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ARCHITECTURAL SALVAGE VS MODERN CONSTRUCTION: INVESTIGATION INTO SUSTAINABILITY AND AESTHETIC VALUES

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ABSTRACT: 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. The quality and aesthetic value of salvaged materials/items is important in terms of their reuse in construction. No previous studies have tried to quantify the aesthetic value of salvaged items and compared it to modern pieces of the same type. Indeed, there is little research on the potential benefits of architectural salvage to the construction sector. This study aimed to: i) evaluate the perceived historical and aesthetic value of salvaged vs new objects and the need for information about their relative sustainability, and ii) compare the environmental performance of common architecturally salvaged materials and furniture vs new items. A survey was developed to identify relative perceptions about the aesthetic and historic value of salvaged pieces. To establish the aesthetic values of objects, a "PAPRIKA" (Potentially All Pairwise RanKings of all possible Alternatives) style survey was used. To investigate the sustainability of architectural salvage of certain materials/products, software was created using the coding language Python. The software was designed to calculate the carbon footprint of the transportation of the specific salvaged material chosen alongside the carbon footprint of the same type and quantity of material if it were manufactured brand new. A total of 55 responses to the survey were secured. Only 17% of respondents had visited an architectural salvage shop. Hence, there is a clear need to raise public/construction sector awareness about the reuse opportunities provided by the salvage/reclamation sector. When asked whether they would consider purchasing salvaged materials, a large percentage of people responded positively, although for the majority the strength/durability of the object/material (42%), or its appearance (34%), would play the most important role in their decision. About half of the respondents expressed interest into being provided with more information concerning the environmental impact of the pieces they were considering for purchase. A key conclusion is that after being prompted to think about environmental impacts, people seem more prone to making a decision about a purchase based on information comparing the relative environmental impacts of salvaged and new items. Software to estimate the sustainability of architectural salvage was successfully developed. Further development 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 and creation of subcategories of materials. For example, glass can have very high or very low embodied carbon (ranging from 5 to 105 kg CO_2e/kg) depending on the type of glass. The conclusions from this study 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.

Keywords: Construction, architectural salvage, environmental impact, carbon footprint, aesthetic value, survey.

1. INTRODUCTION

The world's reliance on natural resources continues to pick up speed. 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). With Earth's limited resources diminishing, it is essential that the modern construction sector reduces its reliance on virgin raw materials. Mining of materials and manufacture of building supplies has devastating effects on the environment, and hence resource efficiency must be practised. (European Environment Agency, 2016). 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 buldings 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, 2010). The construction sector is hence crucial to the global effort to achieve the SDGs via development of sustainable infrastructural projects.

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.

However, both the quality and the aesthetic value of salvaged artifacts is important in terms of their reuse in construction. There is little research on this topic; indeed, to our knowledge, no previous studies have tried to quantify the aesthetic value of salvaged items and compared it to modern pieces of the same type. This paper aims to address this research gap.

[Note: We recognise that global armed conflcts are causing a massive number of deaths and immense destruction to building infrastructure around the world in 2023, with a major war in Ukraine/Russia; civil wars in Afghanistan, Central African Republic, Ethiopia, Libya, Mali, Somalia, South Sudan, Syria, and Yemen; and drug wars in countries like Colombia and Mexico. Clearly this is a colossal drain on human and natural resources and these countries will require significant rebuilding when conflcts end. However, whilst such context is important, it must not trivialise or halt the work of scientists investigating circular economy solutions to ongoing and likely future resource/environmental problems.]

2. SUSTAINABILITY OF SALVAGED ITEMS

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. Architectural salvage has been a popular practice for >2,000 years (Duckworth, 2020), although not always recognised as an official practice (Shantz, 2019). The history of architectural salvage and challenges to the sector are summarized in Ripley and Williams (2023).

The contribution of salvage to more sustainable construction practices, reduction of construction waste and pollution from material production has been acknowledged but not really quantified or evaluated (Bertino et al., 2021). This is partially due to the large number of unpredictable variables present at sites being deconstructed. Couto and Couto (2015) and Greenfield (N/D) recognise the opportunity for salvage to contribute to a circular economy for the construction sector but do not go into detail about the sustainability aspects of salvage. Instead, they focus on the historical and aesthetic value of the pieces and furniture salvaged, comparing them, and commenting on whether historic preservation of pieces in their original state and location provides them with a greater value than reusing/repurposing them and giving them a second life, or vice versa.

