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Rethinking modularity as contextual design thinking

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Abstract

This study aims to reflect and expand the notion of modularity in architectural design methods. The discussion about modular architecture is certainly familiar across architectural discourse; where its universality has been repeatedly challenged by the post-modern movement. The study aims to unpack and rethink the method and significance of modularity, not only as a means of repetition but as a contextual design response. The study explores alternative understanding through design reflections of two modular-based lodge projects. This paper is based on two modular-based design projects in the context of lodging architecture that functions as a small dwelling used for temporal or seasonal inhabitation. The projects used as cases, as lodge architecture provides complexities with regard to various programmatic needs, construction processes, identity, and connection to the surrounding environment. This study examines four reflective concepts which expand the idea and method of modularity in architecture. First, the roof modules in lodge architecture bring new ways of creating efficient spatial programs. Secondly, the use of modularity allows the operation of building programs and the construction to co-exist as parallel processes. Thirdly, the utilisation of visual identity creation and system configuration using modules brings the possibility of creating architecture as parts constructing the whole and the other way around. Fourth, the positioning of the modules arranges the inside and outside experience, which becomes the basis of consideration regarding the environmental setting. This study offers a new perspective on repositioning and expanding modularity not only as a means of repetition but also as a way to rethink the contextualisation of the design process.

Keywords: modularity, context, modular architecture, lodge, design process

Challenging modularity

This paper aims to reflect on and redefine the idea of modularity, which tends to be used as the basis of designing forms, without connection or consideration of the context of the design. Plowright (2014) identifies various frameworks of design, dividing them based on their focus—be it in the application of composition and pattern (pattern-based framework) or in the understanding of the context (forced-based framework). Whilst discussion of modularity often falls into strategies of a pattern-based framework, this study argues that there is a possibility of rethinking modularity as a possible integration of both pattern and force-based frameworks.

Modularity is often associated with modern architecture and emerged through the Industrial Revolution, seemingly locking modular architecture into simply a process of continuous and boring repetition. However, it is argued that the idea of modularity itself goes beyond repetition. Wallance (2021), in his book on *The Future of Modular Architecture,* positions modularity as a possibility of responding to design problems as follows:

> The complex array of forces that have made innovation in design and construction so difficult to accomplish are stubbornly resistant. By adopting design thinking, a methodology for dealing with "wicked problems", the intermodal modular enterprise can resolve the conflicting and competing interests in the construction sector by engaging all stakeholders in an ongoing, collaborative, and iterative process. (p. 11)

Across architectural discourses, modularity with its repetitive character is also often challenged by the idea of design thinking to the contrary. According to Venturi et al. (1977), modularity is more than just functional; it includes practical and aesthetic aspects. Venturi

brings up the idea of contradiction and complexity, bringing the concept of modularity into question. Similarly, Tschumi (1996) has also argued that there is more to modular thinking than simple repetition and uniformity. Modular architecture therefore has the opportunity to be seen as a unity of product and thinking (Lehtonen, 2007).

This study expands the idea of modularity through reflection on architectural design practice. Reflection in practice is an important part of the development of knowledge (Schön, 1983). The architecture of the lodge is chosen as the object of study, due to the suitability of its character as one of fast and rapidly produced architecture (Lee et al., 2015), which often becomes the demonstration of applying modular design techniques. The location of the lodge, as temporally inhabited architecture that is often positioned in a natural context with various topography, and other aspects of locality is key in redefining modular thinking in architecture. This study aims to revisit modularity as more than just a repetitive pattern but positions it as a means of responding to design context.

Modularity: From movement to thinking

Modularity is strongly associated with modern architectural thinking. The modular character emerged as a response to the industrial revolution of the time (Jenks, 1999). However, in line with the development of design thinking, the uniformity of design that emerged due to modularity needs to be revisited, especially with the increasingly complex and diverse world conditions. This section reconsiders the repetitive character of this notion of modularity and its application potential for design approaches.

