Can architectural salvage contribute to net zero resource and waste management?

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Abstract

Factors that influence the success of architectural salvage and reclamation yards are unknown. This study aimed to: i) identify the architectural salvage supply chain and investigate barriers/incentives to processing salvaged materials efficiently, ii) categorise/quantify salvaged materials and critically evaluate their potential, financially and environmentally iii) evaluate perceived historical and aesthetic value of salvaged vs new objects, and iv) compare the environmental performance of common salvage vs new items. Data was collected from an online catalogue to review the scale/composition of the industry in the south-east of England. Surveys of reclamation/salvage yards and the public were undertaken. The architectural salvage market consists of small businesses sourcing salvage from few sources. Businesses have little influence on each other regarding market prices and decide these based on the qualities of individual items. There is limited customer awareness of environmental benefits. Storing architectural salvage items is a key barrier for businesses. Salvage businesses reduce disposal through sales. Raising awareness of salvage yards, their range of products and environmental benefits, are key if reclamation is to contribute to expansion of material reuse. Architectural salvage could make a small but important contribution to net zero resource and waste management, especially in the construction sector.

Keywords

Architectural salvage; Built environment; Climate change; Circular economy; Sustainability; United Nations Sustainable Development Goals.

1. Introduction

The world's reliance on natural resources continues to accelerate. The global material footprint is rising quicker than population growth and economic output, with a 17.4% increase 2010–2017 (United Nations, 2020). The built environment protects life and health, its inhabitants' psychological and social welfare, and supports aesthetic and cultural values (Holm, 2003; Postalcı and Atay, 2019). However, the building of infrastructure consumes vast quantities of resources and energy, and its construction and demolition produces large amounts of waste. It is estimated that the building sector accounts for "38% of all energy-related CO_2 emissions when adding construction industry emissions and that direct building CO_2 emissions need to halve by 2030 to get on track for net zero carbon building stock by 2050" (UNEP, 2020). It is essential that the modern construction sector reduces its reliance on virgin raw materials, and hence resource efficiency must be practised. (European Environment Agency, 2016).

To illustrate, approximately one billion tonnes of waste arise annually from construction and demolition activities in the European Union (EU) alone (European Commission, 2011). Indeed, the World Green Building Council (2019) stated that buildings and infrastructure around the world can reach 40% less embodied carbon emissions by 2030 but that this can only be achieved through urgent transformation. It is crucial that the construction sector designs and builds sustainable infrastructure supported by suitable management tools and regulatory frameworks that address sustainable development issues (Grierson, 2009).

The conservation of existing and historic buildings and building materials is one possible strategy to reduce the mining of raw materials, freshwater use, greenhouse gas emissions and waste arisings when compared to their replacement by new buildings. Sustainable construction contributes to social well-being; achieving a sustainable built environment will impact society's ability to realise the United Nations' Sustainable Development Goals (SDGs). For example, the construction industry can play a fundamental role in achieving SDG 11, which emphasises the pivotal role of urbanisation in sustainable development, describing the necessity for inclusive, resilient, safe, and sustainable cities and communities through pertinent public policy (UN,

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2010). The construction sector is crucial to the global effort to achieve the SDGs via development of sustainable infrastructural projects.

An obvious solution is for the sector to focus on material efficiency, since this will reduce the amount of waste generated, which will naturally lead to cost-savings, reduced impacts on the environment and reduced natural resource depletion. A focus on material efficiency involves undertaking construction projects that follow the waste hierarchy to facilitate the most efficient use of materials over a building's lifecycle. Currently, only a small amount of construction material is reused, as opposed to recycled. There is ample opportunity within the construction industry to improve waste management practices and for the expansion of material reuse (Williams and Turner, 2011).

In this context, architectural salvage is a potential element in the development of a large-scale solution to the present issue of increasing construction sector greenhouse gas emissions, materials and water use and waste arisings. Architectural salvage consists of extracting materials, furniture and objects from a building that is about to be demolished, for the purpose of reusing or repurposing them. It is a process of selective and systematic dismantling of a demolition site to reduce construction waste and create a supply of materials, including some of high aesthetic and historical value. In a circular economy context, the architectural salvage industry has been acknowledged as an option to develop the full potential for reuse of construction materials.

2. Studies review

2.1 History of architectural salvage and reuse

Architectural salvage consists of extracting materials, furniture and objects from a building that is about to be demolished, for the purpose of reusing or repurposing them. It is a process of selective and systematic dismantling of a future demolition site to reduce construction waste and create a supply of materials of high aesthetic and historical value. The first known instances of architectural salvage extend back >2,000 years, with evidence of material salvaging from the ancient Roman Empire (Duckworth, 2020). Initially, salvaged materials were used on account of

material scarcity, and economic benefit (Wong, 2016). The recognition of salvaged materials as high-value items for history, artistry, and artisanship (as well as for practicality) became popularised in the 18th century, with the Society of Antiquaries of London founded in 1707 (Evans, 1956). This fascination for antiquities and historical preservation was prompted, in part, by archaeologists' discoveries of ancient cities such as Pompeii. Collecting historical items became popular amongst the upper classes (Coltman, 2005). There was not yet a complete industry for architectural salvage, instead it was a combination of luxury collectibles for the upper classes and cheap construction necessities for the lower classes.

The architectural salvage industry in the UK, as it is currently recognised, began in the late 1960s. A surge of demolitions of historic structures created an abundance of architectural salvage materials. Concurrently, there was a concern for the loss of historic and cultural monuments and structures. Additionally, the environmental and sustainability movement was gaining popularity. This combination led to public interest in reuse and recycling (Prest, 2011). Gradually a market was established using demolished building elements and materials. The architectural salvage industry now comprises salvaged and recycled materials, and reclaimed materials or architectural antiques.

The Housing Act of 1930 initiated a government-driven slum clearance programme in the UK which ran until 1980. A peak mass clearance occurred in the late 1960s, with 80,000 demolitions per annum (Mumford and Power, 2002). The increased volume of demolished materials triggered a market for reclaimed building materials to grow in the 1970s and more architectural salvage yards were established. A reclamation, or salvage, yard is a place where such old and unwanted building materials, furniture, and other objects are collected and sold. There are probably thousands of small reclamation/salvage yards in the UK, although exact numbers are unknown. By the 1990s, there was a shift in demolition companies, from small contractors using hand labour to large companies using machinery. This advancement increased the materials supplied to salvage yards (Bioregional, 2009).

