ARCHITECTURAL UPCYCLING: BUILDINGS FROM WASTE AND UNCONVENTIONAL MATERIALS

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ABSTRACT

Repurposing building materials has been practised since old civilisations, but recently, it has transcended to utilising not only building materials but to general waste items not typically used in construction. The practice is coined as architectural upcycling. Due to its unconventional nature, several drawbacks exist: the challenge of appropriating the item for its architectural purpose, the limitation on the type of buildings it can be applied to, and the scarcity of research that establishes a guide on architectural upcycling. This research aims to provide an insight on how to achieve the excellent practice of architectural upcycling through design considerations based on the type of buildings fit for this practice. The design considerations are outlined from reviewing previous studies, and the types of small-scale structures typically suitable are identified. Sixteen case studies are chosen from four small-scale typologies: community buildings, single residences, lodgings, and pavilions. Variables observed are the role of the material, functionality, modification, ability to be disassembled and material expression. It is found that the buildings from the four typologies exhibit different approaches to addressing these considerations. The findings serve to guide designers in achieving successful upcycling practice based on the typologies studied.

Keywords: Architectural upcycling, repurposed materials, unconventional building materials.

1.0 INTRODUCTION

The built environment has had a tremendous impact on the environment during both construction and operation. Studies show that the construction sector is the world's heaviest natural resources consumer (Pullen et al., 2012) and accounts for the largest share of the global final energy use (Global Alliance for Buildings and Construction, 2019). The construction of buildings, albeit beneficial to the community, poses harmful effects on the physical environment and natural ecosystems. Architects, builders, and designers should therefore carefully consider the design and construction of buildings to minimize their overall use of resources and impact on the environment.

The practice of reusing and repurposing building materials is a sustainable approach in building construction and in recent years, it has transcended to not only utilizing building materials but to general solid wastes and items not typically used in construction. This practice, which has been coined as architectural upcycling, is a strategy to divert waste from landfills and preserve natural resources. These buildings have a sense of uniqueness in appearance as the materials are not conventional building materials. Because of this, several drawbacks exist, which are the challenge of making the item appropriate for its architectural purpose, the limitation on which type of buildings it can be applied to and the scarcity of research that establishes a guide on architectural upcycling. Since these materials are not normally used in building construction, appropriate methods are required to make them applicable in buildings (Cassidy, 2017). Addressing these challenges is essential to ensure that the practice truly achieves its goal of giving the item a second life. This research aims to provide an insight on how to achieve the good practice of architectural upcycling through design considerations based on the type of buildings fit for this practice.

The objectives of the study are:

- To outline and discuss the considerations in upcycling unconventional materials not typically used in buildings,
- To identify the type of buildings in which this form of upcycling is suitable to be applied, and
- To observe if and how the considerations in upcycling are influenced by the type of buildings it is being applied to.

This research focuses on the up-and-coming practice of upcycling waste materials that are not typically used in building construction, which has recently gained interest mainly in the construction of small-scale buildings. For this study, such materials will be referred to as "unconventional materials." This research will serve as a guide for designers and builders in achieving successful practice in upcycling to ensure that they fulfil the purpose of giving waste a second life and putting it to a longer-lasting use.

2.0 LITERATURE REVIEW

2.1 Upcycling vs. Recycling

The term upcycling was first used by Reiner Pilz (Kay, 1994) in which he described that upcycled products are given more value. The concept was described by McDonough and Braungart (2002) in their book Cradle to Cradle. Upcycling avoids the waste of potentially useful materials by utilising existing ones. Upcycling can be collectively defined as the creation of new products of higher values and/or qualities by transforming or repurposing waste or used material by reusing it in a new way without remanufacturing or material degradation thus giving it a new life (Sung, 2015). Both upcycling and recycling promote the same benefits to the environment. However, they are different in several factors. Upcycling is the repurposing of materials in their current state into something new without the need for breaking them down into raw materials.

The process of recycling requires materials to be broken down and converted into new products or materials, which are then remanufactured, thus using more energy (Ali et al., 2013). Upcycling items rather than recycling them has the advantage of saving in embodied energy. Embodied energy is the overall energy inputs consumed during a product's life cycle (Finkelstein, 2014). Recycling still saves energy as compared to the production of new materials from raw resources (Johnson, 2015). However, upcycling takes a step further in saving energy as it does not require the energy-consuming process of breaking down the materials. The major differences between recycling and upcycling can be summarized in Table 1. Recycling should be seen as the last resort as the process involves chemicals that contaminate the environment. Upcycling is the preferable solution, as it does not consume as much energy and is more environmentally friendly.

