Revealing circular material flow in Terrazzo making process

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Abstract. This paper investigates the value in material expression that reveals the material resource flow through terrazzo making process. The potential of the patterning process as a vital practice in terrazzo making is posed through attention to the use of salvaged elements and fragmented pieces of the material. They are an essential part of circular economy practice knowledge. The patterning process, such as reinforcement and recombination of salvaged materials is decreasing carbon emissions produced by fabricating new components of the terrazzo. Besides, the patterning process enables the materialization of the design intention and locals’ interests and particularities; in which it adds value to the material. This study was conducted through a workshop in Lombok, Indonesia, as part of an exhibition of architectural materials that were produced locally from earth-based ingredients. It is found that the value of sustainability lies in its ability to promote such circular strategies that can enable improved material resource efficiency as well as generate material value.

1. Introduction
In recent years the architectural design and construction industry has begun to focus on the environmental impact of building materials deliberately. A wide range of significant concerns includes the material value and longevity, material composition, and maintenance has risen towards circularity design thinking and practices as it enhances sustainable development [1]. The proliferating industrially produced material involves the ever-accelerating flow of materials [2]. The materials’ flow that is understood in a broad and critical sense related to circularity thinking and practices has gained increasing reflection with regards to the potential of material value generation and resource-life extension practices [1]. It is the understanding of circular material flow that will improve material resource efficiency as well as generate material value.

Understanding the circularity mechanism encompasses an in-depth understanding of the environmental, social and economic challenges and interconnections. Within a sustainability framework, circularity thinking, and practices addresses strategies that are related to the restorative and regenerative acts. Therefore, the circularity mechanism promotes the urgency to understand the material resource flow to generate resource efficiency [1,3] and also to respond to resource depletion. The idea of using salvaged elements and fragmented pieces of material is being highlighted in this study to “bring all resource flows back into a closed loop” [4]. It emphasizes the benefits of a circular economy related to the material resource efficiency that reduces the environmental impact in comparison to a traditional linear economy that requires new material production [1].

This paper addresses the critical role of local and traditional value and labor of terrazzo in the establishment of the circular-economy practice. It particularly highlights the importance of understanding the journey from material expression to the material value that represents material resources flow and shapes what we now understand as the circular practices. Focusing on the material...
resources flow as continuous and optimal processes within the energy and resource system, this study reveals the approaches to circular resource flow to determine what circular operations are essential within the terrazzo making process.

2. Context and Methods
This paper explores the patterning process of the terrazzo through a traditional hand-casting, labor-intensive method. In particular, the patterning process of terrazzo is identified within the three states: particles or materials, parts or components, and products or finished goods. The patterning process involves material extraction, part or component shaping, and product assembly.

The data in this study are collected from a workshop in Suradadi Village, Lombok, West Nusa Tenggara, Indonesia. This workshop is a part of an exhibition of architectural materials that were produced locally from earth-based ingredients [5,6]. The artisan is a Lombok-native who previously worked in Bali. We selected this workshop to be studied during our visit because there were only a few terrazzo workshops in Lombok. The workshop is also in the working process on several terrazzo sample types for a homestay construction project in Kuta, Lombok. Therefore, we had the opportunity to see the lengthy process of developing terrazzo. Photographs, videos, and interview excerpts are used to record the patterning process of the terrazzo. We look closely at what are the steps required to produce terrazzo; tools that are used in each stage; what kind of salvaged material is used in the mix of the terrazzo ingredients; and also the final sample from the different main ingredients. This information is then interpreted to unfold the flow from material expression to reach its value.

3. Revealing the Value in Expression
Incorporation of naturally occurring aggregates [7], recycled glass or plastic, as well as stone or marble that has been salvaged from other buildings makes terrazzo considered as one of the ‘green concrete’ [8] that responds to the resource and energy saving. The National Terrazzo and Mosaic Association (NTMA) stated that aggregates used in terrazzo making processes are the most common sources of recycled content [7]. The aggregates such as post-consumer recycling of colored glass, mirror, metal, brass, aluminum, seashells, broken bottles, bricks, porcelain and concrete are crushed and ground and capable of forming various unique finishes [7,9]. The offcuts leftovers are used for expression of material handling and formation [10] in the patterning process. The potential of the way material is handled, formatted and exposed is significance to the understanding of the material value. Value or significance arises not from things, but from the ways they (materials) are handled, worked, or treated [11]. The notion that material value is an integral part of material expression and labor is being promoted in this study.

