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Material and decision flows in non-domestic building fit-outs

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ABSTRACT

The built environment is the most resource intensive sector of the economy, accounting for a significant share of the extracted materials and the total waste generated. Within the built environment the most recurrent replacements of building materials and components take place during fit-outs, which are the process of installing interior fittings, fixtures and finishes. These materials and components are frequently replaced in non-domestic buildings.

Non-domestic building fit-outs are therefore responsible for a significant consumption of materials and a large source of waste. However, they tend to be excluded and unmeasured in the research on the built environment. The present work aims to study this research gap and analyse the potential for fit-outs to become more sustainable. The approach of this project ties in closely to the concept of circular economy, where materials are kept at their most useful state for as long as possible.

This paper analyses fit-out practices within London, identifying the supply-chain stakeholders, the key materials used and the waste streams generated, while tracing the decision and material flows across the supply chain. A material flow analysis (MFA) is conducted for a fit-out case study, showing the paths and destinations of the waste generated. The mixed methodology includes on-site observations, cross-examination of the corresponding waste reports, MFA, and qualitative analysis of interviews with the involved stakeholders.

The aim of this research is to provide a grounded perspective that allows the identification of process and design flaws as well as potential improvements that support the transition towards more "circular" fit-outs. It is concluded that there are potential areas of improvement as fit-out practices show a predominantly linear tendency both for decision making and material flows, in which there is a discontinuity of communication and material-flow information across the supply chain.

1. Introduction

The built environment is the most resource intensive sector of the economy, accounting annually in the European Union for 50% of all extracted materials, 35% of carbon emissions (European Commission, 2011), and 32% of total waste generated, approximately 830 million tonnes (EEA, 2012). Within the built environment the most recurrent replacements of building materials and components take place during fit-outs, which are defined as the process of installing floor, wall and window coverings, partitions, doors, furniture, equipment, and sometimes mechanical and electrical services (Cole and Kernan, 1996; Forsythe, 2010). In non-domestic buildings these components can be replaced every 3–10 years (Trucker and Treloar, 1994; Roussac et al., 2008; Forsythe and Wilkinson, 2014). In addition, an outgoing tenant may remove the fit-out (de-fit) and the new tenant will reinstall all these fittings, fixtures, and finishes (re-fit). Accordingly, fit-outs account for a significant amount of wasted resources, and associated embodied carbon emissions throughout the lifecycle of a building.

Building fit-outs tend to go unnoticed and unmeasured in the debate about sustainable buildings (Forsythe and Wilkinson, 2014) but this is beginning to change. Building fit-out certification methods, such as SKA Rating (RICS, 2018), BREEAM (BRE, 2018a) or LEED (USGBC, 2018) exist, but have a low uptake (ECORYS, 2014) and do not fully cover the circular economy concept. Growing environmental concerns and the gradual increase of UK's landfill tax (Seely, 2009) certainly encourages stakeholders to pursue waste recycling instead of landfilling. However, most fit-out waste gets downcycled, since the original materials or components are generally not designed with recycling or reusing in mind (McDonough and Braungart, 2002).

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In order to identify key areas of improvement in the fit-out process and in the use and management of resources, it is pertinent to understand the key materials used and waste generated, as well as the destinations of waste streams.

This paper analyses non-domestic fit-out practices within University College London (UCL) and London, identifying the supply-chain stakeholders, the main materials used and waste streams generated, while tracing the decision and material flows across the supply chain. The objective of this work is to set a framework of characteristics of non-domestic building fit-outs and providing a more detailed explanation of a higher education institution (HEI) building fit-out, from a material flow perspective. The aim being to identify potential improvements in the fit-out process and the design of building components, reflecting on the possible benefits for main stakeholders involved and for society as a whole.

The following sections include the "Background" and the "Methodology", following on to present a "Common fit-out framework", in which secondary data obtained through interviews is used to present common characteristics of non-domestic fit-outs in the area. Next, a "HEI building fit-out case study" is closely analysed to show more specific attributes of a fit-out procedure, including a material flow analysis (MFA). Finally, findings are discussed and the paper concludes in the "Discussion and conclusions" section.

1.1. Background

Building fit-outs are a type of refurbishment, and the latter is defined as any building work that modifies the interior or exterior structure or aesthetic appearance of a building (RICS, 1997), normally with the aim to increase its social or economical value (RICS, 1973). In this context, the terms refurbishment and renovation are interchangeable (Lee, 1987) and these include modifications to the building such as retrofits (adding something to improve the building's performance (DBW, 2018)) and fit-outs (which relate to interior modifications).