Le Corbusier's (1986) idea of *modulors* initiated the concept of modules in architecture, examining humans as the subject of architecture and underlying the dimensions of a space based on the proportions and scale of humans. The discourse of architectural design ideas

aligns with the conditions of various life aspects at a specific period of time. For example, in the era of modern architecture, the Industrial Revolution affected multiple aspects of life and brought architecture as part of its response (Combes & Bellomio, 1999). The architecture was then positioned as a series of industrial products, creating universal and uniform materials and configuration architecture (Foster, 1996; Krauss, 1986). In its development, architecture became a system with its series of materials and arrangements (Gropius & Wachsmann, 2021) with a focus on the effectiveness and efficiency (Larson, 1993) of its underlying design process.

The production and assembly system of modularity also allows architecture to be positioned as a standalone product. The possibility of having its components to be assembled and form an architecture underlies the existence of modular architecture without a designer or architect (Rudofsky, 1987). In the context of vernacular architecture, architecture exists as traditional knowledge, where the design process intersects with the act of assembling. Nevertheless, architecture cannot be entirely separated from context. The context of the world develops very dynamically, requiring design to be able to respond to complexity and diversity more intensively (Venturi et al., 1977).

Modern architecture movement with its uniformity and modularity is not simply positioned as the opposite of postmodern thinking with its complexity and diversity. Modularity has existed from classical architecture to the future (Bayliss & Bergin, 2020) and its meaning can be different from time to time (Corcuff, 2012). Thinking about modularity in architecture is not only a form of response in architectural design but also a thought and idea that has the potential to be developed continuously. This study explores the possibilities of modularity to be used in developing the formal composition, but also as the means of responding to

context. Such understanding utilises multiple frameworks of design methods as discussed by Plowright (2014) below:

> A hybrid method uses processes from multiple frameworks arranged in a hierarchical structure—there is a dominant framework in which secondary and tertiary frameworks are nested. The secondary frameworks operate at a different scale from the overarching framework, and, if necessary, occur multiple times within the primary method. (p. 313)

Alexander (1977) reveals that patterns can be used to drive the development of a complex system, particularly in response to site. For example, the idea of metabolism in Japanese architecture sees repetition in modules as an opportunity to position architecture dynamically. Architecture can be replaced periodically, allowing it to be dismantled and rebuilt in different ways as a cycle (Kurokawa, 1977; Tamari, 2014). On the other hand, modular architecture means prefabricated units, which have the potential to be easily constructed in their elements (van der Rohe & Puente, 2008). Modularity becomes an opportunity for designing the arrangements which respond to variations of contexts' diversity.

Such dynamic repositions of architecture reflect the adaptability and flexibility needs of society, enabled by how the modularity of architecture accommodates component combinations and recombination. "Those based on forces access spatial qualities, and pattern-based methods map human events to their formal context" (Plowright, 2014, p. 314). This thinking aligns with current ideas, where architecture should be able to respond to sustainability issues with their adaptability and flexibility. There is a potential for

modularity to respond to and follow the context and dynamism of the various conditions as the driver of architectural design itself.

The idea of flexibility and adaptability aims to perceive the act of repetition as a potential for re-creation or reconfiguration in response to the dynamism of function (Sosa et al., 2022). Flexibility and adaptability are consequences of sustainability and development in architecture. As a series of systems, modular thinking or pattern-based (Plowright, 2014) also has the consequence of positioning architecture in its elements, sequences, and sustainability, or force (Smith, 2011).

Rethinking modularity in contextual architectural design

This study rethinks the idea of modularity through the design of a lodge, which has specific aspects, contexts, and characters. To begin with, modular architecture is closely related to its material composition and arrangement. The organisation of various materials has the potential to become the fundamental element or component of a building that can be assembled and disassembled (Arisya & Suryantini, 2021). According to Frampton (2001, 2013), material tectonics celebrates materials' visual and textural properties. The possibility of combining materials opens up various logic of construction and exploring materials becomes a logical consequence of unpacking modularity in a design (Dharmawan & Alviano, 2019; Frampton, 2001). Understanding material exploration will also closely relate to what nature can provide as part of architectural materials.