The material expression of the terrazzo exposed in the form of surface, color and texture, relies on a mixture of embedded elements, particles and parts. Exposed aggregate in a cementitious or polymeric binder expresses the specificity of materials through the ways it is handled, worked or treated as we know as material labor [10]. “Material value is not in the material itself, but in the labor necessary for its formation” [10]. Material labor generates material ‘expression of assemblage’ [10] of the terrazzo making process and further creates material value and significance. This ‘expression of assemblage’ [10] is achieved through the visual articulation of each particle, parts or components and products of the terrazzo through the patterning process. The patterning process is a medium to highlight the journey from material expression of assemblage to the material value.

The circular economy’s benefits of having the ability to use salvaged and recycled materials means increased flexibility and optimal quality in supply due to access to multiple sources of raw materials. The potential of the terrazzo as building materials being refurbished, rather than replacing existing flooring, stairs, and cladding contributes to reducing waste and environmental impact. “Terrazzo tiles can be reused if they are bedded in a way that makes them easy to remove. They can, for example, be laid in the sand and given a weak lime cement mortar joint [4].” This process enables material expression disassembly to create the new material expression of assemblage. This condition represents substitution flows “in which the new input flow is being replaced with an outgoing flow from another process that has been poorly exploited or not at all. For example, replacing flow of “new” raw
materials consumed within a process with the flow of waste or by-products; this type of synergy can reduce supply costs or the cost of treating an outgoing flow [3].” Figure 1 shows the material resources flow in terrazzo making process from which the continual reuse loops [12] is being circulated within multiple states from particles, parts to products. In this way, substituted and dissembled material expression leads to the condition in which multiple values are being implemented and repurposed.

Figure 1. The material resources flow in terrazzo making

The study highlights the patterning process as a medium that is “limiting environmental impacts and improving the economic competitiveness and attractiveness of the territories” [3] and enhancing sustainability development. “Sustainability is not a utopian concept as within something that is always changing there is no ideal state. What it does demand is the ability to measure resources flows and how resources are used by people to ensure that these are achieved without damaging the ecosystems that supply them [13].” Understanding the journey from material expression to material value indeed acquires instrumental knowledge about sustainable functioning and performance. Moreover, it also requires building the competence to link material resources flow meaningfully together with sustainability factors in an environmentally, socially and economically responsible way.

4. Revealing Circular Material Flow and Operations
Optimizing the flows of resources used must consider the consistency, density, water absorption, and abrasion resistance [14] in the patterning process of the terrazzo production. Compared to the study on the incorporation of aggregates in green concrete production [8] it has shown that it is advantageous to increase the workability of concrete and produce durability properties. Terrazzo is one of the durable materials which “causes less dust problems than a plain concrete floor, and offers a hard, hygienic surface [4].” Particles or materials and parts or components of terrazzo production in particular in the patterning process require careful attention to ensure consistency of mix and coloration. From the workshop, it was apparent that the basic process of terrazzo production is mixing all the ingredients (broken marbles, white cement, calcium) with additional water. Comparison of mixed marble, calcium and white sand fragments is 2:2:1. Water quality and quantity determines the color produced. The
mixture composition depends on its use. Color is added based on the project’s specific order and requirements. Then, sigma dyes are mixed to produce colored terrazzo.

The process of embedding different particles or ornaments is usually done when the new terrazzo dough is poured. When it is almost dry, the terrazzo will be compacted again. After it becomes solid, the terrazzo must be allowed to stand for 1-2 weeks until completely dry. The terrazzo mixture is poured over a mixture of dry and leveled castings using a cement grinder. Based on the material formation, size, type, and color of particles used in the mixture as well as the type of finish used, terrazzo offers a wide range of material expression options.

Figure 2 shows the terrazzo patterning process that denotes the marks of human hands and enables the materialization of the design intention, locals’ interests and particularities. In this way, the process of patterning, embedding and revealing in the terrazzo making process promotes the marks of human hands and the evidence of uncoerced craft [11] that are expressed in the material surface of the terrazzo.

Figure 2. Terrazzo patterning process denotes the marks of human hands.

