Institution: Loughborough University		
Unit of Assessment: C13 Architecture, Built Environment and Planning		
Title of case study: Transforming industry understanding and practice of designing out waste through the development of British Standards on material efficiency		
Period when the underpinning research was undertaken: 2005-2019		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	**Role(s) (e.g. job title):**	**Period(s) employed by submitting HEI:**
Mohamed Osmani	Professor of Sustainable Design and Construction	August 2001- present
Period when the claimed impact occurred: 2014-2020		
Is this case study continued from a case study submitted in 2014? No		

1. Summary of the impact (indicative maximum 100 words)

The construction and demolition sectors are the highest waste producers of all UK industries. Research by Osmani challenged the perception that construction waste is inevitable by accelerating the shift from 'end-of pipe' methods for managing construction waste that has already been produced, towards a preventative approach at source – effectively *designing out waste*. Findings transformed industry understanding and practice of waste prevention which led to the demand for and development of new **British Standard: BS 8895 (Designing for Material Efficiency in Building Projects)** that had substantive reach by guiding international sustainability certification schemes and accelerating industry material efficiency best practice.

2. Underpinning research (indicative maximum 500 words)

The construction and demolition activities in the UK generate over 136 million tonnes of waste per year, being responsible for 61% of all UK waste generation, which equates to five times the combined waste produced by all households. Consequently, construction has been identified as a priority sector by the UK government to optimise material resource efficiency and reduce waste. This matter has a global, EU and UK political profile today unrivalled in recent historical times. For example, the revised EU *Waste Framework Directive 2008/98/EC* prescribed Member States to implement measures to recover a minimum of 70% construction and demolition waste by 2020. At a national level, the *Resources and Waste Strategy for England* aims to eliminate avoidable waste by 2050. This triggered an ever-increasing global research effort that generated construction waste management 'soft' methods and 'hard' experimental technologies to recycle construction waste.

Research and industry practice in the field have been heavily focussed on landfill diversion by improving onsite waste management practices and developing construction waste recycling and treatment methods and technologies. Research at Loughborough University by Professor Osmani spearheaded the shift from 'end-of pipe' endeavours to manage and recycle onsite construction waste streams that have already been produced to waste prevention at source through *designing out waste* solutions. From 2006 to 2019, Osmani led concurrent streams of research that engendered novel methodologies and tools on *designing out waste* across three interconnected research strands to drive design innovation and best practice in material efficiency in construction projects.

1. *Design waste problem-framing research strand* established a causal relationship of design activities and onsite waste generation through the development of a pioneering design waste problem-framing by engaging the UK 100 top architectural practices and

contactors. The findings challenged architects' stereotypical perception that construction waste is inevitable and produced because of contractors' inadequate site operations and misinterpretation of design information **(R1).** Research has established that architects' lack of engagement with *designing out waste* in construction projects was the result of their limited understanding of how construction waste is generated during the design stages and how to design it out (**R1**, **R2**).

2. *Design waste mapping research strand* focuses on source evaluation through the identification of root causes of design waste across the life cycle stages of a construction project. This has culminated in the development of rigorous design waste mapping models to support *designing out waste* decision making (**R3**).

3. *Designing out waste decision support tools research strand*, which addresses the need to enhance *designing out waste* 'know-how' (**R1, R2**), has advanced industry practice and academic knowledge in understanding design waste and embedding waste reduction strategies during the design process. These include: (i) the development of a decision-making framework for enabling *designing out waste* through Building Information Modelling (**R4**); (ii) a building design waste reduction model, which established relationships between design variables and their impact on onsite waste reduction; and was validated in a real-world case study involving 20 buildings (**R5**). More recent research developed a multifaceted account of the interactions between *designing out waste* and the application of circular economy (**R6**). At its core, circular economy aims to *design out waste* through restorative materials, systems, and business models.

3. References to the research (indicative maximum of six references)

R1. Osmani, M, Glass, J, Price, AD (2006) Architect and contractor attitudes towards waste minimisation, *Waste and Resource Management*, 59(2), pp.65-72. DOI: 10.1680/warm.2006.159.2.65.