A lodge design does not only pursue aesthetics but also requires harmonisation and good relations with nature as the context of the place. Another idea related to lodge architecture is the blend of outdoor and indoor spaces, between architecture and nature. This notion

aligns with Le Corbusier's (1986) idea that architecture becomes more than just a building, it is the blending between outside and inside which presents a richer spatial experience. Architecture is not limited to the inner space but becomes an in-between boundary space (Atmodiwirjo & Yatmo, 2019; Boettger, 2014). This concept of threshold space supports the architecture of lodges design principle, where threshold space interacts with the conditions of nature, bringing an overall relaxing experience.

The idea of modularity also supports the existence of lodging architecture as an economic commodity (Lee et al., 2015). Modularity supports the presence of simple architecture (Graafland, 1996), bringing efficiency in economic aspects (Musa et al., 2016) and construction methods. Modularity is closely related to the programmatic simplicity and efficiency in architecture as a unit of activity (Prayitno, 2018). In modern architecture, modularity creates consequences for a more compact scale and size of space, a rationalisation of design that leads to mass production (Gropius, 1965).

Modularity in the economic aspect raises the issue of rapid and temporary construction (Yatmo et al., 2021). Rapid construction with a compact cycle creates faster extraction of material from the environment and a quick building process, as part of industrial material cycles (Silva, 2020). Architectural construction and industrial manufacturing of building elements run parallel (Hogan-O'Neill, 2021), minimising the time parameters of architectural actualisation. In addition, the use of lodge architecture as a temporary and seasonal dwelling influences the life cycle of architecture to be more dynamic (Lee et al., 2015). The characteristics of mass production and efficiency in modular architecture become related to sustainable efforts in the era of the climate crisis (Wallance, 2021).

The modularity of lodge architecture also corresponds with the cultural context in which it exists. Wallace (2021) reveals the potential of the idea of the global vernacular, where the local character in modularity has the potential to be replicated more widely. This idea of replication does not mean limiting the possibility of exploration in design. Architecture can potentially juxtapose or reconfigure modules with others (Tschumi, 1996), showing them rather than hiding them. Local or historical references can be the basis for variation. The lodging architecture could expand the notion of modularity with its contextual relations of cultural diversity.

Modularity is challenged for its universality and boredom of pattern. However, its potential lies in its implementation in specific contexts as a form of possible variation as force. Modularity is not just about effectiveness and efficiency, it is also part of promoting design knowledge. The question of this study is how modularity is reflected as part of the expansion of design methods related to particular design contexts, such as lodging architecture with all its aspects and challenges.

Modular design projects: An overview

In exploring modularity, the investigation of each component in architectural design becomes a logical consequence. Skin as form, space, structure, site, and other elements or stuff can be the basis of its dismantling (Brand, 1995; Duffy, 1990). This qualitative study attempts to deconstruct two lodge architecture design projects, titled *Radika Paradise* and *Drini Hills #1*, which are located in Gunung Kidul, Yogyakarta, Indonesia. This study reflects on the design process and outcome, rethinking modularity as a design thinking that responds to various contextual aspects.

These two projects are located in contoured sites which can be both a potential and an obstruction of the design. Modularity creates the potential to respond to specific local and natural conditions as contextual forces presented by the surrounding local environment. The projects differ through their application of the module, its corresponding materials, and in response to context. Each project demonstrates how modularity plays a role in defining the spatial program, structural configuration, and materials composition. The following sections briefly outline the projects' overall design and application of modularity.