The direction of salvaged material was heavily determined by advancements in waste processing technology in the 1990s. These technologies were promoted by the EU and the UK government as they reduced landfill waste through recycling (DEFRA, 2010). They created a surge in recycling and consequently materials that could be reused, such as stone, brick and timber, were instead being recycled (Bioregional, 2009). The government and the construction industry have not promoted reuse as much as recycling, leading reuse to fall behind recycling in the construction sector.

2.2 Challenges to use of architectural salvage

An array of logistical, legal, and economic barriers can prevent the reclamation of materials, including concerns about costs, material standards, liability, availability, storage, skills, and installation time.

One challenge is the unpredictability of material cost. Many economic barriers stem from the assumption that using salvaged materials is more expensive. Selective demolition requires special techniques, and the best standards are achieved with costly labour-intensive approaches (Durão *et al*, 2014). New technical developments are needed to reduce the time and costs involved in selective demolition so that reclamation of materials becomes more attractive (Durão *et al*, 2014). The unpredictability of costs involving the salvage of materials can deter many companies and individuals from using them, and instead opt for virgin standardised materials that have fixed costs (Gorgolewski, 2018). The rarity or availability of a material at the time also affects its cost. This fluctuating cost can be disconcerting for consumers interested in using salvaged materials (Department for Business Innovation & Skills, 2015).

Architectural salvage used for construction is often regarded as substandard in terms of quality and durability. Systems may be emplaced to examine and regrade materials to a satisfactory standard. The construction sector has traditionally been wasteful, conservative, risk averse and reluctant to adopt innovative technologies and ideas (Williams *et al*, 2014). Many construction companies can be reluctant to use salvaged materials unless they have been accredited through recognised quality standards due to liability concerns (Williams *et al*, 2014). This is, in

part, due to building codes favouring new construction methods and materials (UKGBC, 2020). In fact, building codes often do not provide alternative performance specification for salvaged materials. This lack of a system for certification exacerbates the uncertainty of using salvaged materials in construction. Liability concerns are also professed by insurance companies which further discourages the use of reclaimed materials. However, this hesitancy is fading with the influence of European legislation promoting reuse of construction waste (European Commission, 2017). There is expectation that governmental incentives will induce salvaged materials to be used in mainstream construction.

The uncertainty of availability for architectural salvage is a concern when designing and constructing buildings, especially when there is intent to use a large quantity of uniform material. This can limit the scale of construction using salvaged materials and thus larger projects are less likely to rely on them (Gorgolewski, 2018). Flexible design is required when using salvaged materials, not only is the quantity uncertain but the dimensions of materials may not be standardised. For some construction companies and designers this uncertainty is unfeasible as it can alter the timescale, cost, and design.

Issues can arise when storing reclaimed materials. Reclaimed construction materials require storage for reuse on site or a ready market to sell into. The limited storage options for salvaged materials can deter, especially demolition contractors, from salvaging materials due to the risk of obtaining materials without a buyer or storage capacity.

The installation time for reclaimed materials can be longer than standardised virgin materials as traditional construction methods tend to require more hand-based labour. Tradesmen/women are often unfamiliar with the skills necessary to work with older materials and antique pieces. Creating standards and procedures for salvaged materials will encourage the construction industry and tradesmen to work with salvaged materials in the future.

2.3 Previous studies

The BigRec Surveys in 1998 (Salvo Ltd, 1998) and 2007 (Salvo Ltd, 2007) are the only complete surveys of the reclaimed building materials sector in the UK, and possibly anywhere. A comparison of 1998 and 2007 surveys revealed shifts and changes within the architectural salvage industry showing a substantial increase in value of sales but a general decrease in the volumes of materials salvaged. The reason for this was not determined, and whilst the reports provide useful historical information, they are not publicly accessible, the surveys are now quite dated and there are several research gaps.

Bioregional's (2009) report provided evidence-based recommendations and policy changes to stimulate reuse of building materials, including: the creation of a formal organisation to champion reuse of building materials, investment in kick-starting reuse capacity, direction of local government planners to encourage reuse, and direction of landfill revenues to reuse before recycling. None of these recommendations have been acted on.

Trabulsi and Sofipour's (2020) study on reuse of construction materials reinforced the previously reported lack of incentives, lack of logistics & recovery facilities, lack of an established procedure for quality assurance, warranty issues, and public concerns.

Thus, very few studies have investigated the scale and types of salvaged materials available to the construction sector. These studies are out-of-date leaving considerable gaps in knowledge. Hence, the aims of this case study are to i) identify/review an architectural salvage supply chain and investigate key barriers and incentives to processing salvaged materials efficiently, and ii) to categorise and quantify salvaged materials and to critically evaluate their potential, both financially and environmentally.

3. Methods

3.1 Social survey

A social survey to investigate the perceived aesthetic and historic value of salvaged pieces, and their sustainability, was undertaken. The questionnaire was created using iSurvey (www.isurvey.soton.ac.uk) and invitations to complete the survey were sent by email. The survey was conducted during May 2021.

The survey consisted of 21 questions divided into two sections. Section 1 inquired about views on salvaged pieces, the sustainability of the practice and desired information on salvaged items. Section 2 aimed to establish views on the aesthetic value of objects. This involved use of a Potentially All Pairwise RanKings of all possible Alternatives (PAPRIKA) method for multi-criteria decision making (MCDM) or conjoint analysis (Bourque et al., 2003; Hansen and Ombler, 2008). Participants were presented with a series of questions about building-related items two at a time, with one item being brand new and the other a salvaged item from a reclamation yard (Figure 1). Participants selected the piece that appealed more to them.

Figure 1.

Since the survey took place during the Covid-19 pandemic, and lockdowns were in place in England, the survey had to be undertaken online (Calbi *et al*., 2021). The survey was distributed using social media; the decision to take this approach was made after careful consideration of the different ways a survey can be distributed (Bourque et al., 2003), analysis of the benefits and downsides to using social media and evaluation of the most effective strategy (Jones et al., 2015). Ethical approval was granted from the University of Southampton's Faculty Ethics Committee before research was undertaken, in accordance with the Data Protection Act 2018 (reference number 72713).

3.2 Company survey

A survey of companies dealing with architectural salvage in the Southeast of England was undertaken. Of the English regions, this region has the largest population, with 9.2 million

residents (Statista, 2020); the highest number of properties, with 4.0 million properties, or 15.2% of the UK total stock (Valuation Office Agency, 2021); and increasing growth for housing (House of Commons Southeast Regional Committee, 2010). In the UK there are large geographical divides of wealth, with high-wealth families most concentrated in the Southeast of England. The Southeast has the highest number of high-wealth families, with >3 million adults living in families with net wealth per adult >£250,000 (Office for National Statistics, 2019). The Southeast is second (behind London) for the highest gross disposal income per head. Hence, the Southeast's relative wealth, and active property, construction and demolition sectors means that it is ideal for this study. The questionnaire was created online using iSurvey (www.isurvey.soton.ac.uk). The survey was conducted during February/March 2021.