R2. Osmani, M., Glass, J. & Price, A.D. (2008) Architects perspectives on construction waste minimisation by design, *Waste Management*, 28(7), pp.1147-1158. DOI: 10.1016/j.wasman.2007.05.011.

R3. Osmani, M. (2013) Design waste mapping: a project life cycle approach, *Waste and Resource Management*, 166(3), pp.114-127. DOI: 10.1680/warm.13.00013.

R4. Liu, Z., Osmani, M., Demian, P. & Baldwin, A. (2015) A BIM-aided-construction waste minimisation framework, *Automation in Construction*, 59, pp.1-23. DOI: 10.1016/j.autcon.2015.07.020.

R5. Llatas, C and Osmani, M (2016) Development and validation of a building design waste reduction model, *Waste Management,* 56, pp. 318-336. DOI: 10.1016/j.wasman.2016.05.026.

R6. Adams, K, Osmani, M, Thorpe, T, Thornback, J (2017) Circular economy in construction: current awareness, challenges and enablers, *Waste and Resource Management*, 170(1). DOI: 10.1680/jwarm.16.00011.

The body of research was funded by competitively awarded grants from 2005 to 2019 by EPSRC, Technology Strategy Board (now Innovate UK), the European Commission, and Regional Development Agencies. R1-R3 and R5-R6 are published in leading international journals for waste management following rigorous peer review.

4. Details of the impact (indicative maximum 750 words)

Research by Osmani underpinned measures that transformed industry understanding and practice of *designing out waste*, leading to the development of a **new multi-part British Standard (BS 8895 series)**. We describe (1) pathways to new British Standards on designing for material efficiency; (2) development and publication of BS 8895 series; and (3) demonstrate the multifaceted impact and reach since 2014.

(1) Pathways to new British Standards for designing for material efficiency

In 2009, the British Standards Institution 'Built Environment Design Advisory Committee' had identified "*design waste in building projects as a potential area for standardization. At this time, it was felt that designers would benefit from clear and unified guidance to help them achieve their sustainable construction goals and see those much-desired cost savings and reduced environmental impacts*" (Anthony Burd, Head of the Construction Sector, BSI). Osmani was identified as the expert in this area and directly invited by Clare Price (Market Development Manager, BSI) to convene a collaborative think tank with RIBA (Royal Institute of British Architects) and WRAP (Waste & Resources Action Programme) to explore industry need for new British Standards on designing out waste. This was followed by a series of exploratory workshops with stakeholder groups and an online questionnaire sent to designers as potential users of the Standards. The results indicated that 85% of respondents concurred that there is a need for standards in this area. A multi-part standard across all design stages was the most popular option among responding architects. Subsequently, the think tank was extended to form a steering group, chaired by Osmani, to develop new British Standards: BS 8895 (Code of Practice: Designing for Material Efficiency in Building Projects). In accordance with the questionnaire results, the panel members agreed to publish a four-part standard to be linked to the RIBA Plan of Work Stages (0-7) (Figure 1): Part 1, published on 31 July 2013, is associated with project briefing (Stages 0 & 1); **Part 2, published in 2015**, is linked to concept and developed design (Stages 2 & 3); **Part 3, published in 2019**, relates to technical design (Stage 4); and Part 4, which is currently in progress, is associated with construction, handover and close out, and in use phases (Stages 5, 6 & 7).

