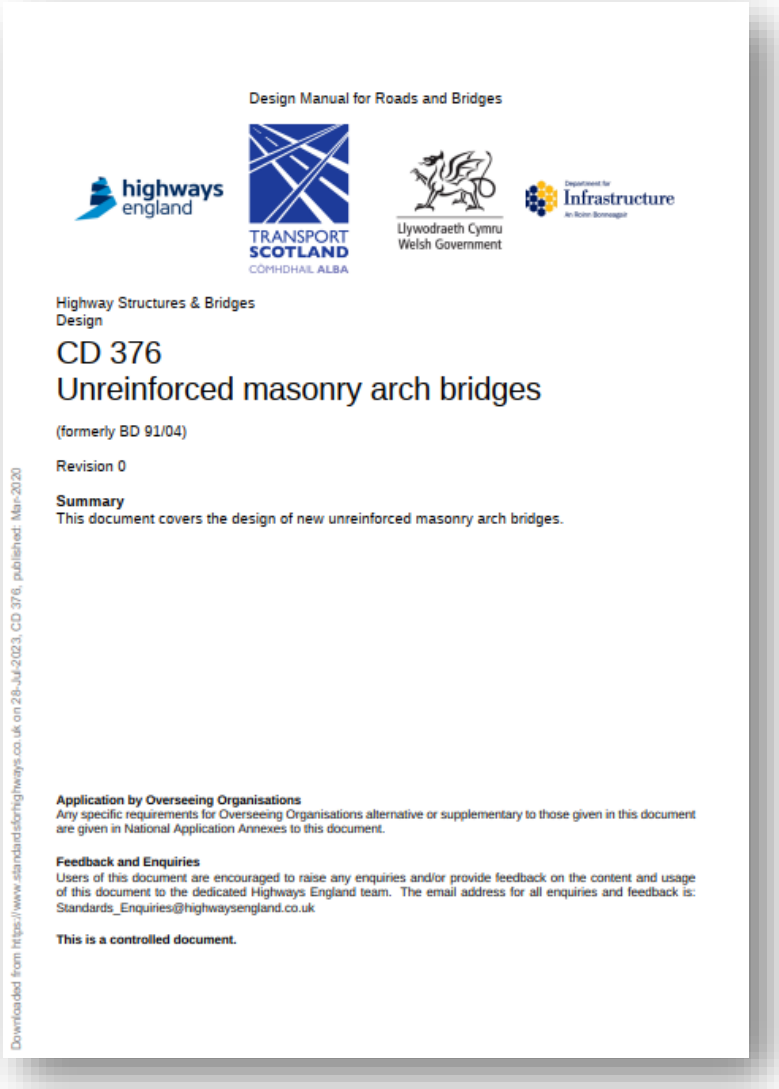
New stone bridges – why?

For

Durability?
Low maintenance?
Whole-life cost?
Whole-life carbon???
Design standards?

Against

Capital cost?
Design competence?
Material availability?
Construction competence?
Construction programme?



Design Manual for Roads and Bridges

highways england | TRANSPORT SCOTLAND / CÒMHDHAIL ALBA | Llywodraeth Cymru Welsh Government | Department for Infrastructure

Highway Structures & Bridges
Design

CD 376
Unreinforced masonry arch bridges

(formerly BD 91/04)

Revision 0

Summary
This document covers the design of new unreinforced masonry arch bridges.