Architectural salvage companies were selected using a specialist directory. Contact emails were obtained (with permission) from the Salvo Directory (Salvo Ltd, 2022), a comprehensive online directory that consists of salvage yards and specialist businesses that manage architectural salvage. Participants had to be owners of, or associated to, an architectural salvage business in the Southeast of England and had to be above the age of eighteen. Ethical approval was granted from the University of Southampton's Faculty Ethics Committee before research was undertaken, in accordance with the Data Protection Act 2018 (reference number 70709).

Secondary data was collected (with permission) from the Salvo Directory. Key information was taken for each business; for example: the business name; the county the business resides; the category of architectural salvage. The secondary data provided a general overview of the architectural salvage industry to complement the company survey data.

3.3 Estimation of carbon emissions

To investigate the sustainability of architectural salvage of selected materials/items, a bespoke program was created. The program required input from the user consisting of the:

- Type and quantity (in kilograms) of a material,
- Type of vehicles used in transportation,
- Distance (in kilometers) that the material will be transported.

The program calculates the carbon emissions for transportation of the specific salvaged material chosen and the carbon footprint of the same type and quantity of material if it were manufactured brand new. It then compares the two and produces:

- The amount of carbon dioxide produced by using architectural salvage as well as new fabrication as methods of construction,
- The amount of carbon dioxide saved/expended using architectural salvage compared to brand new production,
- The more sustainable method of construction based on the amount of carbon dioxide produced by each.

The program was given a simple and easy to use interface since it was designed to be used by salvage businesses. It was written in the language Python and used the Tkinter binding to create the Graphical User Interface (GUI).

The values used for embodied carbon (in kgCO_2 e/kg) of each material when newly manufactured are displayed in Table 1; the values were sourced from the Inventory of Carbon and Energy Data Base (ICE DB), (Circular Ecology, 2020).

Table 1. Embodied carbon measured in kg CO_2e/kg produced during manufacture of new materials.

Material	**Embodied Carbon, kg CO_2e/kg**
Brick	0.45
Timber	0.493 (no carbon storage; average of all data)
Iron	2.03
Steel	2.47
Concrete	0.103
Glass	50
Mineral Fibre Roof Tiles	2.7
Clay tiles	0.48
Ceramic tiles	0.78

Marble tiles	0.21
Granite tiles	0.7
Slate tiles	0.063
Stone	0.079

Due to the large variety of different subtypes of each material, either an average value or a worst-case scenario of the embodied carbon was taken for some of the materials. For timber, carbon storage was not considered, since the value of the embodied carbon would be -1.03 kg CO_2 e/kg, of which carbon storage would be -1.52 kg CO_2 e/kg, (average for different kinds of timber). This simplification of the values, and consequently of the choices presented to the user, allowed for a simpler and quicker user experience, especially if the program is needed to be used on-site when speed is essential in the architectural salvage practice.

To calculate the carbon emissions from a newly produced material, the formula shown in Equation 1 was used:

Equation 1: $$CF_{new\_manufacture} = Quantity\ of\ material * Embodied\ Carbon\ of\ material$$

where CF is the carbon footprint, the quantity of material is the value input by the user, and the embodied carbon is the appropriate value taken from Table 1 for the selected material.

The carbon emission values measured in kg CO_2/km for each type of vehicle typically used to transport items are displayed in Table 2. These values depend on a vehicle's weight limit and are based on the Euro VI Emission Standard, a European vehicle emission standard that has been in effect since 2012 (ICCT - The International Council of Clean Transportation, 2016). The values were obtained from the parliamentary Large Goods Vehicles: Exhaust Emissions debate during which a set of carbon dioxide emission speed curves for road vehicles for different emission standards was provided (TheyWorkForYou, 2013).

277 Table 2. Embodied carbon measured in kg CO_2e/kg produced during transport of salvaged
278 materials.

Type of Heavy Goods Vehicle (HGV)	Carbon emissions, kg CO_2e/km	Emission standard
HGV-rigid: 3.5-7.5t weigh limit	0.297	Euro IV
HGV-rigid: 7.5-12t weigh limit	0.424	Euro IV
HGV-rigid: 12-14t weigh limit	0.455	Euro IV
HGV-rigid: 14-20t weigh limit	0.54	Euro IV
HGV-rigid: 20-26t weigh limit	0.67	Euro IV
HGV-rigid: 26-28t weigh limit	0.712	Euro IV
HGV-rigid: 28-32t weigh limit	0.825	Euro IV
HGV-rigid: >32t weigh limit	0.812	Euro IV
HGV-artic: 14-20t weigh limit	0.528	Euro IV
HGV-artic: 20-28t weigh limit	0.681	Euro IV
HGV-artic: 28-34t weigh limit	0.722	Euro IV
HGV-artic: 34-40t weigh limit	0.821	Euro IV
HGV-artic: 40-50t weigh limit	0.921	Euro IV

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280 Carbon emissions during deconstruction of the materials was not taken into consideration since
281 it often consists of mostly manual labour. Even in cases where machines are needed to collect a
282 material, their usage is minimal, and the carbon emitted is negligible (Maconzoma, 2001).

283

284 To calculate the carbon emissions emitted during transport of a salvaged material, the formula
285 shown in Equation 2 was used:

286

287 Equation 2: $CF_{salvaged} = Distance\ of\ transport * Carbon\ emission\ of\ vehicle$

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where CF is the carbon footprint, the distance of transport is the value input from the user for transport distance to storage, and carbon emissions is the appropriate value taken from Table 2 for the selected HGV (Heavy Goods Vehicle).

3. Results and Discussion

4.1 Social survey

The survey was completed by a total of 55 people. This group consisted of ages from 18 to 65 years and people from different nationalities and backgrounds as well as different occupations and financial circumstances.

Most respondents (83.3%) stated that they had not been to an architectural salvage shop. This is expected since this is a relatively niche industry where shops are not usually found on the high street of urban areas. When asked whether they would consider purchasing salvaged materials, a large percentage of people responded positively; however, for the majority either the strength and durability of the material (41.8%) or its appearance (34.5%) would play an important role in their decision.