Revealing the potential of the patterning process enables the materialization of particularities which add the material value. “One aspect of this essence lies in local geography, climate, and customs, involving the use and transformation of local, ‘natural’ materials... Clearly, the engagement with particularities is one way the domination of technology can be interrupted [10].” In the process of embedding waste particles into the composition of terrazzo, the craftsmen’s intimate handling of the material requires the engagement with particularities, locality and specificity [10,15]. “Intimate handling of the material, the sense of the presence of the maker in the artefact, had considerable consequence on the evocative power of the work and perhaps, by association, its emotional accessibility [15]. At the micro-level, the design, the choice and formation of materials, the manner of its treatment, the tools, the color, the pattern, the texture, and all their compositions reflects the character of the local craftsmen and the depth of surface in the cultural sense [16] that can be seen in Figure 3.
At a macro level, sustainable performance permeated the built environment of the terrazzo making process to the accommodation of socio-economic relations. Investigating the circular resource flow of terrazzo making process to the accommodation of socio-economic relations also involves the engagement with particularities as Leatherbarrow suggested [10]. The collection system of salvaged materials is one of the keys to circular practice in the terrazzo making process. Due to the availability of the local craftsmen and terrazzo workshop in Lombok is limited, traditional labor has relied on large quantities of cheap and easily accessible materials and energy. In the collection system of salvaged materials, repurposing the waste as a resource is related to the circular supplies as well as resource recovery [17]. The identification of all the active and relevant ‘agents of expression’[18] around the terrazzo making process defines the actor-network through which the value in an expression is enhanced.

5. Conclusion

The understanding of circular material resource flow expands to take account of the value in the material expression and formation. Understood in a broad and critical sense, terrazzo making process concerns material expression that impact on material value. Through the micro and macro level understanding of circular material resources flow within the three states of terrazzo making process, the important characteristics of the circular value chain are established, to retain the material value in use and ensure an enhanced sustainable performance. The value of sustainability lies in its ability to promote such circular strategies that can enable improved material resource efficiency as well as generate material value. It is found that the patterning process in the terrazzo making process promotes the circular material flow which adds value to the material, to the socioeconomic relations and could optimize the quality of circular supplies and continual resource flow.

References

[1] Charter M 2018 Designing for the Circular Economy (Abingdon, Oxon; New York, NY: Routledge, 2018.: Routledge)
[2] Hagan S 2007 The New and the Renewed Material matters: architecture and material practice ed K Lloyd Thomas (London; New York: Routledge) pp 250–7
[3] Gallaud D and Laperche B 2016 Circular economy, industrial ecology and short supply chain
[4] Berge B 2009 The ecology of building materials (Oxford: Architectural Press)
[5] Atmodiwrjo P and Yatmo Y A 2020 “Tanahku Indonesia”: On Materialscape as the Materiality of a Nation Archit. Cult. 1–22
[6] Johanes M and Wahid A R 2018 Tanahku Indonesia: Celebrating the Indigenous Interior Interiority I 79–86
[7] The National Terrazzo & Mosaic Association, Inc. 2018 Green Terrazzo: The Environmental Impact of the Use of Cement and Epoxy Terrazzo
[8] Garas G L, Allam M E and Bakhoum E S 2014 Studies undertaken to incorporate marble and granite wastes in green concrete production ARPN J. Eng. Appl. Sci. 9
[9] North American Terrazzo, Inc. 1999 Terrazzo Specifications & Design Guide
[10] Leatherbarrow D and Mostafavi M 2002 Surface architecture (Cambridge, Mass: MIT Press)
[11] Leatherbarrow D 2009 Architecture oriented otherwise (New York: Princeton Architectural Press)
[12] Durmišević E 2018 Reversible building design Designing for the Circular Economy ed M Charter (Abingdon, Oxon ; New York, NY : Routledge, 2018.: Routledge) pp 344–59
[13] Garcia E and Vale B 2017 Unravelling sustainability and resilience in the built environment (London ; New York: Routledge, Taylor & Francis Group)
[14] Karam G and Tabbara M 2009 Properties of pre-cast terrazzo tiles and recommended specifications Cerâmica 55 84–7
[15] Shotton E 2007 Material Imprecision Material matters: architecture and material practice ed K Lloyd Thomas (London ; New York: Routledge) pp 92–102
[16] Eichinger G and Tröger E 2011 Touch Me! das Geheimnis der Oberfläche ; Gregor Eichinger spricht über die Benutzeroberfläche in der Architektur (Baden, Schweiz: Müller)
[17] McDonough W and Braungart M 2002 Cradle to cradle: remaking the way we make things (New York: North Point Press)
[18] Lloyd Thomas K 2007 Material matters: architecture and material practice (London ; New York: Routledge)

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