The topic of whether architectural salvage can be classified as saving rather than "stealing from" or degrading heritage structures has been a research subject for over two decades. Although the trend of preserving artifacts by using old building parts probably has a positive environmental impact, its popularity has given rise to ethical concerns regarding the potentially illegal acquisition of architectural antiques (Henkels, 2001). The only way to eliminate the trade of stolen pieces is for a document stating their origin to be required. However, this can be a practically impossible task since many pieces have a long history and often numerous owners. Historic preservationists have expressed concerns that an antique's historic value is lost once it is removed from its original context (Henkels, 2001; Prest and Linebaugh, 2011; Repovich and Chiuini, 2009). This is likely if the salvaged pieces are not presented to buyers with accurate historic information and if homeowners mix up pieces from different periods creating a misleading and historically inaccurate interior design (Prest and Linebaugh, 2011).

There has been very little research into the sustainability of architectural salvage. Maconzoma (2001) highlights that a model for sustainable construction begins with conservation and reuse. Here, an emphasis is put on the consideration of a building's life cycle during the design stage and its importance during deconstruction, so that extraction of the maximum amount of salvage for reuse can be achieved. Durão *et al* (2014) reinforce that selective demolition requires special techniques, and the best standards are achieved with (relatively expensive) labour-intensive approaches. Durão *et al* (2014) also state that new technical developments are necessary to cut the time/costs involved in selective demolition so that reclamation of materials becomes more desirable. Williams and Turner (2011) suggest that there is ample opportunity within the construction industry for the expansion of material reuse. However, Williams *et al* (2014) highlight that many construction companies can be hesitant to use salvaged materials unless they have been accredited through recognised quality standards. Couto and Couto (2015) report on the guidelines, steps, and strategies to maximise material extraction, reuse, and recycling. No extensive research, however, has been undertaken to evaluate more specifically the sustainability of architectural salvage and how much carbon is released into the atmosphere during the salvage of materials/pieces.

In summary, very few studies have investigated the potential benefits of architectural salvage to the construction sector. This study aims to partially address this research gap by: i) evaluating the perceived historical and aesthetic value of salvaged vs new objects and the need for information about their relative sustainability, and ii) comparing the environmental performance of common architecturally salvaged materials and furniture vs new items.

3. METHODS

A combination of a social survey and modelling were used to address the study's aims. The perceived historical and aesthetic value, and sustainability of salvaged and new objects was evaluated through a social survey. A computer programme was developed and utlised to facilitate a comparison of (matched) common architecturally salvaged materials/ furniture and new items with respect to sustainability, using carbon emissions as a surrogate indicator for the latter.

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 designed to assure a sound response rate in a short period of time. The invitation to complete the survey was sent out by email. The survey was conducted during May 2021. Copies of the survey are available on request.

The survey consisted of 21 questions in total that were divided into two distinct sections. Section 1 included 10 questions that 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). Survey participants are presented with two alternatives, each has a pair of options, both alternatives' options relate to the same two criteria (Hansen and Ombler, 2008) (Figure 1). Participants must then select which of the two alternatives they prefer. In our survey, 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. Participants selected the piece that appealed more to them. Data from the survey was synthesized, categorised and evaluated. The items compared were:

- a chandelier
- a wall light
- a desk light
- a floor light
- a fireplace
- a wardrobe
- a table
- gates
- an armchair
- a set of dining chairs.

Since the survey took place during the Covid-19 pandemic, and lockdowns were in place in England during early-mid 2021, 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; Merolli et al., 2014). 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). Participants were presented with a participant information sheet and consent form prior to completing the survey, informing that their anonymity would be maintained, and they were free to withdraw at any point without providing reason.

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.

3.2 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 then calculates the carbon emissions for transportation of the specific salvaged material chosen. It also calculates 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). A copy of the programme is available on request. 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).

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

Carbon emissions during deconstruction of the materials was not taken into consideration since it often consists of mostly manual labour, for example, when removing bricks, roof cladding, tiles, etc. Even in the cases where machines are needed to collect a material (e.g. larger blocks of concrete or stone), their usage is minimal and the carbon emitted from them is negligible (Maconzoma, 2001).

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

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

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).

4. 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 probably to be 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 (Figure 2).