Application by Overseeing Organisations
Any specific requirements for Overseeing Organisations alternative or supplementary to those given in this document are given in National Application Annexes to this document.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Highways England team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

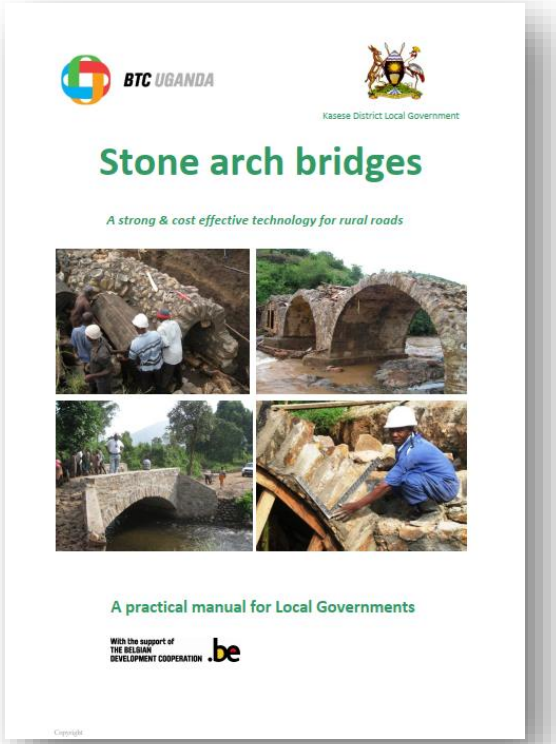
This is a controlled document.

Tan y Manod, 2004

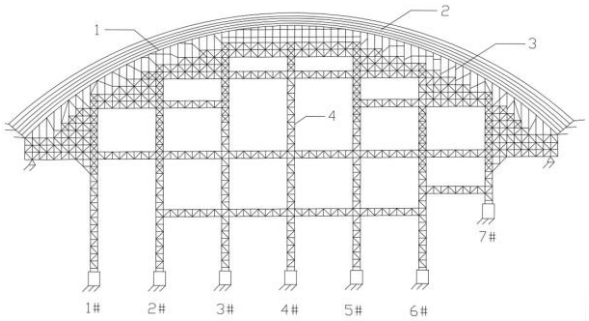
Abergeirw, 2003

Abergeirw, 2003

Masonry bridge widening, north Wales, source: Osian Richards, YGC



New stone bridge construction, Tanzania, 2018 – to date, Enabel and partners



Danhe Bridge, China, 2008, source: highestbridges.com

Digital stone bridges – Adrienn Tomor

Source: "Feasibility of new masonry arch bridges in the 21st century", 12th North American Masonry Conference, Adrienn Tomor

Suransuns Bridge, Switzerland, 1999, source: author's photo

Waterfall Bridge, Switzerland, 2013,
Jürg Conzett, source: arcdog.com

Waterfall Bridge, Switzerland,2013,
Jürg Conzett, source: arcdog.com

Dorfbrücke Vals, Switzerland, 2009,
Jürg Conzett, source: arcdog.com

ReCrete Bridge, EPFL, Switzerland

ReCrete Bridge, EPFL, Switzerland

Steve Webb, RIBA Journal, 29 May 2020

Teufelsbrücke, Heinz Hossdorf, source: *Schweizerische Bauzeitung* (1954)