Table 1 The difference between recycling and upcycling

Classification	Recycling	Upcycling
Process	Requires breaking down into raw materials	It does not require breaking down into raw materials
Embodied Energy	More energy-saving than the production of new materials	More energy-saving than recycling
Form & character	Original form & character may change	The original character is retained, form is still recognisable

2.2 Architectural Upcycling: A New Way of Building?

What makes upcycling distinct is precisely the incorporation of the transformation process in the product (Wegener, 2016). Opening up this kind of unconventionality paves the way for new methods in efforts to avoid contributing to the landfill. Another reason for encouraging this change to be more widespread is it can open new opportunities for creativity. Due to the nature of the materials used, this architecture may deviate from conventions. Variety is found in this deviation. Furthermore, the use of materials out of context and in unconventional ways invites experimentation and discovery (Cassidy, 2017). When an item is repurposed, its function and/or application are changed to fit a new purpose. It is at this point that creativity comes into play in realising the new outlook and application of the item. A material or item that is repurposed is modified into something different from its original form, often in more ways than one. The most apparent modification is seen in the way the item is being used or its function. For instance, used plastic containers which are used to store food and goods, are transformed into building façade screens that shade the interior from rain and sun.

Materials can also be modified in the way they are assembled, jointed, or put together. In upcycling, this is achieved by low-tech and innovative strategies of assembly, which encourages a ready-made approach over large energy-consuming methods of reprocessing material compositions (McDowell, 2013). The ready-made strategy for upcycling relies on connections, joints and details.
Another aspect of modification can be seen in the way the material is perceived or valued. Waste materials that have lost their usefulness can be converted and elevated to form aesthetic elements or products of artistic value. Such transformations have the potential to produce unique spatial environments and design qualities, as the design character and qualities of the material are clearly emphasised. An example of this is the Wat Pa Maha Chedi Kaew, a Buddhist temple in Thailand, which was built using beer bottles. Local monks, who were tired of seeing beer bottles littering their local town, spearheaded the Temple of a Million Bottles. (Sunkara, 2018). The monks succeeded not only in reducing waste, but also in elevating glass bottles of little worth into an architectural beauty. The key process in upcycling, which is modifying an item's function and/or application, method of assembly, perceived value, or all of the above, opens the doors to new creations.

2.3 Suitability in Small Scale Typologies

In recent years, the practice of architectural upcycling using generic waste items has gained interest mostly in the construction of small-scale buildings and temporary structures. More predominantly in the USA, there has been a trend of upcycling tiny homes from large vehicles such as trucks and buses (Property, 2020). A more common architectural upcycling practice that has also been garnering attention is the upcycling of ISO shipping containers. The idea of ISO shipping containers as houses has been revolutionized in European countries for years. It began to appeal in many major cities in the United States, Canada, Netherlands, China, Australia, New Zealand, and much of Europe (Wong et al., 2018). The unconventional use of materials has also become a trend in the motel industry. Across the world, shipping containers and even concrete pipes have been used in temporary accommodation such as hotel rooms and lodgings. If these upcycled items were indeed used, discarded and no longer of value, then the practice is resourceful and thus it is a win-win situation (Cassidy, 2017). But if the supposedly upcycled items were new, still useful, and merely used for aesthetics, then it is a futile effort, and no different than building from new resources.

Upcycling unconventional materials have also been applied in small-scale community buildings, where members of a community tend to gather for group activities, social support, public information, and other purposes. The Glass Chapel by Rural Studio, located in Masons Bend, USA

is an example of a small community centre which serves as a transportation stop, community gathering space and chapel for the town residents. Perhaps most frequently seen cases of upcycling are in the form of pavilions or temporary installations. Often in these cases, the use of materials is more diverse and explorative as there is less concern on functionality and practicality. Even though the practice of upcycling is constricted to small-scale building typologies, it is an incremental step towards a more sustainable architecture that creates potential for creative solutions. It insists that the designers 'think out of the box' and out of their comfort zone. The conventional way of designing encourages the designer to explore the form or shape of a design.

2.4 Considerations in Upcycling Unconventional Materials

When designing using upcycled materials, it is important to establish criteria to ensure that the material is able to fulfil its role accordingly. The material may not be used in the same way it was used before, but it should fit its new purpose appropriately, and preferably be able to provide a solution to an issue or a purpose to a space (Ali et al., 2013). The primary considerations highlighted in this research are shown in Table 2.

