UNIVERSITY OF CAMBRIDGE

Minimising Energy in Construction

Dr John Orr MEng (hons) PhD CEng MIStructE FHEA

RECBE Meeting 24th September 2018

MEICON

- “Minimising Energy in Construction”
  - **www.meicon.net**

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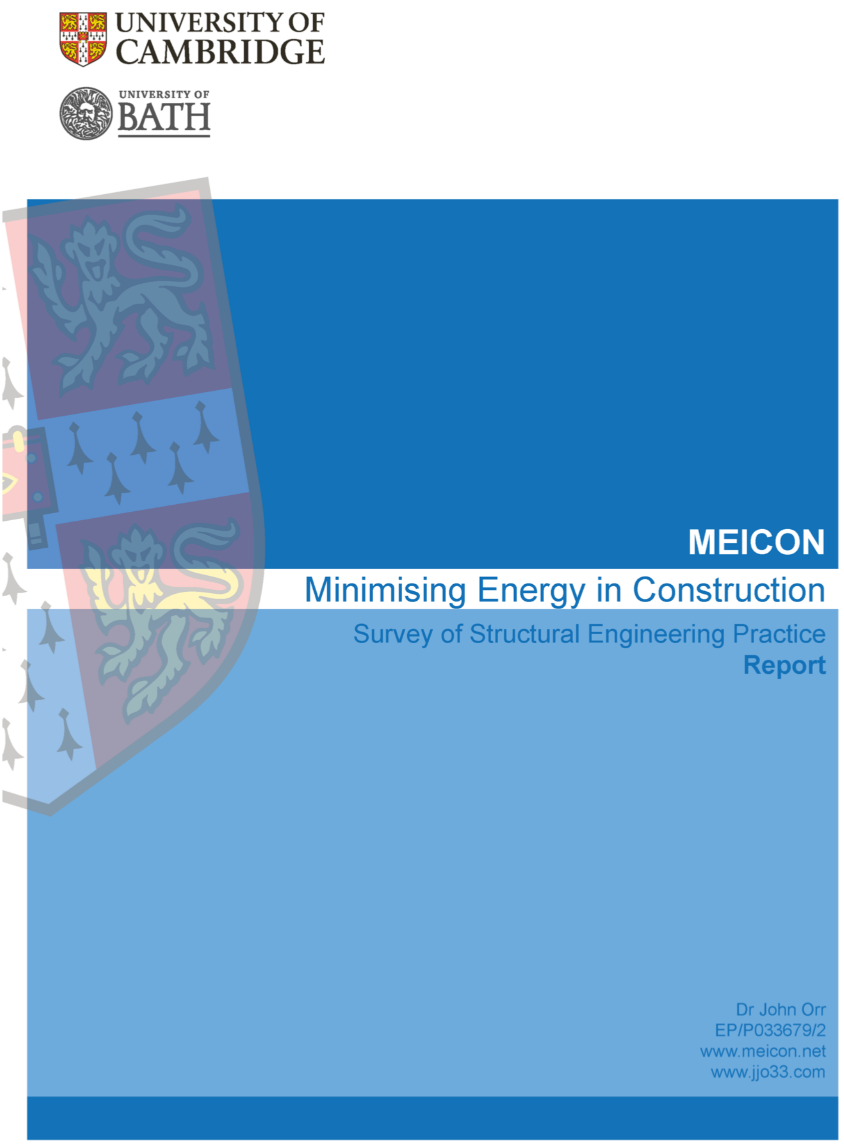
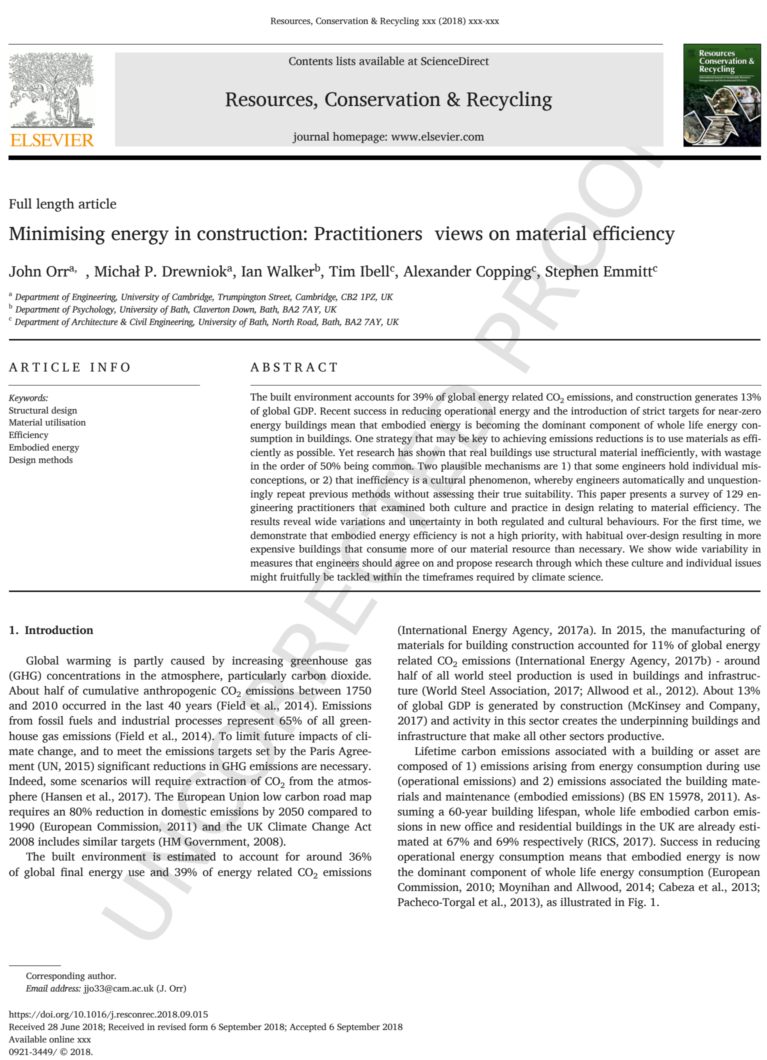
- EPSRC Energy Feasibility Study
  - Our long-term vision is for the built environment to be designed cost-effectively, based on whole life cycle energy consumption using minimum material resource for appropriate performance. Our immediate ambition is to use feasibility studies to identify and address sources of wasted embodied energy, value-less cost, and performance over-design in the construction industry to transform sector wide design practice and define the research areas that will underpin this transformation.