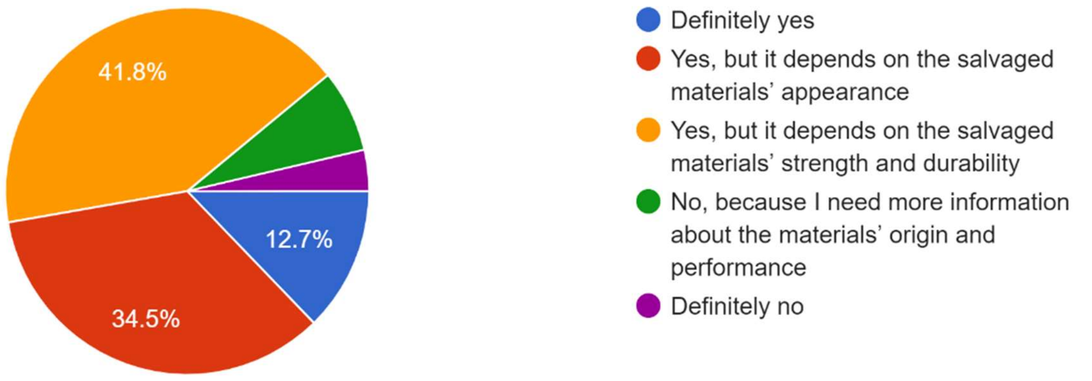


Figure 2. Responses to the question, 'When renovating your home, would you consider buying salvaged materials instead of newly manufactured ones?'

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 (Figure 3). Half of the participants expressed interest into being provided with more information concerning the environmental impact of the pieces they were interested in purchasing.

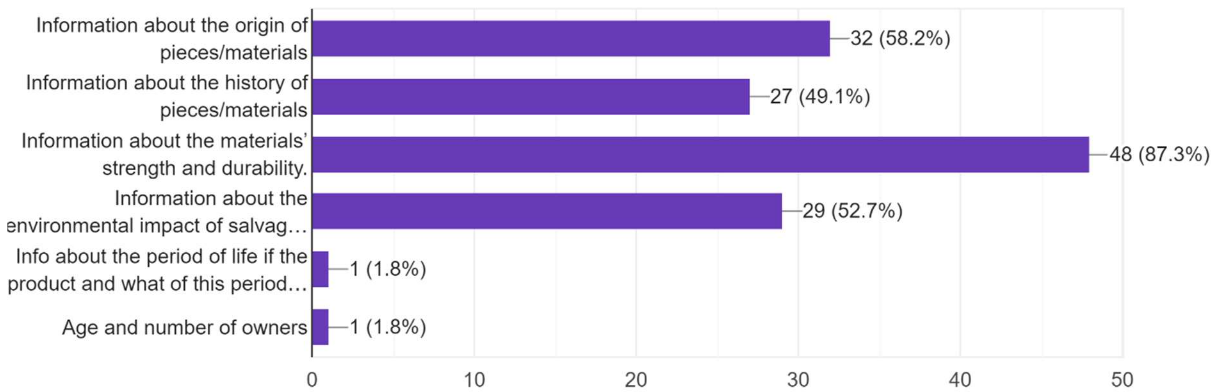
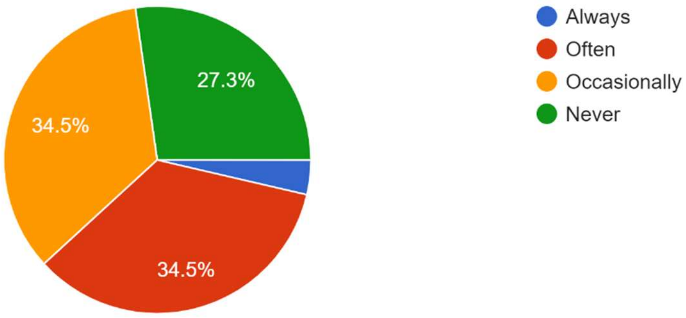


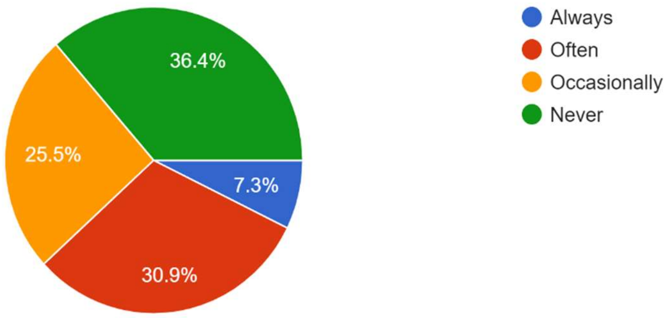
Figure 3. Responses to the question, 'What information would you like for people working in the architectural salvage trade to provide about what they offer?'