When asked what they as customers would like in terms of information about the materials on offer, the participants selected a wide range of answers with the most desired information being about the materials' strength and durability (87.3%). The history and origin of the salvaged items were also selected as desired information by half of the participants, and specifically the age of the items and number of owners as well as information about the age of an item and its estimated life expectancy from purchase. Half of the participants expressed interest into being provided with more information concerning the environmental impact of the pieces they were interested in purchasing.

The participants were prompted to give their opinion on whether they consider the environmental impact of things they purchase when those things are a piece of furniture, a decorative piece, or a construction material. Approximately a third said they never think about it. A total of 30.9% stated they consider sustainability occasionally, with the highest positive

response being when purchasing pieces of furniture and the lowest when buying a decorative piece. Those who said they always consider the environmental impact of the items/materials they buy are a minor fraction of all respondents. This shows that although sustainability is becoming more important to the public, it is still not supported with information and still not a priority. This can be due to the lack of easily accessible information about an item's carbon footprint; people cannot do their own research into the environmental impact of everything they purchase. In addition, provision of such information by sellers would probably only be viable for larger value items given the time, skills and complexity involved.

The participants were asked about information on sustainability and the carbon footprint of items and materials. The overwhelming majority of responses were affirmative; 89% wanted information about a salvaged item's carbon footprint, 94% wanted to be shown the comparison between the carbon footprint of a salvaged and a new item, and 89% stated that this information, if provided, would affect their decision on whether to buy a specific item or not. This data shows that after prompting, people are more interested in an item's sustainability and seem more willing to make a decision that involves relative environmental impacts. Indeed, when asked if they would consider purchasing from a salvage shop instead of a shop offering newly manufactured items if the salvaged item is less harmful to the environment, 94% said "yes."

For the 'paprika' style portion of the survey, most of the questions received an approximately 50/50 answer ratio. For example, when presented with a classically shaped chandelier, 55% chose the modern one. This is most likely due to old chandeliers using candles or out-of-date light fittings so it would require work to update it. Furthermore, old chandeliers tend to have a heavier, more massive look, while nowadays people like to decorate with more slick, simple, clean furniture that focus more on functionality and positive performance (Coleman and Sosnowchik, 2006).

Similarly, 54% chose a modern wall light over a salvaged version. Although both have a similar design, the old one is larger than the new one. Today houses and flats are much smaller than previously (Robshaw-Bryan, 2021) and hence many may not have enough space in their homes

and would require a light proportionate to the size of their home. When comparing desk and floor lights, a small majority would rather have the old desk light. Both desk lights were similar in colour, shape and size, but the old one can give a subtle elegant vintage look to a desk. Whilst the floor lights were similar in size, the new one is simple and practical and could fit in a variety of interior designs. The older floor light had an interesting and unconventional design, but it can take up more space and it might not fit within the rest of a person's home. The old fireplace was chosen by 60% of participants, likely due to aesthetic preferences. Seventy-one percent chose a new wardrobe, probably for aesthetic reasons since the slick simple design of the new wardrobe can fit into many different interior home designs. The material of construction can also play a part, since older wood can have a smell that people find unpleasant and be damaged, and hence could catch onto clothes and create tears.

It is clear from the survey that aesthetic values cannot be easily predicted or quantified. In 70% of the questions, views were split approximately 50/50. People see to lean more heavily towards new items (wardrobe, armchair and dining chair) when size, style and fashion become both objectively and subjectively important since older items can usually only fit in older homes and specific interior designs. Aesthetic beauty is a concept that relies heavily on culture, nationality, upbringing, outside influences (e.g. prevailing fashion, peer pressure), and many other factors which shape what each individual deems aesthetically pleasing. A summary of the survey's results is provided in Table 3.

Table 3. Summary of results from the public social survey.

№	Question	Answer	Responses (%)	Responses (№)
Part 1				
2	Have you been to/purchased from an architectural salvage shop before?	Yes	17	9
		No	83	45
3	When renovating/refurbishing your home, would you consider buying salvaged materials instead of newly manufactured ones?	Yes	13	7
		Yes, but it depends on the salvaged materials' appearance	34	19

№	Question	Answer	Responses (%)	Responses (№)
		Yes, but it depends on the salvaged materials' strength and durability	42	23
		No, because I need more information about the materials' origin and performance	7	4
		No	4	2
4	What information would you like for people working in the architectural salvage trade to provide about what they offer? (select more than one)	Information about the origin of pieces/materials	58	32
		Information about the history of pieces/materials	49	27
		Information about the materials' strength and durability	87	48
		Information about the environmental impact of salvaged pieces compared to new manufacture of pieces of the same type.	53	29
		Other: "Information about the period of life the product and what of this period is remaining ahead, as of the date on which I am buying it"	2	1
		Other: "Age and number of owners"	2	1
5	Do you consider the environmental impact of an item you are purchasing when that item is a piece of furniture?	Always	4	2
		Often	34	19
		Occasionally	34	19
		Never	27	15
6	Do you consider the environmental impact of an item you are purchasing when that item is a decorative piece?	Always	7	4
		Often	31	17
		Occasionally	26	14

№	Question	Answer	Responses (%)	Responses (№)
		Never	36	20
7	Do you consider the environmental impact of an item you are purchasing when that item is a construction material?	Always	9	5
		Often	31	17
		Occasionally	33	18
		Never	27	15
8	If you go to an architectural salvage store/website, would you like to be provided with information about an item's carbon footprint (a carbon footprint is the total greenhouse gas emissions caused by a product during its lifecycle of manufacture, distribution, and functional life)?	Yes	89	49
		No	11	6
9	Would you also like to be given information about how a salvaged item compares to a newly produced item of the same type?	Yes	94	52
		No	6	3
10	And would that information impact your decision of purchasing it?	Yes	89	49
		No	11	6
11	Would you consider purchasing from a salvage shop if it has been shown that the items provided there have a less harmful impact on the environment compared to newly manufactured items?	Yes	94	52
		No	6	3
Part 2				
12	Chandelier	Old	45	24
		New	55	29
13	Wall light	Old	46	25
		New	54	29
14	Desk light	Old	54	30
		New	46	25
15	Floor light	Old	42	23
		New	58	32
16	Fireplace	Old	60	33
		New	40	22
17	Wardrobe	Old	29	16
		New	71	39

№	Question	Answer	Responses (%)	Responses (№)
18	Table	Old	60	33
		New	40	22
19	Gates	Old	46	25
		New	54	30
20	Armchair	Old	13	7
		New	87	47
21	Dining chair	Old	26	14
		New	74	41
*Note: Question 1 not listed since it concerns the consent to participate in the survey				

4.2 Company survey

A total of thirty-two responses were secured from a target population of 205, a satisfactory response rate of 16% (approx.1 in 6). For comparison, the BigRec Survey (Salvo Ltd, 2007) received a response rate of 9% (approx. 1 in 10). At least one survey response was received from each county within the Southeast of England.