First MEICON Report



- Survey of structural engineering practitioners to examine culture and practice in structural engineering design relating to embodied energy
- First report PDF download from www.meicon.net/survey2018
- Analysis results in **21** Research Questions and **18 Industry Questions** (Michal has circulated)
- Please help us answer them (link above or email jjo33@cam.ac.uk)

First MEICON Paper



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Full length article

Minimising energy in construction: Practitioners views on material efficiency

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ABSTRACT

The built environment accounts for 39% of global energy related CO_2 emissions, and construction generates 13% of global GDP. Recent success in reducing operational energy and the introduction of strict targets for near-zero energy buildings mean that embodied energy is becoming the dominant component of whole life energy consumption in buildings. One strategy that may be key to achieving emissions reductions is to use materials as efficiently as possible. Yet research has shown that real buildings use structural material inefficiently, with wastage in the order of 50% being common. Two plausible mechanisms are 1) that some engineers hold individual misconceptions, or 2) that inefficiency is a cultural phenomenon, whereby engineers automatically and unquestioningly repeat previous methods without assessing their true suitability. This paper presents a survey of 129 engineering practitioners that examined both culture and practice in design relating to material efficiency. The results reveal wide variations and uncertainty in both regulated and cultural behaviours. For the first time, we demonstrate that embodied energy efficiency is not a high priority, with habitual over-design resulting in more expensive buildings that consume more of our material resource than necessary. We show wide variability in measures that engineers should agree on and propose research through which these culture and individual issues might fruitfully be tackled within the timeframes required by climate science.