Table 2 Considerations in upcycling unconventional materials

Consideration	Description
Defining the Role of the Material within the Building	Establishing the role of the building, and the primary role of the material within that building, (Cassidy, 2017). What is the primary intention of using the material? What needs will the material fulfil?
Functionality and Purpose	Questioning how the material relates to the building system and the building material it replaces (Cassidy, 2017). Finding connections between the two reveals the item's potential for repurposing as an architectural project. Utilising the item's embedded intelligence, which is its qualities and properties, will take advantage of what it was built to accomplish best but in a new context.
Modification	Because the items are not standard construction materials, some modifications might be required. Ease of change is therefore vital. The modifying works should be a simple enough skill that the typical labour can learn.
Ability to be Disassembled	Efforts need to be focused on designing with pieces that can come apart in order to allow future reuse. Reversible joints such as bolts and screws are preferable (Gorgolewski et al., 2009).
Material Expression in Building	This relates to how the material will be expressed in the building. Will it be a prominent design feature? Or is it purely functional? Unless the material is not visible, it should have meaning in the space and should not cause disharmony with the materials around it. How the material is expressed – whether bold and contrasting or subtle and nuanced – should relate back to the design intent.

When upcycling unconventional materials, there is a preconceived notion that the building will ultimately look like junk, literally. While that may be true in some cases, it is not an ideal way to promote upcycling. If upcycling is ever going to compete with using new materials, aesthetics needs to be prioritised. Two buildings, though both made from upcycled materials – Scrap House in the USA and Upcycle House in Denmark – demonstrate contrasting design outcomes. As seen on the

exterior of Scrap House, the materials upcycled, which are road signs, are vividly expressed and can be easily recognised by those who come across it. On the contrary, the materials used in Upcycle House, which were shipping containers, recycled aluminium soda cans, champagne cork leftovers and others, were more subtle and refined. The recycled and upcycled materials are not very visible and the building does not radiate a reclaimed look – it appears and functions like a contemporary house built from conventional materials (Arkitekter, 2013). Naturally, this does not mean materials that are expressed vividly cannot achieve pleasing aesthetics. The Wat Pa Maha Chedi Kaew Temple is an example of a building where the upcycled materials can easily be recognized. The colourful glass bottles created a stunning visual effect.

3.0 METHODOLOGY

Four typologies of small-scale buildings are chosen as the research sample which are community buildings, single residences, lodgings and pavilions or temporary structures. Four buildings were observed from each typology, making a total of sixteen case studies, as shown in Table 3. The selection criteria for case studies are building designs that portray new ways of using waste materials that are not typically used in building construction. The variables observed in the case studies were selected based on the factors that need to be considered in upcycling unconventional materials. The variables are listed in Table 3.

Table 3 Case studies selection classified based on typologies

Typology	No.	Building Name	Upcycled Item	Building System
Community Building	1	Glass Chapel, Masons Bend, USA	Car windshield	Envelope (cladding)
	2	Bima Microlibrary, Bandung, Indonesia	Plastic containers	Façade screen
	3	Wat Pa Maha Chedi Kaew Temple, Thailand	Glass bottles	Envelope (wall and floor finishes)
	4	Cyberjaya Community Recycling Collection Centre, Malaysia	Plastic bottles	Envelope
Single Residences	5	Upcycle House, Denmark	Container	Envelope
	6	Scrap House, San Francisco, USA	Phonebooks, road signs, fire hose, keyboards	Envelope (cladding), interior finishes
	7	Reclaimed Modern. Washington, USA	Corrugated metal	Envelope (cladding)
	8	Container Homes, Pahang, Malaysia	Shipping container	Envelope
Hotel / Lodging	9	Save the Beach Hotel, Rome, Italy	General discarded items / trash	Envelope, wall finishes
	10	Geneseo Inn, California, USA	Shipping container	Envelope

	11	Time Capsule Retreat, Pahang, Malaysia	Concrete tube	Envelope
	12	The Ocean Residences Suites, Langkawi, Malaysia	Shipping container	Envelope (walls, roof)
Pavilion / Temporary Structure	13	Rising Moon Pavilion, Hong Kong	Plastic bottles	Shading
	14	Bat-Yam Cans Pavilion, Israel	Tin cans	Shading
	15	Tulane City Park Canopy, New Orleans, USA	Road signs	Shading
	16	ETH Future Pavilion, New York, USA	Wooden pallets, beverage cartons	Structure support, shading