Radika Paradise: *An industrial-material modularity*

Radika Paradise (Figure 1) is a lodge design project situated on a relatively steep contoured land in the mountainous Gunung Kidul area, a part of Sewu Highlands, Indonesia. The exciting context of the design is that the site is located on a hill, nevertheless, within a certain distance, visitors can enjoy a view of the sea or the south coast of Java. The *Radika Paradise's* lodge module responds to the region's need for a tourist lodge. The target market is lower middle-class lodging, so sufficient capacity is critical in architectural design. The lodge module is designed with a combination of concrete structures as the stage of the form and steel structures as the basis of its wall and roof frames. The stilt form of the building structure was chosen because of ecological considerations, to change the landscape as little as possible as the overall site of the hills is part of the karst landscape of the highland. Thus, keeping karst hills in their original form and function is part of the attempt to maintain the sustainability of the unique karst ecosystem.
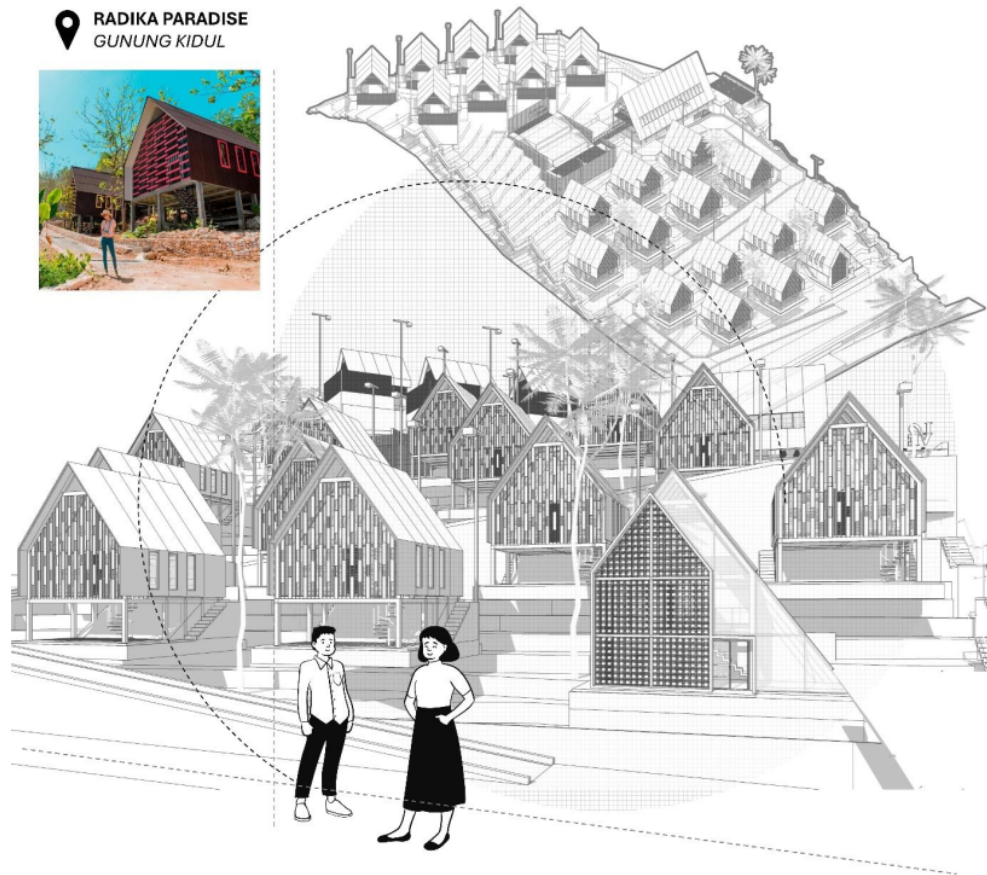
Figure 1. *Radika Paradise* lodge at Gunung Kidul (Image by authors)

The design consideration chooses steel structure because of the construction speed and the structural ability of a wide span which is needed to support larger capacity of the lodging units. The roof covering material uses a cellulose fibre industrial sheet material, a mixture of cellulose fibres created from recycled paper, bitumen, resins, and adhesives. Such use of material is due to the context need for construction speed and cost. In addition, the facade material is designed using a steel frame as the basis of a glass fibre-reinforced concrete (GRC) panel cover.