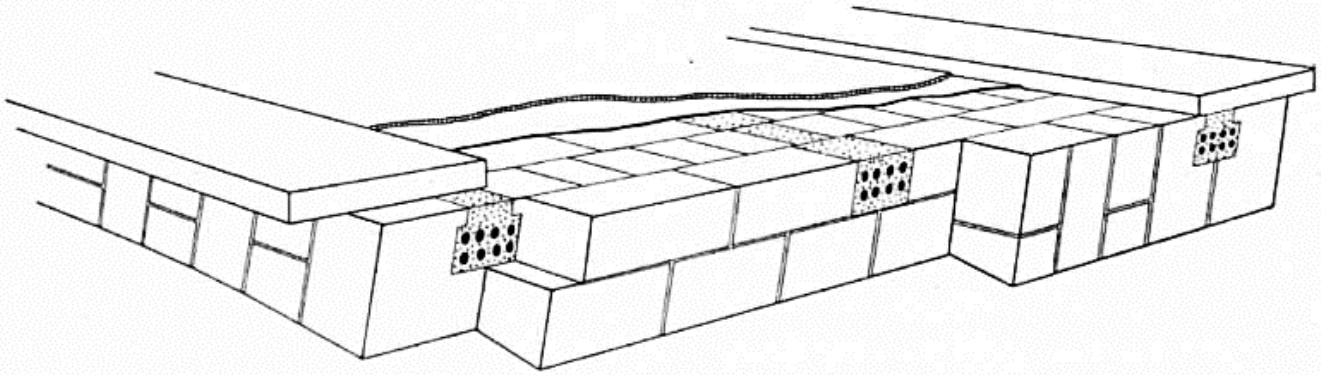


Bild 2. Querschnitt in der Nähe der Mittelpfeiler mit prinzipieller Anordnung des Mauerwerkes und der Spannkabel