Table 4 Variables observed in case studies

No.	Considerations for upcycling unconventional materials	Classification
1	Driving factors of the use of unconventional waste materials	Aesthetic & Appearance
		Sustainable factor (relating to waste reduction, saving resources and embodied energy)
		Social factor (relating to social significance, education, awareness)
		Local factor (relating to locality, culture, history)
2	Functionality: relation between the waste material and the building system/material it replaces	Very much related
		Somewhat related
		Not at all related
3	Modification required	No modification
		Minor modification required
		Major modification required
4	Ability to be disassembled	Can be disassembled
		Can be disassembled but will cause minor damage
		Cannot be disassembled without causing major damage
5	Material expression in building	Vividly expressed
		Subtly expressed / less obvious
		Not expressed in building appearance

The data obtained from the case studies are tabulated and compared among each other for each variable. It is then discussed how, in the context of architectural upcycling, these typologies differ from one another in terms of their design considerations.

4.0 RESULTS

The sixteen case studies, classified by typology, are cross-checked against each of the factors of

considerations which are the role of material within the building, functionality, modification required, ability to be disassembled and material expression in the building. The data is tabulated in Table 5, Table 6, Table 7, Table 8 and Table 9.

Table 5 Case studies cross-checked against the tole of material within building

No.	Typology	Building Name	Role of Material within the Building			
			Aesthetic & Appearance	Sustainable factor (relating to waste reduction, saving resources and embodied energy)	Social factor (relating to social needs, education & awareness)	Local factor (relating to locality, culture and history)
1.	Community	Glass Chapel, USA	/	/		
2.		Bima Microlibrary, Indonesia	/	/	/	
3.		Wat Pa Maha Chedi Kaew Temple, Thailand	/	/	/	/
4.		Cyberjaya Community Recycling Collection Centre, Malaysia	/	/	/	
Percentage			100%	100%	75%	25%
5.	Residence	Upcycle House, Denmark	/	/		
6.		Scrap House, USA	/	/	/	
7.		Reclaimed Modern, USA	/	/		
8.		Container House, Malaysia	/	/		
Percentage			100%	100%	25%	-
9.	Hotel / Lodging	Save the Beach Hotel, Italy	/	/	/	/
10.		Geneseo Inn, USA	/	/		
11.		Time Capsule Retreat, Malaysia	/	/		
12.		The Ocean Residence	/	/		

		Suites, Malaysia				
Percentage			100%	100%	25%	25%
13.	Pavilion	Rising Moon Pavilion, Hong Kong	/	/	/	
14.		Bat Yam Cans Pavilion, Israel	/	/	/	
15.		Tulane City Park Canopy, USA	/	/		
16.		ETH Future Pavilion, USA	/	/	/	
Percentage			100%	100%	75%	-

Table 6 Case studies cross-checked against functionality

No.	**Typology**	**Building Name**	**Functionality: relation between the waste material and the building system/material it replaces**		
			Very much related	Somewhat related	Not at all related
1.	Community	Glass Chapel, USA	/		
2.		Bima Microlibrary, Indonesia		/	
3.		Wat Pa Maha Chedi Kaew Temple, Thailand	/		
4.		Cyberjaya Community Recycling Collection Centre, Malaysia			/
Percentage			50%	25%	25%
5.	Residence	Upcycle House, Denmark	/		
6.		Scrap House, USA			/
7.		Reclaimed Modern, USA	/		
8.		Container House, Malaysia	/		
Percentage			75%	-	25%
9.	Hotel / lodging	Save the Beach Hotel, Italy			/
10.		Geneseo Inn, USA	/		
11.		Time Capsule Retreat, Malaysia		/	
12.		The Ocean Residence Suites,	/		

		Malaysia			
Percentage			50%	25%	25%
13.	Pavilion	Rising Moon Pavilion, Hong Kong			/
14.		Bat Yam Cans Pavilion, Israel			/
15.		Tulane City Park Canopy, USA			/
16.		ETH Future Pavilion, USA			/
Percentage			-	-	100%

Table 7 Case studies cross-checked against modification required

No.	**Typology**	**Building Name**	**Modification required**		
			No modification	Minor modification required	Major modification required
1.	Community	Glass Chapel, USA	/		
2.		Bima Microlibrary, Indonesia		/	
3.		Wat Pa Maha Chedi Kaew Temple, Thailand	/		
4.		Cyberjaya Community Recycling Collection Centre, Malaysia	/		
Percentage			75%	25%	-
5.	Residence	Upcycle House, Denmark		/	
6.		Scrap House, USA		/	
7.		Reclaimed Modern, USA		/	
8.		Container House, Malaysia		/	
Percentage			-	100%	-
9.	Hotel / lodging	Save the Beach Hotel, Italy	/		
10.		Geneseo Inn, USA		/	
11.		Time Capsule Retreat, Malaysia		/	
12.		The Ocean Residence Suites, Malaysia			/
Percentage			25%	50%	25%
13.	Pavilion	Rising Moon	/		