The estimated mean number of employees for the surveyed architectural salvage businesses was 7.3 employees. However, 50% of responses declared <5 employees and only one response reported 20–49 employees. No company reported fifty or more employees. The relatively small number of employees indicate the specialist nature of architectural salvage businesses. Few employees and specialisation can be a barrier to business growth and expansion, although small businesses can be more responsive to customers and encourage entrepreneurship and innovation (Amah, 2013).

A variety of specialist categories of architectural salvage were identified. *General reclamation yards* were the most chosen option, with *antique landscape and garden* and *other* also prevalent. The *other* option was open-ended, allowing participants to clearly describe their business if it did not fit into any of the given categories. Examples for the *other* responses included: *architectural antiques, reclaimed building materials*, and a *wood recycling project.* No business surveyed identified as a *lighting ornaments and decoration* business.

The questions used to address the supply chain involving architectural salvage businesses were: *Where do you source architectural salvage? Who do you sell architectural salvage to?* and *How do you sell architectural salvage?* Participants were able to choose multiple options for each question as well as an *Other* open-ended option. A total of 62% of surveyed businesses reported purchasing architectural salvage *privately (from individuals). Demolition sites* (53%), c*onstruction companies* (44%), *auctions* (38%), *retail stores/wholesalers* (34%) were also reported as common sources for architectural salvage. Only two participants claimed to receive *private donations* to source architectural salvage. Responses to the *other* option (25%) included: *purchase from institutions, purchase from farmers*, and *being associated to a demolition company as part of a group*. Architectural salvage has a long-life cycle therefore mismatch between supply and demand is expected, giving salvage businesses more flexibility with their sources and customers (Simatupang, 2000).

A total of 94% of surveyed businesses reported selling to *private individuals/homeowners* with 62% selling to *architects/designers* and *tradespeople.* This suggests that a large portion of architectural salvage is being used for home improvements, decoration, new architectural builds, and construction. Only 3% reported selling to *artists* and 7% to *historical preservationists*.

Many factors impact how salvage businesses choose to trade, including business location (for example, differences between urban and rural locations), business size, type of architectural salvage sold, type of customer *etc*. The responses from the survey show *walk-in at business premises* (75%), *online orders* (75%), and *telephone orders* (62%) to be the most common methods of trade. These methods are inclusive and accessible to the majority of the public. *Events, market stores*, and *other* all received zero responses.

Each surveyed business had a varying supply chain, with variations in source, selling methods, type of customers as well as the number of different sources, trade methods, and customers for each business. Figure 2 illustrates a typical architectural salvage business' supply chain; the

example shows an architectural salvage business with three sources, three trade methods and three types of customers.

The survey identified that most businesses preferred to have fewer sources of materials, with 81% of surveyed businesses reporting having 1-3 sources of architectural salvage. A total of 25% of surveyed businesses reported sourcing architectural salvage from only one source. An average of 2.63 sources was estimated for the surveyed companies. These small numbers suggest that finding sources of architectural salvage can be a challenge, although it may also be economically beneficial for salvage businesses to buy larger volumes of salvage from few sources (Schiele, 2019).

In terms of different trading methods used, 25% reported using 1-2 methods, 67% used 3-4 methods and only 6% used five trading methods. None of the businesses reported selling to only one type of customer. Approximately two-thirds (68%) of businesses sold to 3-4 types of customers. An average of 3.8 different customers per business was estimated. These results suggest that Figure 2 illustrates a supply chain similar to many of the surveyed businesses, and it can probably be taken as a typical model, regarding the number of sources, trade methods and customers for a small architectural salvage company.

Figure 2.

A variety of factors determine the price of architectural salvage. Participants rated each factor's importance in deciding the price for an architectural salvage item. Overall, and unsurprisingly, the *condition* of an architectural salvage item was typically deemed to be the principal factor in determining the item's price. The *rarity* and *size* of the item were also deemed highly important. *Local competitor prices, national or international market prices* and *bargaining* do not relate to the qualities of an item and hence these three factors were rated the least important, inferring that an architectural salvage item's price is more dependent on its individual qualities rather than on external factors.

Respondents were asked to rank the top three salvage items that generate the highest sales revenues. The responses given strongly depended on the specialisation of the business. There was a relatively large number of survey responses from business categorised as *general reclamation yards, antique landscape and garden*, and *timber beams and wooden flooring* and this is proportionally represented.

The reuse potential of an architectural salvage item depends on its ability to be sold quickly. Storing architectural salvage, particularly for longish periods, can be problematic for businesses. A total of 42% of businesses had items for *1–6 months* and 32% had items for *6 months–1 year* before they were sold. Only 7% of businesses had items for *more than 1 year*.

A total of 84% of businesses reported using *online/website* to advertise, with *flyers* (47%) and *social media* (44%) used by almost half of surveyed businesses. Only 16% of businesses reported advertising in *newspapers* and none used *television*. *Online/website* and *social media* were reported as the most frequently used, with some businesses advertising daily and weekly. Modern types of media are often free ways to advertise and do not require external assistance. *Newspaper* and *television* require collaboration with a publisher or broadcaster and payments, often beyond the means of small companies. Whilst *flyers* are used by almost half of surveyed businesses, they are not as frequently used, either seasonally or annually.

All respondents agreed that architectural salvage contributes to the reduction of environmental harm, with 66% agreeing that architectural salvage contributes strongly and 34% agreeing that architectural salvage contributes in a minor way to the reduction of environmental harm. However, 59% of surveyed businesses did not make any claims of environmental benefits, 12% made claims of environmental benefits for only specific items and 28% made claims of environmental benefits for all architectural salvage items. Businesses reported that architects/designers and historic preservationists are most concerned about environmental benefits of a salvaged item, with *tradespeople* rating the least concerned.

The survey asked two questions regarding disposal: *How do you dispose of architectural salvage items?* And *How long do you keep architectural salvage items before disposing of them?* A total of 13% of businesses did not want to give an answer to this question and responded with *skip*, this could imply that these businesses do not dispose of salvage or businesses may not want to disclose illegal disposal methods. Furthermore, 10% responded with *N/A.* A total of 42% reported they did not dispose of items, with 29% keeping items until they were sold and 13% reducing the price of items until they were sold. About one third (35%) reported disposing of items, with 29% of businesses disposing by recycling, crushing, or chipping items, and 6% of businesses first reducing the price before recycling. Timeframes to disposal were investigated. A total of 65% of businesses reported not disposing of salvaged items. Of the 35% of businesses that reported disposing of items, 54% reported keeping items for *more than 2 years,* 13% for *1–2 years*, and 3% *less than 6 months.* The long timeframe for storing items before disposal suggests unwanted/unsold salvage items can be a burden on architectural salvage businesses.