The composition of the GRC panel unit combination is designed as a colourful component to attract the lodge's target market audience. Capacity is a significant consideration in the design, where one lodge module is expected to accommodate approximately six residents, like a hostel, a communal lodging concept for optimising the operational costs of this lodge. The elaboration of material uses in the previous paragraph shows the exploration of industrial materials results from the need for speed of construction, economic factors, and ease of construction implementation by local communities. In the construction process, *Radika Paradise* is built in stages and operates partially according to the completion of construction per lodge unit. Figure 2 illustrates the idea of modules in the design of *Radika Paradise*.
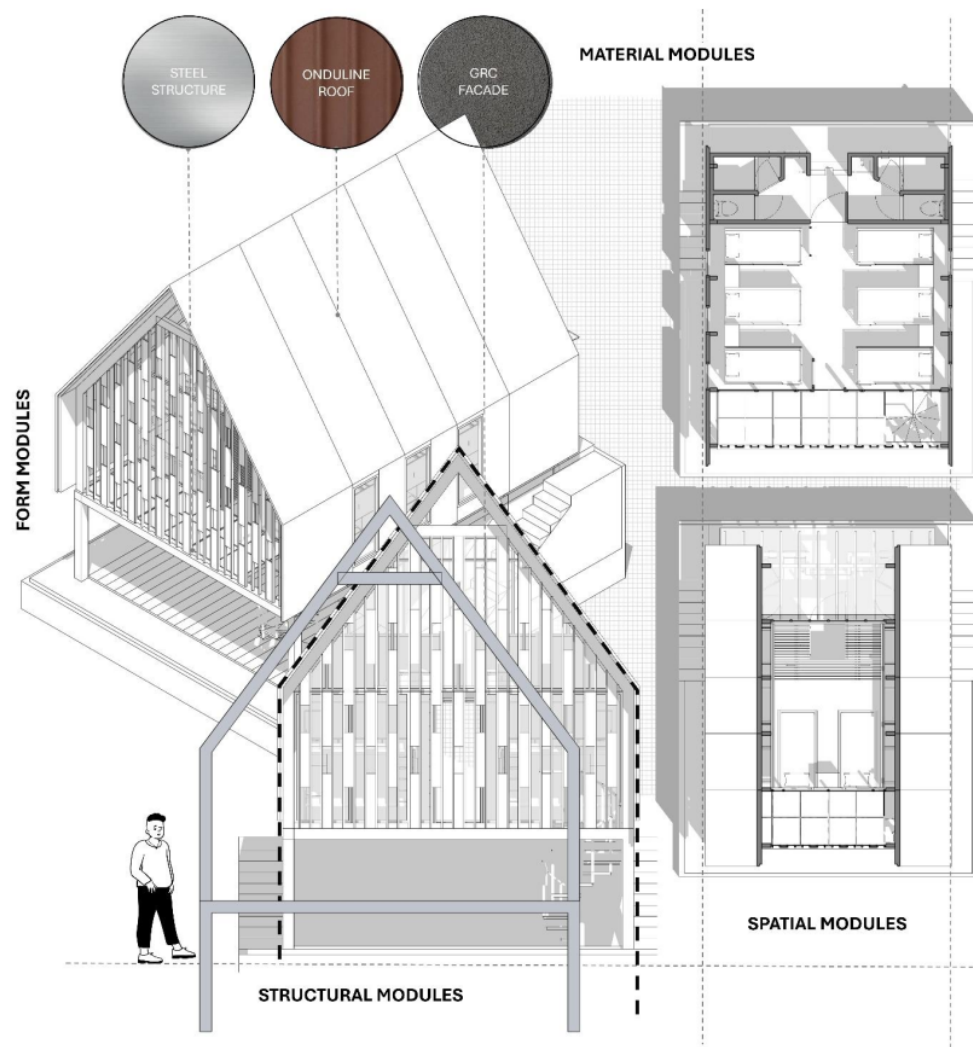
Figure 2. Modularity on *Radika Paradise* lodge (Image by authors)

Drini Hills #1: *Natural-material modularity*

Drini Hills #1 is a lodge design project situated on a gently sloping contoured land, also in Gunung Kidul, Yogyakarta (Figure 3). The exciting context of the design consists of its elongated footprint, which allows for multiple configurations of lodging units and entertainment facilities for the target users who are dominated by family lodgers.