		Pavilion, Hong Kong			
15.		Bat Yam Cans Pavilion, Israel	/		
16.		Tulane City Park Canopy, USA		/	
17.		ETH Future Pavilion, USA	/		
Percentage			75%	25%	-

Table 8 Case studies cross-checked against ability to be disassembled

No	**Typology**	**Building Name**	**Ability to be disassembled**		
			Can be disassembled	Can be disassembled but will cause minor damage	Cannot be disassembled without causing damage
1.	Community	Glass Chapel, USA	/		
2.		Bima Microlibrary, Indonesia	/		
3.		Wat Pa Maha Chedi Kaew Temple, Thailand			/
4.		Cyberjaya Community Recycling Collection Centre, Malaysia	/		
Percentage			75%	-	25%
5.	Residence	Upcycle House, Denmark	/		
6.		Scrap House, USA		/	
7.		Reclaimed Modern, USA		/	
8.		Container House, Malaysia	/		
Percentage			50%	50%	-
9.	Hotel / lodging	Save the Beach Hotel, Italy		/	
10.		Geneseo Inn, USA	/		
11.		Time Capsule Retreat, Malaysia		/	
12.		The Ocean Residence Suites, Malaysia			/
Percentage			25%	50%	25%

13.	Pavilion	Rising Moon Pavilion, Hong Kong	/		
14.		Bat Yam Cans Pavilion, Israel	/		
15.		Tulane City Park Canopy, USA	/		
16.		ETH Future Pavilion, USA	/		
Percentage			100%	-	-

Table 9 Case studies cross-checked against material expression

No	Typology	Building Name	Material expression in building		
			Vividly expressed	Subtly expressed / less obvious	Not expressed in building appearance
	Community	Glass Chapel, USA	/		
1.		Bima Microlibrary, Indonesia	/		
2.		Wat Pa Maha Chedi Kaew Temple, Thailand	/		
3.		Cyberjaya Community Recycling Collection Centre, Malaysia	/		
Percentage			100%	-	-
4.	Residence	Upcycle House, Denmark		/	
5.		Scrap House, USA	/		
6.		Reclaimed Modern, USA	/		
7.		Container House, Malaysia		/	
Percentage			50%	50%	-
8.	Hotel / lodging	Save the Beach Hotel, Italy	/		
9.		Geneseo Inn, USA	/		
10.		Time Capsule Retreat, Malaysia	/		
11.		The Ocean Residence Suites, Malaysia	/		
Percentage			100%	-	-
12.	Pavilion	Rising Moon Pavilion, Hong Kong	/		
13.		Bat Yam Cans	/		

		Pavilion, Israel			
14.		Tulane City Park Canopy, USA	/		
15.		ETH Future Pavilion, USA	/		
Percentage			100%	-	-

5.0 DISCUSSIONS

The data collected is then evaluated to produce an outline of factors that need to be considered in upcycling unconventional materials based on the building typology. The relationship between the building typology and the considerations for upcycling materials for building use is established.