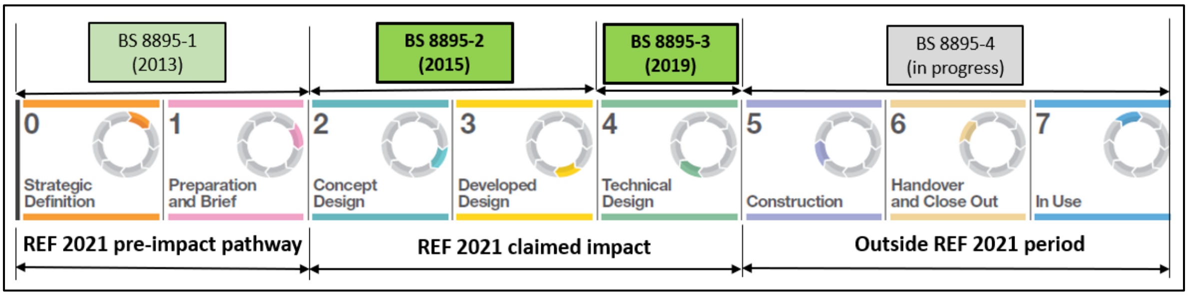

Figure 1: Development of BS 8895 series in line with RIBA Plan of Work Stages

BS 8895-1:2013, which is a pre-impact pathway, aimed to integrate the process of designing for material efficiency during the pre-design and briefing stages of building or refurbishment projects to determine the material efficiency strategic direction and objectives in the project brief, which will be converted into designing out waste recommendations and actions in **BS 8895-2:2015** and **BS 8895-3:2019**.

(2) Development of BS 8895 series: BS 8895-2:2015 and BS 8895-3:2019

Building on BS 8895-1:2013, Osmani led the development of BS 8895-2:2015 (**S1**) and BS 8895-3:2019 (**S2**). Dr Anna Fricker, BSI Standards Development Manager, confirmed that "*Professor Mohamed Osmani has served as the Convenor of the B/209/-/4 panel: Designing for material efficiency in building projects"* (**S3**). She stated that the panel, under Osmani's Chairing, was "*responsible for the publication of **BS 8895-2:2015** Code of practice for concept and developed design and **BS 8895-3:2019** Code of practice for technical design*" (**S3**). Osmani managed collaborative input from the panel members comprising client organisations, architects, engineers, contractors; and coordinated contributions from Arup, BRE, RIBA and WRAP that led to the publication of BS 8895 Part 2 in 2015 and Part 3 in 2019.

BS 8895 series set out the process to create a standardized and qualified approach for the integration of designing for material efficiency across the life cycle stages of buildings allowing clients, design teams, consultants, and contractors to integrate the principles of designing out waste in construction projects. Material efficiency encompasses the efficient use of materials, waste prevention and reduction, minimizing damage to the environment and minimizing depletion of natural resources.

BS 8895-2:2015 (**S1**) aimed to progress material efficiency objectives of the initial project brief into a design strategy that encompasses a systematic identification of material efficiency opportunities and *designing out waste* actions during concept and developed design stages. Osmani's research on *designing out waste* (**R2**) and design waste mapping (**R3**) are included as references in BS 8895-2 Bibliography (**S1**).

BS 8895-3:2019 (**S2**) gave recommendations for the implementation of actions and outcomes from the developed design investigations in BS 8895-2 on optimising material efficiency in production information, such as information models, detailed drawings and material specification and coordination of technical design work undertaken by architects, structural and building services engineers, consultants, and specialist sub-contractors. Osmani's research on design waste mapping (**R3**) is included as a reference in BS 8895-3 Bibliography (**S2**).

(3) Demonstrating the impact reach and significance

The impact reach and significance are demonstrated through: (i) reference to BS 8895 as the principal resource to optimise material efficiency and *designing out waste* practice in two international sustainability certification schemes (BREEAM and New Zealand Homestar) and a UK quality and sustainability assessment scheme (Home Quality Mark); and (ii) increased industry adoption of material resource efficiency in building projects.

<u>(i) Guiding sustainability certification schemes</u>
Reference to BS 8895 as the lead resource to guide designers and contractors to enhance material efficiency and *designing out waste* strategies and optimise associated credits in BREEAM (Building Research Establishment Environmental Assessment Method) (**S4, S5**). Dr Shamir Ghumra, BREEAM Director, noted that BREEAM *"bases the materials efficiency assessment methodology on the BS 8895 principles, published and led by Prof Osmani as Convener of the British Standards panel*"; and the "*original research led by Osmani, its translation into the British Standard and the subsequent reference as the key material efficiency resource in BREEAM demonstrates the importance of this work as a key methodology to reduce the 136 million tonnes per year of construction waste in the UK*" (**S5**).

BREEAM is a global leader in the drive for a sustainable built environment and has contributed to the strong focus on sustainability in building design, construction and use that now exists in the UK. Underpinned by sound science and an independent assessment and certification process, the scheme provides clients with a means of assessing the environmental performance and potential of their buildings, management policies, processes, and supply chains using a standard that is consistent, flexible, and adaptable to local market drivers and opportunities **(S5)**.