Figure 3. *Drini Hills #1* lodge at Gunung Kidul (Image by authors)

Similar to *Radika Paradise*, *Drini Hills #1* lodge module responds to the region's need for lodging for tourism, however, the intended market is middle-class family lodging, with the expected capacity of two to four people for each module. The lodge module has a concrete

structure as its foundation stage and a timber structure for the upper wall frame and roof. The design considers timber structure because of the possibility of exploring the tectonics of the material to the interior experience, which is expected to be a particular attraction. Such use of wood structures demonstrates how the design explores natural materials resulting from the sense and experience of vacationing close to nature.
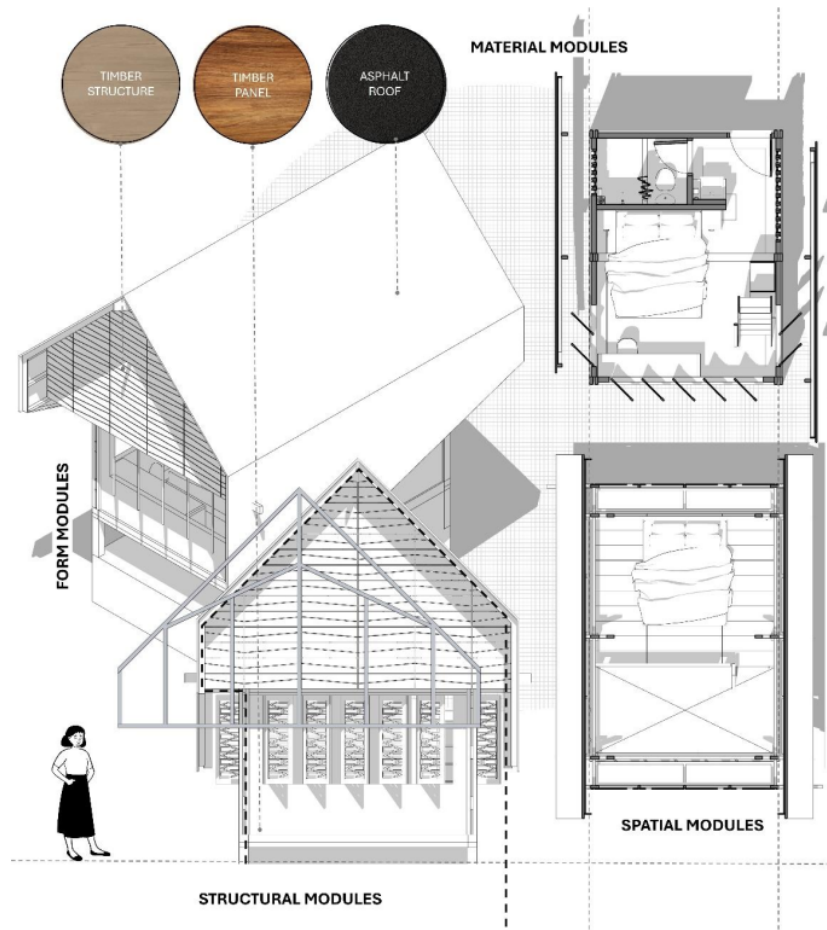

Figure 4. Modularity on *Drini Hills #1* lodge (Image by author)

Figure 4 illustrates the idea of modules in the design of *Drini Hills #1*. Similar to *Radika's* design, the stilt building structure of *Drini Hills #1* was chosen due to ecological considerations, intervening as little as possible the hills that are part of the karst landscape.

Drini Hills #1 was built in phases along with additional facilities such as a restaurant and swimming pool. The roof covering material uses a cellulose fibre sheet covering that matches the configuration of the supporting structure. The facade material is designed based on a wooden frame that is covered with wooden slat panels. The composition of the combination of wood panel units is then designed to reflect this area's locality. It is expected that one lodge module can ideally accommodate a small family, which is divided into a two-storey building with one room for each floor, creating an intimate lodging experience.

Lessons learned: Modularity of lodge architecture as contextual design

Form follows roof*: Roof form as the basis of spatial and programmatic efficiency*

The first reflection of the exploration of modularity in the design of the above works is the redefinition of the role of the roof element as a formal element of the building that drives the building's programming. The use of roof elements as part of space has been widely applied for various reasons such as creating a more compact space, as discussed in how "(t)hey sought economy by reducing the house from three to two stories, in which the partially excavated walk-out basement became the lower level, and the "attic" under the gently sloped roof became the upper level" (Wallance, 2021, p. 83).