5.1 Role of the Material within the Building

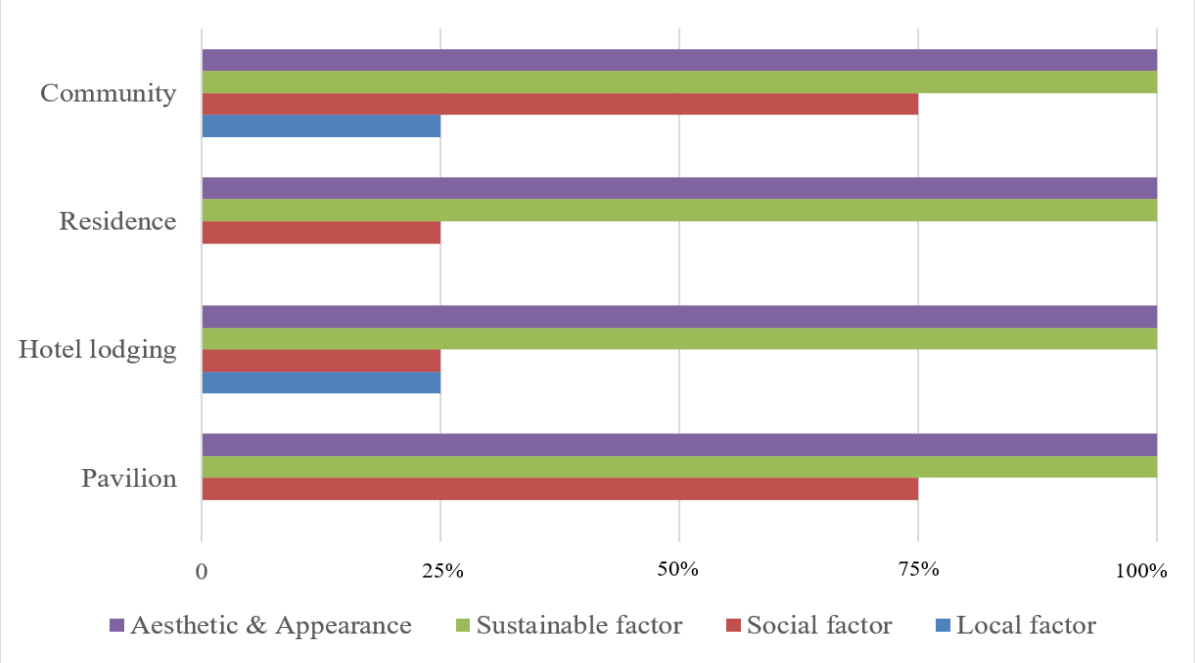

Fig 1: Bar chart of the analysis on the role of the material within the buildings in each typology

Figure 1 shows that aesthetic & appearance and sustainable value are the two most common driving factors behind the practice of architectural upcycling, which means the upcycled material is most usually intended for aesthetics and sustainability purposes. All upcycling projects in these four typologies are driven by aesthetics and appearance, which implies that the material is seen as a prominent design feature and intended for creating visual interest. Sustainable value is also a common driving factor, which infers that these practices are intended to reduce waste and/or the need for new materials.

In small community buildings and pavilions, the use of unconventional materials is more driven towards social factor, whereas in residence and hotel lodgings this factor is not significant. Social factor relates to addressing social issues, for example, education and awareness, and matters relating to society and community. For instance, the use of plastic containers in Bima Microlibrary is not only as façade screen. While exploring options on how to arrange 2000 ice cream buckets, the

designers realized that the buckets could be interpreted as zeros (opened) and ones (closed), thus giving them the possibility to embed a message in the façade in the form of a binary code. They decided to ask the Mayor of Bandung, Ridwan Kamil, who was a supporter of the project, to give a message. He agreed and gave a message which said "books are the windows to the world" (SHAU, 2016). Not only does the façade screen shade the interior and allow cross ventilation, it gives additional meaning to the building. The use of upcycled materials in community buildings and pavilions are more driven by this factor as they are primarily designed for the public and are therefore a more impactful medium to address social issues.

5.2 Functionality: Relation Between the Waste Material & the Building System/Material It Replaces

Figure 2 shows that in residences and hotel lodgings, most upcycled materials tend to be very much related to the building system it replaces. The Container House, for example, uses upcycled shipping containers as the building envelope. Function-wise, shipping containers are used to store and protect goods. Similarly, a building envelope that consists of walls, roof and floors are the physical separators that protect the interior and the occupants from heat, light, noise and other external factors. On top of that, shipping containers are durable and have strong built quality.

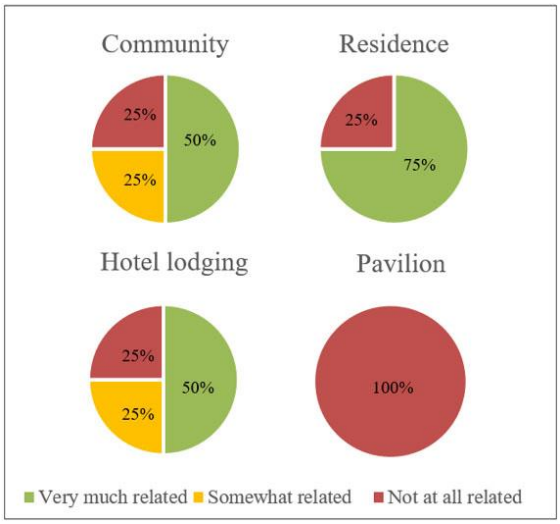

Fig 2: Pie chart on the analysis on functionality: relation between the waste material & the building system/material replaces

Thus, they relate very well to the building envelope. On the other hand, upcycled materials used in pavilions are not at all related to a building system. The use of upcycled materials in pavilions tend to be more out-of-the-box. Examples include everyday waste such as tin cans and bottles. This is because pavilions are mostly temporary structures and are typically used for the short term. The choice of materials is less filtered on their functionality. In residence and hotel lodgings, however, the materials need to have some embodied qualities of the building system it replaces. It needs to be able to function well as a substitute to the conventional material, as the building is a living space and human comfort is essential. Repurposing waste materials should not be an excuse for poor building performance.

