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Inventorying Toronto's single detached housing stocks to examine the availability of clay brick for urban mining

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ABSTRACT

This study examines the stocks of clay brick in Toronto's single detached housing, to provide parameters for city scale material reuse and recycling. Based on consensus from the literature and statistics on Toronto's single detached housing stocks, city scale reusable and recyclable stocks were estimated to provide an understanding of what volume could be saved from landfill and reintroduced into the urban fabric. On average 2523–4542 m^3 of brick was determined to be available annually for reuse, which would account for 20–36% of the volume of virgin brick consumed in new house construction in 2012. A higher volume, 6187 m^3 of brick, was determined to be available annually for recycling because more of the prevalence of cement-based mortar, which creates challenges for brick reuse in Toronto. The results demonstrated that older housing containing reusable brick were being mostly landfilled and replaced with housing that contained only recyclable brick.

1. Introduction

Redevelopment of the residential buildings in the City of Toronto, Ontario, Canada is subsidized by an unsustainable linear metabolism of materials derived from hinterland and global resources. On one hand, raw resources are extracted, manufactured, and transported to Toronto for new construction and on the other hand, the majority of materials from obsolete buildings are transported 200 km outside the city and landfilled (City of Toronto, 2013c).

Of the building types present in Toronto, single-detached houses (SDH) are highly prone to redevelopment, which contributes significantly to the amount of demolition waste headed to landfill each year. SDH redevelopment largely stems from the city's increasing land value, largely due its geographical limitations to sprawl. For example, Toronto Open Data reported that from 2008 to 2012 an average of 727 SDH were demolished annually for redevelopment, representing 86% of total demolition permits cleared by the City of Toronto and a significant proportion of the total floor area covered by all cleared demolition permits within that time.

Successful research on urban metabolism of construction materials has largely relied on periodical data available from government sources (Warren-Rhodes and Koenig, 2001; Hendricks et al., 2000). However no such governmental data exists for the City of Toronto. As such, while the city has been the subject of four urban scale Material Flow Analyses that uniquely quantified energy, water, or food flows and/or stock, no literature has attempted to outline the metabolism of Toronto's building materials that takes into account the city's historical SDH mosaic (ICLEI, 1996; Bristow and Kennedy, 2013; Codoban and Kennedy, 2008; Sahely et al., 2003).

Unlike resources such as energy, water, or food, building materials tend to remain static for long periods of time. Because of this, the urban fabric can be seen as an organized stockpile of raw and manufactured resources that have accumulated overtime (Kennedy et al., 2007). Descriptions and quantification of this stockpile provides insight into the past and ongoing relationship between urban centre and surrounding environment, which can be useful for developing approaches to create more sustainable, closed loop metabolic systems of materials.

Developing policy and infrastructure approaches to reshape Toronto's metabolism of building materials is critical as the city already feels the impacts of shrinking hinterland resource availability. For example, Toronto has been notoriously riddled with difficulties in securing long-term space for landfill (City of Toronto, 2013c; Yeheyis et al., 2013). Even the current landfill site is estimated to reach capacity by 2029 (City of Toronto, 2013c). Waste generation models based on national statistics indicate that roughly 38–64 thousand tonnes of material was landfilled in 2012,

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adding significant stress to a dwindling supply of void landfill space (City of Toronto, 2013a; NRCan, 2006).

1.1. Waste-to-resource

At disposal sites, about 80% by mass of building materials are landfilled while 20% are diverted to recycling. Alternatively, it is estimated that about 75% of the content of landfill in Canada has some residual value, which could be utilized through reuse and recycling (Yeheyis et al., 2013). Reuse is a waste management strategy that uses reclaimed materials or objects in their original or mostly original form, sometimes involving cleaning, repair, or minimal manufacturing. Thus, when a material is reused most of the initial energy inputted into producing the material carries through into its subsequent lives (Olson, 2011).

Conversely, recycling is a waste management strategy that generally involves cleaning and breaking down or melting reclaimed materials to extract desirable elements and using those elements as ingredients for secondary products. The elements are processed/manufactured, which typically involves integration with other (often virgin) elements to produce secondary, but also new, products (PWGSC, 2000).

Because reuse typically involves significantly less energy to prepare a material for secondary use than recycling, it is generally considered as environmentally preferable. The distinction of alternative waste management strategies based on their negative impact on the natural environmental can best be demonstrated through the waste hierarchy shown in Fig. 1.