1. Introduction

Global warming is partly caused by increasing greenhouse gas (GHG) concentrations in the atmosphere, particularly carbon dioxide. About half of cumulative anthropogenic CO_2 emissions between 1750 and 2010 occurred in the last 40 years (Field et al., 2014). Emissions from fossil fuels and industrial processes represent 65% of all greenhouse gas emissions (Field et al., 2014). To limit future impacts of climate change, and to meet the emissions targets set by the Paris Agreement (UN, 2015) significant reductions in GHG emissions are necessary. Indeed, some scenarios will require extraction of CO_2 from the atmosphere (Hansen et al., 2017). The European Union low carbon road map requires an 80% reduction in domestic emissions by 2050 compared to 1990 (European Commission, 2011) and the UK Climate Change Act 2008 includes similar targets (HM Government, 2008).

The built environment is estimated to account for around 36% of global final energy use and 39% of energy related CO_2 emissions (International Energy Agency, 2017a). In 2015, the manufacturing of materials for building construction accounted for 11% of global energy related CO_2 emissions (International Energy Agency, 2017b) - around half of all world steel production is used in buildings and infrastructure (World Steel Association, 2017; Allwood et al., 2012). About 13% of global GDP is generated by construction (McKinsey and Company, 2017) and activity in this sector creates the underpinning buildings and infrastructure that make all other sectors productive.

Lifetime carbon emissions associated with a building or asset are composed of 1) emissions arising from energy consumption during use (operational emissions) and 2) emissions associated the building materials and maintenance (embodied emissions) (BS EN 15978, 2011). Assuming a 60-year building lifespan, whole life embodied carbon emissions in new office and residential buildings in the UK are already estimated at 67% and 69% respectively (RICS, 2017). Success in reducing operational energy consumption means that embodied energy is now the dominant component of whole life energy consumption (European Commission, 2010; Moynihan and Allwood, 2014; Cabeza et al., 2013; Pacheco-Torgal et al., 2013), as illustrated in Fig. 1.

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- Paper with results in Resources, Conservation and Recycling (accepted for publication)

- Will circulate link at a later date

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Evening meeting

- There will be an evening meeting at IStructE HQ to present the results in detail and open the report to discussion
- Date **TBC** but will be before December
- We will circulate this information shortly

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Design occupancy for office building with 16 floors and 30,000m^2 office area

Calculations are approximate to illustrate variation between disciplines.

Ventilation — 3,000 people

BSRIA Rules of Thumb Guidelines for Building Services 5th Edition, Table 3

10m^2 per person = 3,000 people

Space Planning — 3,750 people

BCO Specification for Offices, 2014

High Density	= 8m^2 per person	= 3,750 people
Low Density	= 13m^2 per person	= 2,308 people

Fire Design — 7,500 people

BS 9999:2017 Table 9, Typical Office Floor Space Factors

High Density	= 4m^2 per person	= 7,500 people
Low Density	= 10m^2 per person	= 3,000 people

Structural Design — 85,500 people

BS EN 1990, BS EN 1991-1-1

Ultimate Limit State, γ_q = 1.5 (live load partial factor), α_N = 0.50 (reduction factor at ground floor column)

q_k = 3kN/m^2 over 95% of floor area (Typical value not including partitions or 5% more heavily loaded areas)

Total load ($\gamma_q \alpha_N q_k A$) = 64MN. Assuming each occupant = 0.75kN = **85,500 people**

Without reduction α_N = *171,000 people*

Serviceability Limit State, γ_q = 1.0 (partial factor for live load), α_n = 0.5 (reduction factor for multi-storey)

Total load ($\gamma_q \alpha_N \alpha_A q_k A$) = 43MN. Assuming single occupant 0.75kN = **57,000 people**

Without reduction α_N = *114,000 people*

IQ4: What might the benefit be of design code floor loading values being based on data gathered from a systematic global survey of loading levels in buildings?

Help answer this, and other "**Industry Questions**" given in our latest report:
http://bit.ly/meiconreport

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Thank you

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