5.3 Modification Required

When upcycling unconventional materials, sometimes modifications must be made to transform them into an appropriate building material. As seen in Figure 3, the upcycled materials in small community buildings and pavilions require no modification for the most part, while in residences, all require minor modification. In hotel lodgings, half of them required minor modification, a quarter required major modification, while another quarter did not require any.

The level of modification relates to the aspect of functionality. Residence and hotel lodgings are dwellings, residence for long-term and hotel lodgings for short term. Dwellings or living spaces need to provide the utmost human comfort to the occupants. Therefore any material that is repurposed into dwellings should be able to provide it. Ultimately using unconventional materials will have some limitations in its function, and thus, modifications need to be made to compensate for its inadequacies.

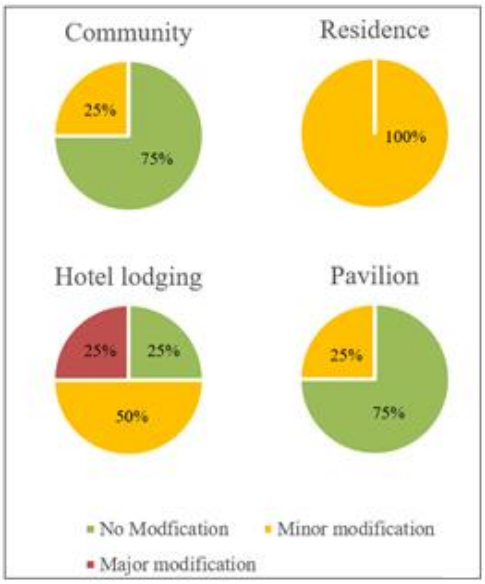

Fig. 3: Pie chart on the analysis on modification required

5.4 Ability to be Disassembled

Figure 4 shows the evaluation of the ability of the upcycled material and components to be disassembled. This factor allows the components to be reused and thus further extending their life cycle. It is seen that in all pavilions, the materials and components are able to be disassembled. While in small community buildings, 3 out of 4 buildings can be disassembled.

From this, it is noticeable that in the construction of pavilions, more focus is given to the consideration of the upcycled material's ability to be disassembled, as compared to the buildings in the other three typologies. This is because most pavilions are temporary structures that can be taken apart, moved and put back together again. This quality is still lacking in the other three typologies. Suppose all buildings were designed with more consideration on this factor. In that case, construction waste could be greatly reduced and the life cycle of not only upcycled materials, but also new materials and components can be extended.

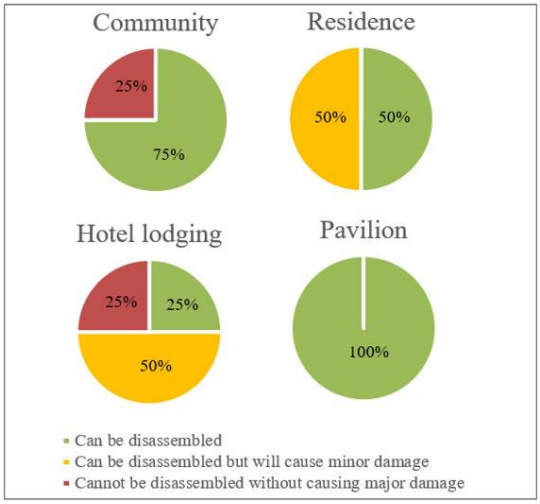

Fig. 4: Pie chart on the ability to be disassembled

5.5 Material Expression in Building

This factor relates to how the upcycled materials are expressed and aesthetically applied in the building and how the materials, even after repurposed, can still be identified in their original form. As seen in Figure 5, in all of the buildings, there is not a single use of unconventional materials that is not expressed or visible in some way. It can be said that the use of unconventional materials is heavily attributed to its aesthetics and its unconventional look. It is for that purpose mainly that they are chosen as building materials, thus their form is clearly seen and boldly expressed. Among the buildings in the residence typology, 2 out of 4 buildings use upcycled materials that are only subtly expressed, which means the appearance of upcycled material is less obvious and can blend with the new materials of the buildings. While we celebrate the use of waste materials, it does not mean that it must look like 'trash' or stand out in appearance. This is a suitable approach, especially for residences, whereby people would usually decorate and personalize their living spaces. The upcycled materials should look more subtle and not cause disharmony considering that there will be future personalization according to the occupants' interior design preferences.