The company survey has provided new and important insights into the operations of architectural salvage businesses. In our case study, most businesses utilise few employees, on average 7.3. Few employees and a very specialised business can hinder business growth, however smaller businesses can be more flexible and responsive to customer demand. The supply chain of architectural salvage businesses typically consists of few sources, allowing salvage businesses to purchase larger volumes of salvage from fewer sources which can be more economical. The most common methods of trade were the most accessible and inclusive to much of the public, including walk-ins, online and telephone orders. Salvage businesses sold to a variety of different customers, on average 3.8, with >90% selling to private individuals. The factors determining the price of an architectural salvage item depended on the characteristics of the item, including its condition, size, and rarity. External factors, such as local and national/international market prices, and bargaining, were not seen as important or influential a salvaged item’s price.

A variety of architectural salvage items were deemed most profitable in terms of generating the highest sales revenue. Construction materials, such as timber, tiles and bricks were deemed profitable. Old and rare items were identified as generating high sales revenues. The time-period architectural salvage items took to sell was relatively short, due to the burden of storing items, with only 7% of businesses keeping items for more than one year. Businesses reported using modern media for advertisement with online advertisement being used by 84% and social media used by 44%; these types of advertisements are often free to use and have a large outreach.

Salvage businesses are clearly aware of the potential environmental benefits of architectural salvage but few report making environmental claims to their customers. This may be because many architectural salvage businesses do not deem their customers to be particularly concerned about this aspect of their business.

Secondary data showed that the number of architectural salvage businesses within a county can depend on a multitude of factors including the size of the county and population, demand for architectural salvage, the county's economy, and the size of the regional construction and demolition industry. Kent had the largest number of architectural salvage businesses per county with forty-eight salvage businesses. Kent is the most populous county in the Southeast (City Population, 2020) and whilst it is only the fifth wealthiest county in terms of mean income (HM Revenue and Customs, 2020), its proximity to London improves trade. Surrey had the second largest number of architectural salvage businesses; this could be in part due to it being the wealthiest county in the Southeast by mean income.

Figure 3 summarises the categories of architectural salvage business in the South East of England. *General reclamation yards* are the largest category (23%), with *Timber, beams and wooden flooring* and *Antique furniture* are second and third largest, respectively. These businesses have wide appeal in contrast to niche and specialised businesses, for example *Fireplaces and chimneys* and *Reclaimed metalwork.*

Figure 3.

In the South East of England, Berkshire, Kent, Oxfordshire, Surrey, and West Sussex have an evenly distributed architectural salvage market, with not one category dominating the market. Buckinghamshire, East Sussex, and Hampshire have architectural salvage markets with an uneven distribution of different architectural salvage. *General reclamation yards* account for 38% of Buckinghamshire's architectural salvage market. East Sussex has two dominating salvage categories, *Timber, beams, and wooden flooring* (33%) and *Antique furniture* (26%). Hampshire's architectural salvage market consists predominantly (48%) of *General reclamation yards.*

4.3 Estimation of carbon emissions

The developed program provides the user with valuable information about how the carbon footprint of salvaged materials compares to that of newly manufactured ones. This can be very beneficial to those working in the industry. Having data not only about the origin and history of the salvaged items but also about how the salvage process affects the environment and making this data easily accessible and simply summarized for the public, can help people make the more sustainable choice when purchasing materials. Results from the survey also show that when prompted to think about sustainability, people want to know more and have information presented to them. This program offers an easy way for those working in the trade to calculate the carbon produced by the transport of the materials they salvage and instantly compare it to the carbon produced by the same material when newly produced. The simple user interface of the program allows for this to even be done directly on site.

For example, if a 50 kg concrete column has been salvaged from a demolition site, it will need to be transported 100 km to where it is going to be kept in storage, and an HGV with a weight limit of 3.5-7.5 t will be used in transport. In this case the newly manufactured material turns out to have a smaller carbon footprint. It must be noted, however, that one vehicle will not be used for just one material, but it will carry multiple salvaged materials. The value of an item's carbon footprint for the salvaged material depends only on the vehicle used during transport, and not on

the type or quantity of the material. This means that, since heavy goods vehicles carry more than just the one selected material, the carbon produced during transport will remain the same, while carbon produced during new manufacture of each material will add up. Resulting from this is the fact that all salvaged materials which will be transported together must be treated as a unit to accurately calculate and compare the carbon footprints from transport and from new manufacture. The code is available upon request.

4. Conclusions

This study has successfully investigated and evaluated the potential of the architectural salvage industry to contribute to net zero resource and waste management plans for the construction sector. It has successfully evaluated the perceived historical and aesthetic value of salvaged vs new objects and the need for information about their relative sustainability, and developed software to compare the environmental performance of common architecturally salvaged materials and furniture vs new items.

There is a clear need to raise public/construction sector awareness about the reuse opportunities provided by the salvage/reclamation sector. *General reclamation yards* are the largest category of architectural salvage businesses, with *timber beams and wooden flooring* and *antique furniture* the second and third largest, respectively. These establishments appeal to a broad range of different people and other businesses. There are also niche, specialised businesses where demand is lower.

The architectural salvage market in the South East of England consists of small businesses sourcing materials/products from relatively few different sources, including from demolition sites and private individuals. The companies are small and sell to a variety but limited range of different customers using accessible approaches. Online and social media advertisement gives these businesses a larger customer base since online technology provides a useful alternative to in-person purchasing.

Architectural salvage businesses have little influence on each other regarding local market prices. Salvage businesses decide their prices based on the qualities of individual items. There is limited public awareness of the environmental benefits of architectural salvage. Businesses are aware of the environmental benefits but seem unable to communicate this to customers. Raising awareness of salvage yards, the range of products they sell and their environmental benefits, are all key if reclamation is to contribute significantly to expansion of material reuse within the construction sector.

Storing architectural salvage items that are struggling to be sold has is a key barrier for businesses. Besides storing items, recycling, crushing, and chipping have been the only identified disposal method, however, salvage businesses try to reduce disposal through price reduction and sales. To improve the opportunities for reuse of salvaged materials, condition must be as high as possible. This requires careful demolition and maintenance of existing buildings, and standards implemented to ensure the quality of items are upheld. Rare items are potentially of high value therefore more awareness and education are necessary to avoid such items being disposed.