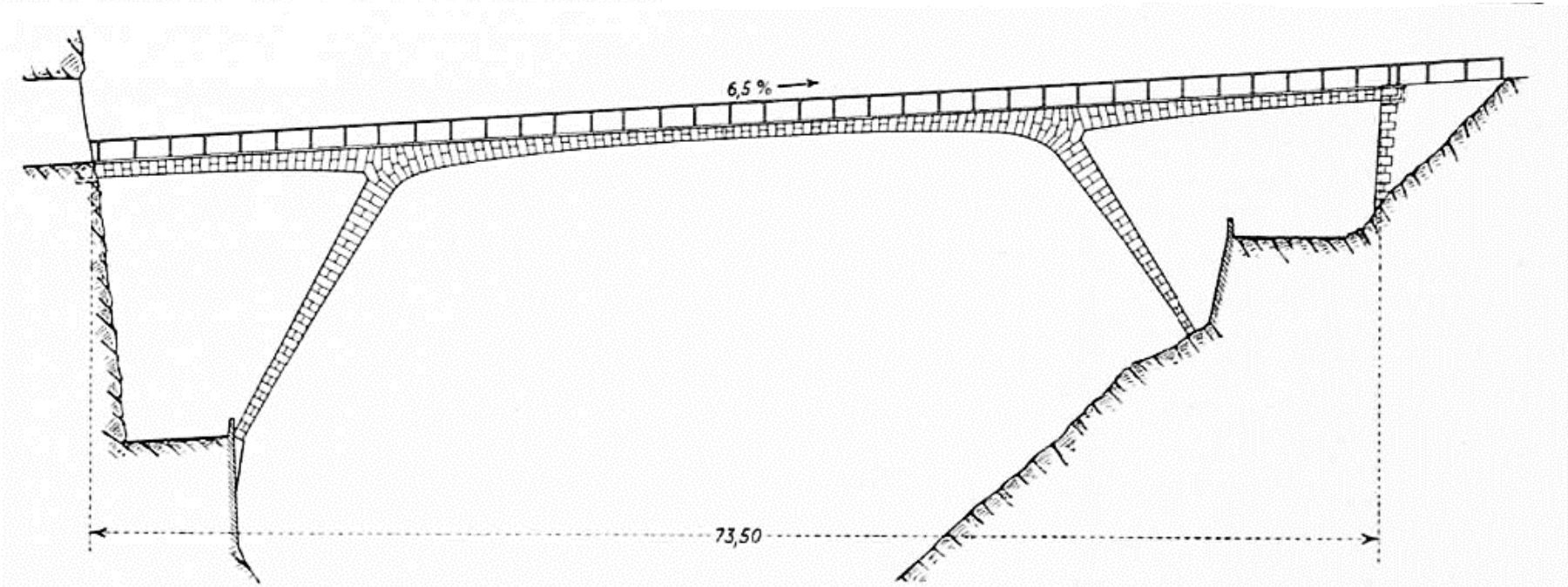
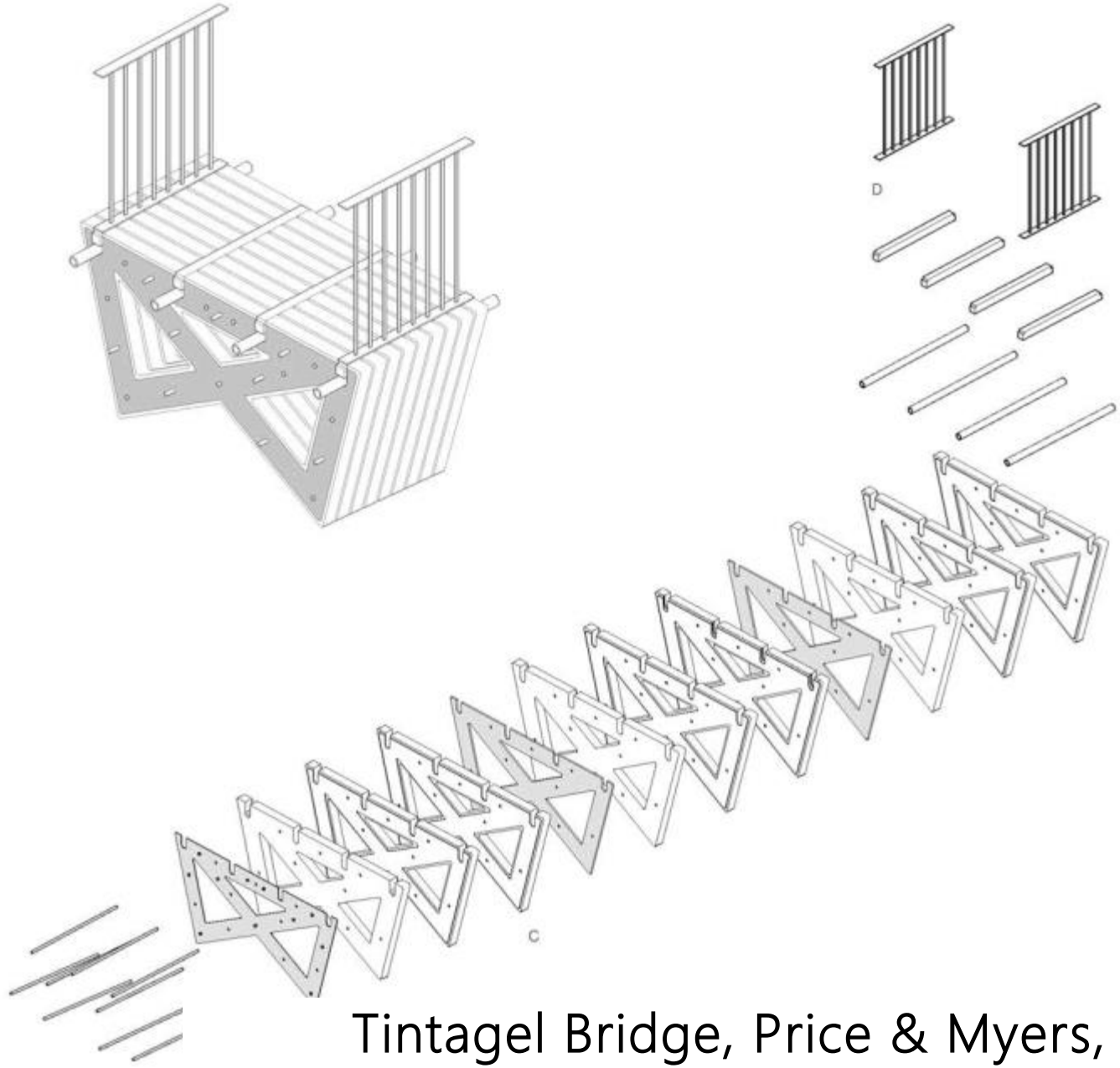


Bild 1. Teufelsbrücke in vorgespanntem Granit. Masstab 1:750

Town Centre Gardens, 14.35m span, Stevenage, Kusser, 2011



Tintagel Bridge, Price & Myers,
source: [Malcolm Reading Associates]

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