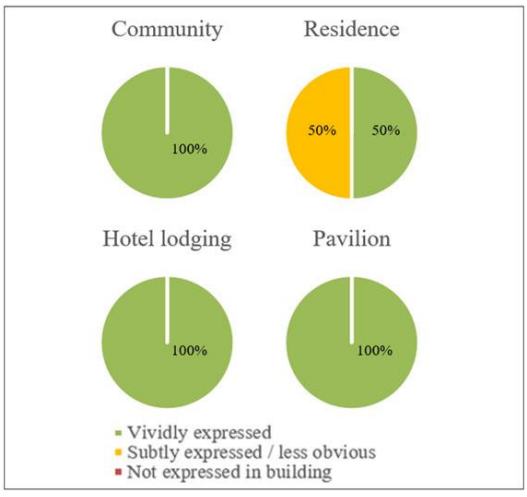

Fig. 5: Pie chart on the upcycled material expression in the buildings

5.6 Considerations for Upcycling Unconventional Materials in Each Typology

This research establishes that although in general the use of unconventional materials requires certain factors to be considered, the buildings in each of these 4 small-scale typologies exhibit different approaches to addressing these considerations.

In small community buildings, the use of unconventional materials is significant for its social factor which relates to addressing social needs as they are primarily designed for the public and are therefore a more impactful medium to address social issues. Overall, the use of unconventional materials in the buildings from this typology do not require modification which suggests the materials in their natural form are able to fit its new purpose appropriately. The materials are boldly expressed, and their form and features remain true. This suggests the use of unconventional materials is celebrated and intentional and is thus a prominent feature in the design. In residences, the unconventional materials have embodied qualities that are largely related to the building system and material it replaces. Greater importance is placed on functionality and practicality; thus, it is very important to have the materials tested and assessed on these qualities. Due to great importance being placed on these factors, most of the materials have to undergo minor modification for them to serve their architectural purpose appropriately. It is also observed that in residences, consideration is being given to making the materials harmonise and blend well with other materials. Thus the 'upcycled' appearance is less obvious. This can potentially increase its appeal to a wider market and can further encourage the use of upcycled materials.

In hotel lodgings, there is also emphasis in functionality, though few tend to go for unusual material choices. Great importance is also placed on the uniqueness of the material to attract potential customers, which is also the reason why upcycled materials in hotel lodgings are vividly expressed. However, buildings from this typology are still lacking in the ability to be disassembled.
In pavilions, there is less restriction in terms of functionality. Therefore the use of unconventional materials is more out-of-the-box and able to produce unique designs. There is also no modification required, which means the materials are being reused in their exact form. This is also due to the less need for practical use. As most pavilions are temporary structures, great consideration is being given to allowing the materials and components to be disassembled, thus allowing them to be moved and put back together again. Overall, it can be said that the use of unconventional materials in buildings from all four typologies are attributed to the aesthetic appearance and sustainable factor of the materials. While the use of these materials can produce unique designs, it is first and foremost crucial to give considerations to the factors discussed to ensure the practice truly achieve the goal of putting waste to good use and giving it a second life.

6.0 CONCLUSION

Architectural upcycling is a promising sustainable alternative to mainstream construction practices. It is suitable to be applied in the construction of small-scale buildings. The main small-scale buildings identified include small community buildings, residences, hotel lodgings and pavilions or temporary structures. When upcycling unconventional materials, several factors need to be considered are the role of material, functionality, modification, ability to be disassembled and material expression. This research establishes that although in general, the use of unconventional materials requires these factors to be considered, the buildings from the four small-scale typologies exhibit different approaches to addressing these considerations. In small community buildings, the material is valued for its social significance; in residences, functionality and practicality are more emphasized; in hotel lodgings, uniqueness of appearance is greatly valued, while in pavilions, more importance is placed on its ability to be disassembled and uniqueness of appearance. The findings of this research serve

as a guide for designers and builders in achieving successful practice in upcycling. It is important to note that elegance and aesthetics do not have to be sacrificed in the name of sustainability. As designers, we attain aesthetics by strategizing how to apply the things and materials we employ. Only by overcoming this challenge can the use of waste materials increase and compete with new materials in the architectural scene.

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