More communication is necessary between salvage businesses. Instead of keeping or recycling unsaleable items, items could be traded amongst salvage businesses where the item may be more in demand. This combats storage problems and reduces the more negative environmental impacts associated with recycling, extending the life cycle of the salvaged items.

Software to estimate the sustainability of architectural salvage was successfully developed. It can make it easy for the supplier to provide quantitative data that compares salvaged vs new materials/products. Such software can prove extremely beneficial to both parties – seller and buyer – although there is room for improvements, since only the carbon emissions during transport of salvaged materials were considered. Further developments could include more detailed inputs by the user, which could include the type of machinery used during deconstruction for which carbon emissions can be calculated (depending on the period of time for which it was in use) and creation of subcategories of materials to express their different

embodied carbon values. An option to store selected materials in a database and the ability to select those which are transported together and sum up the carbon footprints of each, may prove helpful.

These conclusions serve as an important stepping stone for further development of the architectural salvage industry as one piece in the jigsaw puzzle we need to complete to realize a full circular economy for the construction sector. Given the scale/impacts of the global construction sector, most of the UN's SDGs will probably only be achieved via urgent delivery of material efficiency, with a focus on reuse.

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References

Amah, E. (2013). Size and Organization Effectiveness: Maintaining a Balance. *Advances in Management & Applied Economics,* **3**(5), 2013, 115-123.

Bioregional (2009). Pushing Reuse Towards a Low-Carbon Construction Industry. Available at: www.bioregional.com/resources/ (Last accessed: 25/02/2022).

Bourque, L.B., Fielder, E.P., Fink, A., Litwin, M.S. and Sabine Mertens Oishi (2003). *The Survey Kit. 1: The Survey Handbook*. Thousand Oaks: Sage.

Calbi, M., Langiulli, N., Ferroni, F., Montalti, M., Kolesnikov, A., Gallese, V. and Umiltà, M.A. (2021). The consequences of COVID-19 on social interactions: an online study on face covering. *Scientific Reports*, [online] 11(1). Available at: https://www.nature.com/articles/s41598-021-81780-w [Accessed 30 Apr. 2022].

Circular Ecology. (2020). *Embodied Carbon Footprint Database - Circular Ecology*. [online] Available at: https://circularecology.com/embodied-carbon-footprint-database.html [Accessed 5 Apr. 2022].

City Population (2020). United Kingdom: South East of England. Available at: South East England (United Kingdom): Counties and Unitary Districts & Settlements - Population Statistics, Charts and Map (citypopulation.de) (Last accessed: 04/05/2022).

Coleman, C. and Sosnowchik, K. (2006). *Interior Design Trends and Implications*. [online] Available at: https://www.academia.edu/1622346/Interior_design_trends_and_implications [Accessed 15 Apr. 2022].

Coltman, V. (2005). Fabricating the Antique: Neoclassicism in Britain, 1760-1800. Available at: https://www.cambridge.org/core/journals/journal-of-british-studies/article/viccy-coltman-fabricating-the-antique-neoclassicism-in-britain-17601800-chicago-university-of-chicago-press-2006-pp-256xii-4800-cloth/03F1B308358E31D67649E889331828FF (Last accessed 21/01/2021).

Department for Business Innovation & Skills (2015). Consumer Empowerment Survey Report. Available at: Consumer empowerment survey (publishing.service.gov.uk) (Last accessed: 27/02/2022).

Department of Environment, Fisheries and Rural Affairs (DEFRA) (2010). Environmental Permitting Guidance: The Landfill Directive. Available at: https://www.gov.uk/government/publications/environmental-permitting-guidance-the-landfill-directive (Last accessed: 24/01/2022).

Duckworth, C.N. and Wilson, A. (2020). Recycling and Reuse in the Roman Empire. Available at: https://oxford-universitypressscholarship-com.soton.idm.oclc.org/view/10.1093/oso/9780198860846.001.0001/oso-9780198860846-chapter-12 (Last accessed: 20/01/2022).

Durão, V.; Caixnhas, J.; Osório-Peters, S.; den Boer, E.; Williams, I.D.; Curran, T; Pertl, A. (2014). Zero-waste networks in construction and demolition in Portugal. *Waste and Resource Management*, **167**(WR4), 153-168. http://dx.doi.org/10.1680/warm.13.00032.

European Commission and Joint Research Centre (2011). Supporting Environmentally Sound Decisions for Construction and Demolition Waste Management. Available at: waste-Guide-to-LCTLCA-for-C-D-waste-management-Final-ONLINE (1).pdf (Last accessed: 04/04/2022).

European Commission (2017). Public Procurement for a Circular Economy Good Practice and Guidance. Available at: Public_procurement_circular_economy_brochure.pdf (europa.eu) (Last accessed: 01/02/2022).

European Environmental Agency (2016). More from Less – Material Resource Efficiency in Europe. Available at: More from less — material resource efficiency in Europe — European Environment Agency (europa.eu) (Last accessed: 04/04/2022).

Evans, J. (1956). A History of The Society of Antiquaries. Available at: -a-history-of-the-society-of-antiquaries-by-joan-evans-oxford-1956-1-15s.pdf (Last accessed: 21/01/2022).

Gorgolewski, M. (2018). Resource Salvage: The Architecture of Reuse. Available at: Resource Salvation - Resource Salvation - Wiley Online Library (oclc.org) (Last accessed: 01/02/2023).

Grierson, D. (2009). Towards a sustainable built environment. *CIC Start Online Innov. Rev.* **2009**, *1*, 70–77.

Hansen, P., Ombler, F., 2008. A new method for scoring additive multi-attribute value models using pairwise rankings of alternatives. *J. Multi-Criteria Decis. Anal*. **15**, 87–107. https://doi.org/10.1002/MCDA.428

HM Revenue & Customs (2020). Income and Tax by County and Region. Available at: Income and tax by county and region - GOV.UK (www.gov.uk) (Last accessed: 04/05/2022).

Holm, F.H. (2003). Towards a Sustainable Built Environment Prepared for Climate Change? *A Paper Presented at the Global Policy Summit on the Role of Performance-Based Building Regulations in Addressing Societal Expectations, International Policy, and Local Needs.* 3–5 November 2003; National Academy of Sciences: Washington, DC, USA, 2003.]

House of Commons South East Regional Committee (2010). Housing in the South East. Available at: untitled (parliament.uk) (Last accessed: 17/02/2022).