BREEAM is a successful UK export, active in 89 countries worldwide and the scheme of choice for 80% of the buildings assessed in Europe **(S5)**. BREEAM has been used to rate the environmental performance of many thousands of buildings, with 14,000 trained building professionals and the issue of over 594,000 certificates for BREEAM assessments (**S5**). With over 2.3 million international projects registered for assessment and achieving certification, the international reach of the scheme is set to continue (**S5**).

In addition to BREEAM, reference to BS 8895 as a prime resource to optimise material efficiency and designing out waste best practice in construction projects is noted in:

- The '*Methodology*' and '*Waste Minimisation Actions'* in Home Quality Mark (HQM), which is a UK quality and sustainability scheme for new homes, which uses a 5-star rating to provide impartial information from independent experts on housing design, construction, quality and sustainability **(S6)**.

- '*Construction Waste Management'* and '*Construction Waste Reduction'* in New Zealand Green Building Council 'Homestar' rating system, which is an independent rating tool that certifies efficiency and sustainability of New Zealand homes (**S7**).

(ii) Accelerating industry implementation of material resource efficiency

The last few years saw a significant surge in the adoption of BS 8895 guidance to improve material resource efficiency in the construction industry. Swan Housing Association, which provides high-quality affordable homes in England, prescribed in their Environmental Sustainability Strategy (2016-2021) that "*Swan will adhere to the BS 8895 standard (Designing for Material Efficiency in Building Projects part 1 &* ***2****). This ensures we consider the efficient use of materials from inception*" (**S8**). Similarly, a waste assessment report for the development of Southend Airport Business Park identified the following benefits from implementing BS 8895-2: "*helps achieve higher levels of resource efficiency*"; provides "*a flexible approach in applying material efficiency*"; "*looks at the efficient use of materials*"; fulfil "*corporate social responsibility criteria"; and addresses interrelated issues and processes" ... to improve material efficiency in building projects"* (**S9**). Construction stakeholders reported the following BS 8895 benefits (**S10**):

- Understanding and implementing material efficiency: "*I am actually in the process of trying to establish what materials efficiency means for our projects and how we're going to implement it and also to give guidance to our future suppliers about how they can implement it. So a series of standards on this topic is really important for us*" (Andrea Charlson, Sustainable Materials Manager, HS2).
- Clarity of material efficiency tools and checklists: "*BS 8895 is useful because it gives designers clear tools and checklists in order to make sure that they are designing for material efficiency*" (Matthew Teague, Senior Architect, Tata Steel).
- Cost savings: "*One of the key benefits with material resource efficiency is the business benefits and what we mean by that is the cost savings. The cost savings for producing less waste, using less materials, cost savings through the construction program in terms of looking at different techniques, which may address materials efficiency but also savings in terms of the program such as prefabrication and also looking at in terms of the whole life cycle of the building and there may be cost savings in terms of how buildings are maintained and refurbished* "(Katherine Adams, Principal Consultant, BRE).

5. Sources to corroborate the impact (indicative maximum of 10 references)

S1 BS 8895-2:2015 Designing for material efficiency in building projects: Code of practice for Concept Design and Developed Design.
S2 BS 8895-3:2019 Designing for material efficiency in building projects: Code of practice for Technical Design.
S3 Testimonial letter from Dr Anna Fricker, BSI Standards Development Manager, confirming Osmani's role as the Chair of BS 8895 series Panel.
S4 BREEAM (Building Research Establishment Environmental Assessment Method) New UK Construction, Technical Manual, 2018.
S5 Testimonial letter from Dr Shamir Ghumra, BREEAM Director, confirming BS 8895 as the lead resource to optimise material efficiency in all post-2014 BREEAM schemes.
S6 Home Quality Mark (HQM), Technical Manual, 2018.
S7 New Zealand Green Building Council 'Homestar' rating system, 2017.
S8 Swan Housing Association Environmental Sustainability Strategy (2016-2021).
S9 Southend Airport Business Park Waste Assessment Report, 2015.
S10 BS 8895 Brochure, BS 8895-2:2015 launch video and quotes.