Buildings can be seen and analysed in different layers, depending on function and replacement rate. Brand (1994) proposes six different layers: Site (geographical setting), Structure (load-bearing elements), Skin (building envelope), Services (cabling, plumbing, HVAC), Space plan (walls, partitions, ceiling, floor), and Stuff (furniture and equipment). These layers have increasing rates of replacement, from the Site being permanent to the Space plan and Stuff being replaced every three years or so. Fit-outs relate to the most frequently replaced layers: Services (sometimes), Space plan and Stuff. Brand (1994) demonstrates that in a 50-year cycle, the changes within a building cost three times more than the original building. Multiple authors state that the embodied energy of fit-outs eventually outweighs that used to construct the building (Cole and Kernan, 1996; Zabalza et al., 2009).

Non-domestic buildings, represent 26% of the total EU building stock per floor area, where 6% of the total are offices and 4% education buildings (Economidou, 2011). Non-domestic buildings may have 30 to 40 fit-outs during their lifecycle, accounting for an estimated 11% of UK construction spending (RICS, 2018).

The Construction Resources and Waste Platform (2009) carried out a study based on fit-out waste data contained in the SmartWaste (BRE, 2018b) tool. The average rate of waste generation is reported to be 6.4t per 100 m^2 of gross internal floor area (GFA) for offices (based on four UK office fit-out projects), 10.3t per 100 m^2 of GFA for retail (based on six projects), and 33.7t per 100 m^2 of GFA for education institution buildings (based on two projects). The reasons for the variability among types of space are not discussed.

The Better Building Partnership et al. (2015) used a fit-out case study in Sydney, Australia to record the types and amounts of waste generated. A rate of waste generation of close to 10t per 100 m^2 of GFA was found, and 63% of this waste was diverted from landfill. The materials that were not able to be recycled were ceiling and carpet tiles, timbers, office furniture, and paint.

The Institute for Sustainable Futures (2014) performed a series of interviews in Sydney to identify the main waste contributors during fit-outs. The same few materials were consistently nominated: plasterboard, ceiling tiles, carpet, packaging, office furniture (particularly workstations) and the resultant MDF (medium-density fibreboard) and particleboard. It is stated that although some issues can be solved systematically, each material stream needs to be tackled specifically.

Hardie et al. (2011) interviewed twenty-three experts in commercial refurbishments in Sydney to find out the average rate of reuse and recycling. They report that building materials and components such as aluminium, structural steel, steel reinforcing bars, bricks, and concrete, are subject to a high level of recycling, however, little recovery is made from the removal of most internal fittings and finishes during the fit-out process.

The findings of the present work were partly presented in a conference paper at PLATE 2017, in which a similar fit-out case study to the one included in this paper was used to carry out a material flow analysis (MFA), aiming to tie the fit-out process with the concept of circular economy (Casas-Arredondo et al., 2017).

Non-domestic building fit-outs generally represent the most recurrent refurbishment in the built environment and thus present an important opportunity to apply the principles of circular economy. The circular economy is a model proposed to replace the current 'take-make-dispose' scheme and to decouple environmental pressures from economic growth. The four sources of value creation in a circular economy to achieve this decoupling are (EMF, 2013): 1) minimising material use over a product's lifespan; 2) maximising the number of consecutive use cycles; 3) diversifying reuse across the value chain and across industries; and 4) using higher quality input materials. The term "circularity" is used in this work to reflect to what extent building materials or components keep their functional value either by being retained (*in-situ*), reused (onsite or offsite) or closed loop recycled.

There are current organisations or companies that support the transition towards more circular building fit-outs, acting as a sort of reuse intermediaries. Redistribution networks, such as Globechain (2018), Mobius-Reemploi (Mobius-reemploi, 2018), Rotor Deconstruction (RotorDC, 2018), or Warpit (2018) allow potential "re-users" to find reclaimed building components in order to reuse them in building projects.

2. Methodology

A mixed methodology approach is taken composed of specific methods to answer specific research questions. The research output contains a common framework of the non-domestic building fit-out process and an explanation of a HEI building fit-out case study, from a material flow perspective. Fig. 1 shows a graphical representation of the methodological procedure. The research tasks were divided into three categories, as follows:

1) Mapping out the stakeholders within the fit-out supply chain who determine the specification of building components and the management of waste: exploratory interviews were conducted using chain-referral (snowball) sampling. Twelve people related to the fit-out industry were contacted and interviewed. The interview data was cross-checked to lead to an objective interpretation.
2) Describing the function of actors at each stage in the fit-out process and defining the relationships among them