ICCT - The International Council of Clean Transportation (2016). *A Technical Summary of Euro 6/VI Vehicle Emission Standards*. [online] theicct.org. Available at: https://theicct.org/sites/default/files/publications/ICCT_Euro6-VI_briefing_jun2016.pdf [Accessed 5 Apr. 2022].

Jones, M., Dusek, G., Yurova, Y. and Ruppel, C. (2015). Using Social Media and Targeted Snowball Sampling to Survey a Hard-to-reach Population: A Case Study. *International*

Journal of Doctoral Studies, [online] 10. Available at: http://www.informingscience.com/ijds/Volume10/IJDSv10p279-299Dusek0717.pdf [Accessed 5 Mar. 2022].

Maconzoma, D. (2001). *Building Deconstruction*. [online] Available at: http://site.cibworld.nl/dl/publications/Pub278/05Deconstruction.pdf [Accessed 20 Nov. 2022].

Mumford, K. and Power, A. (2002). Boom or Abandonment: Resolving Housing Conflicts in Cities. Available at: Boom or abandonment : resolving housing conflicts in cities - LSE Research Online (Last accessed: 22/02/2022).

Office for National Statistics (2019). Total Wealth in Britain: April 2016 to March 2018. Available at: Total wealth in Great Britain - Office for National Statistics (ons.gov.uk) (Last accessed: 17/02/2022).

Postalcı, İ.E.; Atay, G.F. (2019). Rethinking on Cultural Sustainability in Architecture: Projects of Behruz Çinici. *Sustainability*, *11*, 1069.

Prest, M. (2011). Architectural Salvage: Understanding the Values and Improving the Practice. Available at: https://drum.lib.umd.edu/bitstream/handle/1903/12877/Margaret%20Prest%20HISP%20Final%20DRUM.pdf?isAllowed=y&sequence=1 (Last accessed: 24/01/2021).

Robshaw-Bryan, S. (2021). *Property Trends: How Our Homes Have Changed Over the Years*. [online] Movehomefaster.co.uk. Available at: https://movehomefaster.co.uk/blog/article/property-trends-home-changes-over-years/ [Accessed 15 Apr. 2022].

Salvo Ltd (1998). BigRec Survey a Survey of the UK Reclamation and Salvage Trade. Available at: big-rec-survey-1998 (4).pdf (Last accessed: 15/02/2023).

Salvo Ltd (2007). BigRec Survey a Survey of the UK Reclamation and Salvage Trade. Available at: bigrec-survey-2007 (7).pdf (Last accessed: 15/02/2023).

Salvo Ltd (2022). Salvo Directory. Available at: Architectural Salvage Salvo directory on Salvoweb (Last accessed: 12/03/2023).

Schiele, H. (2019). Purchasing and Supply Management. Available at: 2019_Schiele_HandbookOperations_Purchasing.pdf (Last accessed: 05/05/2022).

744 Simutupang, T. (2000). Information and Incentives: Supply Chain. *Proceedings of the 7th*
745 *Annual New Zealand Engineering and Technology Postgraduate Conference*, Massey
746 University,Palmerston North, New Zealand, 23-24 November 2000, pp.269-274. Available at:
747 https://www.researchgate.net/publication/233994116_Information_and_incentives_in_a_sup
748 ply_chain (Last accessed : 01/09/23).
749 Statista (2020). Population of the United Kingdom in 2020, by region. Available at: • UK:
750 population by country | Statista (Last accessed: 22/02/2022).
751 TheyWorkForYou. (2013). *Large Goods Vehicles: Exhaust Emissions*. [online] Available at:
752 https://www.theyworkforyou.com/wrans/?id=2013-03-01a.144740.h [Accessed 28 Mar.
753 2022].
754 Trabulsi, D. and Sofipour, M. (2020). Reuse of Construction Materials a Study on How a
755 Strategic Collaboration Can Facilitate the Reuse of Construction Materials. Available at:
756 Microsoft Word - E34_Sofipour & Trabulsi_Reuse of construction materials.docx (diva-
757 portal.org) (Last accessed: 01/09/2023).
758 United Kingdom Green Building Council (UKGBC) (2020). Circular Economy How-to Guide:
759 Reusing Products and Materials in Built Assets. Available at: how-to-guide-reuse.pdf
760 (ukgbc.org) (Last accessed: 01/09/2023).
761 United Nations (UN) (2020). The Sustainable Development Goals Report. Available at:
762 https://sdgs.un.org/publications/sustainable-development-goals-report-2020-24686 (Last
763 accessed: 04/04/2023).
764 United Nations (UN) (2010). *Transforming Our World: The 2030 Agenda for Sustainable*
765 *Development, A/RES/70/1*; Preparatory Committee for the United Nations Conference on
766 Sustainable Development; First Session, 17–19 May 2010; United Nations General
767 Assembly: New York, NY, USA, 2010.
768 United Nations Environment Programme (UNEP) (2020). 2020 Global Status Report for
769 Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and
770 Construction Sector. Nairobi. Available at: https://globalabc.org/news/launched-2020-global-
771 status-report-buildings-and-construction (Last accessed 30 August 2023).

Valuation Office Agency (2021). Council Tax: stock of properties Statistical Summary. Available at: Council Tax: stock of properties Statistical Summary - GOV.UK (www.gov.uk) (Last accessed: 22/02/2022).

Williams, I.D. and Turner, D. (2011). Waste management practices in the small-scale construction industry. Proceedings of the *Thirteenth International Waste Management and Landfill Symposium.* S. Margherita di Pula, Cagliari, Sardinia, Italy, October 3/7. Paper No. 003. ISBN 978-88-6265-000-7.

Williams, I.D.; Curran, T.; den Boer, E.; Pertl, A.; Lock, D.; Kent, A. and Wilding, P. (2014). Resource efficiency networks in the construction of new buildings. *Waste and Resource Management*, **167**(WR4), 139-152. http://dx.doi.org/10.1680/warm.13.00030.

Wong, L. (2016). Adaptive Reuse: Extending the Lives of Buildings. Available at: https://ebookcentral.proquest.com/lib/soton-ebooks/detail.action?docID=4793914 (Last accessed: 20/01/2022).

World Green Building Council (2019). Bringing Embodied Carbon Upfront Available at: https://worldgbc.org/article/bringing-embodied-carbon-upfront/ (Last accessed: 01/09/2023).

Figure captions

Figure 1. Examples of images of paired items used in the social survey. Salvaged item on the left, new item on the right. Top: chandelier; middle: fireplace; bottom: wardrobe.

Figure 2. Example of a supply chain for a typical architectural salvage company in the South East of England (2021).

Figure 3. Categories of architectural salvage businesses in the South East of England (2021).