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 (Figure 4). 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 (Figure 4). Across the board, a similar percentage of people responded with often to the three questions – approximately one third. 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.

a) a piece of furniture



b) a decorative piece



c) construction material

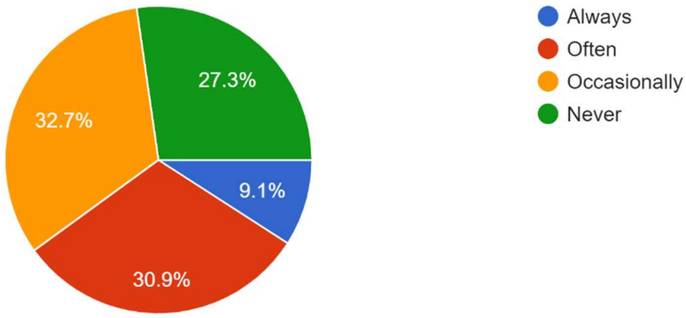


Figure 4. Responses to the questions, 'Do you consider the environmental impact of an item you are purchasing when that item is a: a) piece of furniture, b) decorative piece, c) construction material?'

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 being prompted by the survey to think about the impact that items and materials have on the environment, 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."

When it comes to Part 2 of the survey – the ‘paprika’ style portion of the questionnaire – most of the questions have 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.

In summary, the saying “beauty is in the eye of the beholder” clearly holds true. 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 social survey.

№	Question	Answer	Responses (%)	Responses (№)
Part 1				
2	Have you been to/purchased from an architectural salvage shop before?	Yes	16.7	9
		No	83.3	45
3	When renovating/refurbishing your home, would you consider buying salvaged materials instead of newly manufactured ones?	Yes	12.7	7
		Yes, but it depends on the salvaged materials’ appearance	34.5	19
		Yes, but it depends on the salvaged materials’ strength and durability	41.8	23
		No, because I need more information about the materials’ origin and performance	7.3	4
		No	3.6	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	58.2	32
		Information about the history of pieces/materials	49.1	27
		Information about the materials’ strength and durability	87.3	48

№	Question	Answer	Responses (%)	Responses (№)
		Information about the environmental impact of salvaged pieces compared to new manufacture of pieces of the same type.	52.7	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"	1.8	1
		Other: "Age and number of owners"	1.8	1
5	Do you consider the environmental impact of an item you are purchasing when that item is a piece of furniture?	Always	3.6	2
		Often	34.5	19
		Occasionally	34.5	19
		Never	27.3	15
6	Do you consider the environmental impact of an item you are purchasing when that item is a decorative piece?	Always	7.3	4
		Often	30.9	17
		Occasionally	25.5	14
		Never	36.4	20
7	Do you consider the environmental impact of an item you are purchasing when that item is a construction material?	Always	9.1	5
		Often	30.9	17
		Occasionally	32.7	18
		Never	27.3	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	89.1	49
		No	10.9	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	94.5	52
		No	5.5	3
10	And would that information impact your decision of purchasing it?	Yes	89.1	49
		No	10.9	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	94.5	52
		No	5.5	3
Part 2				
12	Chandelier	Old	45.3	24
		New	54.7	29
13	Wall light	Old	46.3	25
		New	53.7	29
14	Desk light	Old	54.5	30
		New	45.5	25

№	Question	Answer	Responses (%)	Responses (№)
15	Floor light	Old	41.8	23
		New	58.2	32
16	Fireplace	Old	60.0	33
		New	40.0	22
17	Wardrobe	Old	29.1	16
		New	70.9	39
18	Table	Old	60.0	33
		New	40.0	22
19	Gates	Old	45.5	25
		New	54.5	30
20	Armchair	Old	13.0	7
		New	87.0	47
21	Dining chair	Old	25.5	14
		New	74.5	41
*Note: Question 1 not listed since it concerns the consent to participate in the survey				

4.2 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 summarised 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.

5. CONCLUSIONS

This case study 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.

The survey highlightesd that only 17% of respondents had visited an architectural salvage shop.

Hence, there is a clear need to raise public/construction sector awareness about the reuse opportunities provided by the salvage/reclamation sector. When asked whether they would consider purchasing salvaged materials, a large percentage of people responded positively, although for the majority the strength/durability of the object/material (42%), or its appearance (34%), would play the most important role in their decision. About half of the respondents expressed interest into being provided with more information concerning the environmental impact of the pieces they were considering for purchase. A key conclusion is that after being prompted to think about environmental impacts, people seem more prone to making a decision about a purchase based on information comparing the relative environmental impacts of salvaged and new items.

Software to estimate the sustainability of architectural salvage was successfully developed. It can make it easy for the supplier, i.e. the people working in the salvage trade, to provide quantitative data that compares salvaged vs new materials/products. Since the survey identified that the public are interested in this information, the software may 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 development 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. For example, glass can have very high or very low embodied carbon (ranging from 5 to 105 kg CO_2e/kg) depending on the type of glass. 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.

The conclusions from this study 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.

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