1.2. Clay bricks

Clay brick, or brick, is historically, and continues to be, an iconic building material used in SDH construction in Toronto. The use of brick first became widespread in Toronto after the city's second great fire in 1904, when regulatory requirements reduced the use of wood (City of Toronto, 2013b). Brick was the obvious alternative. It met the structural, mechanical, and aesthetic needs of Toronto residences and could be manufactured locally. During the 20th century 36 brickyards were active in and around the Toronto area which was one of the most actively mined shale deposit regions in Canada (City of Toronto, 2013b; Guillet, 1967; Rutka and Vos, 1993).

In Toronto's early SDH development, brick was used as a structural material, where it was arranged in double or triple widths as primary component of the building envelope (CMHC, 2006). However during the 1930s clay brick was slowly replaced with concrete block in the inner width, which was and still remains considerably more affordable (CMHC, 2006). This trend persisted until platform wood frame construction became prominent in the 1970s. Even so, and still to this day, clay brick is widely used as a cladding material, chosen for its aesthetic quality, durability, and performance characteristics. Rutka and Vos (1993) reported that in the 1990s, 90% of brick produced in Ontario was sold to the regional residential construction industry.

However, Toronto brick manufacturers no longer contribute to the supply of cladding brick. While high quality shale deposits in the Toronto area exist, demographic and economical pressures favouring urbanization have made them inaccessible (Rutka and Vos, 1993). The city's last brick manufacturer, Don Valley Brick Works, closed in 1984. From then on, the material was imported from increasingly further distances within the surrounding Southern Ontario region (Rutka and Vos, 1993).

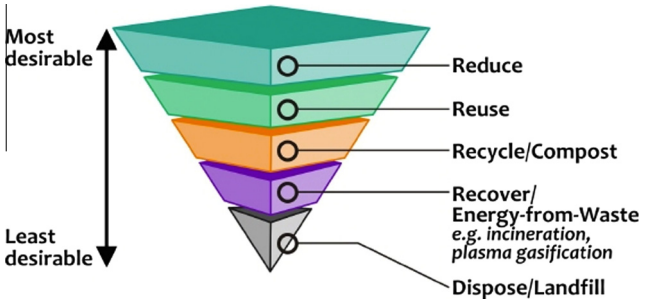

Fig. 1. Hierarchy of environmentally desirable waste management strategies (City of Ottawa, 2012).

1.3. Research problem

Closed-loop metabolism of common building materials, like brick, addresses the City of Toronto's concerns over sustainable supplies of landfill space and brick. This paper seeks to understand the availability of brick in Toronto's SDH stock that can be reclaimed for reuse and recycling. To understand availability, this paper estimates the volume of brick that can be mined for reuse and recycling in Toronto's stock of typical single-detached housing. Where both short-term, annually available brick is estimated as well as long-term availability is examined as indicated by the composition of Toronto's SDH in 2012.

2. Methodology

To determine the amount of brick that is embedded in all of Toronto's in-use SDH and the annually available brick from obsolete SDH that are demolished, five archetypes were developed to represent typical Toronto SDH construction styles common to different eras and are outlined in Table 1. Developing archetypes is a valuable tool for analyzing heterogeneous data sets that are difficult to measure, such as Toronto's SDH stock (Cutler and Breiman, 1994). For example, Blaszak (2010) applied a similar approach to evaluate life cycle optimal material choices for reducing energy consumption in Toronto's SDH.

Archetypes were developed based on an extensive review of the literature including City of Toronto archived architectural plans, home and architecture magazines, and government and industry publications.

Construction drawings of the five archetypes were obtained from various sources including homeowners and government organizations. Archetype drawings were evaluated and chosen based on their likeness to the design, construction materials, layout, and dimensions indicated in the literature.

Table 1
Five SDH archetypes and their key features.

Archetype	Construction time period	Usable floor area	Key features
Century	Pre-1930	116 m^2	Double and triple width brick SDH, over 100 years old.
Wartime	1931–1960	102 m^2	Small one and half story double width brick SDH built en-mass after the Second World War.
Baby Boomer	1961–1975	128 m^2	Larger SDH built for baby boomers entering the market, wanting more space to raise families.
Ontario Building Code (OBC)	1976–2000	173 m^2	SDH built with the first provincial building code, enacted in 1975.
Modern	Post-2001	262 m^2	Larger SDH built to current OBC standards.

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