The idea of modularity aligns with the strategy applied to *Radika Paradise's* and *Drini Hills #1*'s roof space design. The need for a large enough capacity in one lodging unit makes the role of the roof space expand into a living space. The roof structure module becomes an integral part in forming the architecture. The effectiveness of the program and space efficiency (Larson, 1993) occur through this modular roof element strategy as the building envelope wall and roof elements integrate and become one unified unit. The roof exists not

just as a shade but also acts both as the form elements and as an activity space of the lodging unit. Space efficiency occurs without increasing the footprint area, creating maximum occupant capacity without increasing the number of floors in the building. The building form follows the shape of the roof and the shape and the internal element of the roof define the space that occurs in it, including the furniture position and inner space configuration. The roof's slope becomes an important strategy for design in a tropical natural context, creating protection from water splash, particularly for a context that has a high rainfall intensity. Figure 5 illustrates how the roof, building form, and space integrate into the design.
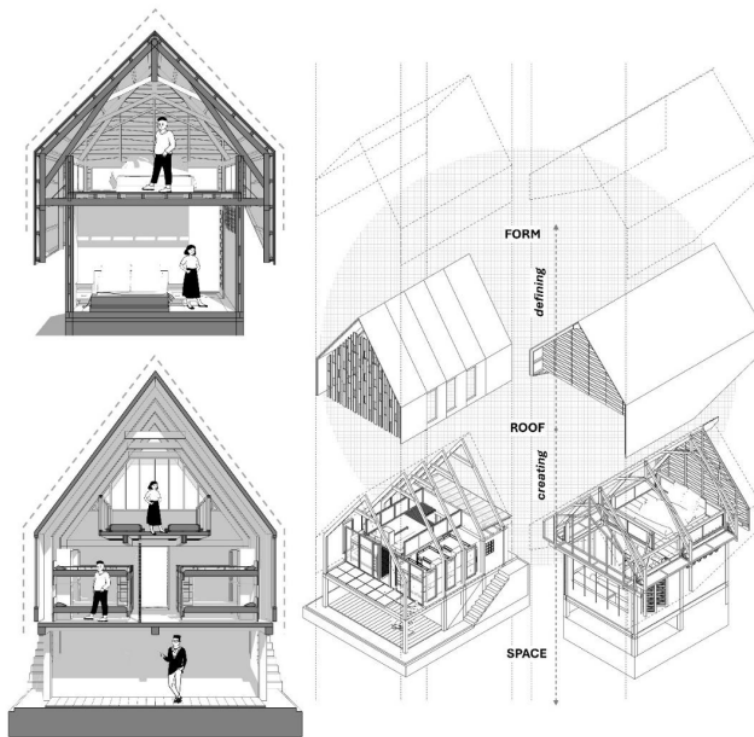

Figure 5. Roof defines form and creates space (Image by authors)

Constructing while operating: Prefabricated production

The second reflection from modularity exploration in the design of the above projects shows the possibility of conducting the prefabrication process in parallel with the process of construction. The use of modularity as a method of prefabrication also presents the need for ready-to-disassemble design or Design for Disassembly (DfD), a potential possibility for the dynamic presence of sustainable architecture (Arisya & Suryantini, 2021). "DfD promotes modularity and prefabrication, as well as simplified and standardized methods for constructing buildings that allow for easy deconstruction" (Wallance, 2021, p. 184). This idea aligns with 'fast architecture' (Lee et al., 2015), where buildings easily assembled industrially (Silva, 2020), can be dismantled and reconstructed in different places. Such easiness certainly supports economic efficiency in commercial architecture as well as supporting the sustainability of the project and its lifecycle.

Whitfield (2022) stated that modular design and construction are suitable for lodges that need to operate in stages without a fully completed construction phase. The construction concept is a response to economic factors, where the overall lodge can operate partially and be expanded as demands and market needs evolve. With modular thinking, the construction process in the challenging contoured context can occur more quickly because it is developed partially. Each lodging unit is constructed separately from the subsequent development unit. If a project is built in phases, some parts of the building could be occupied while others are still under construction. This requires careful planning and coordination to ensure safety and minimise disruption. Once the main structure is complete, the unit development may be able to begin the interior fit-out work on their spaces while the rest of the building is still

under construction. Figure 6 illustrates the construction cycle that supports the economic efficiency and operation of the facility with a phased system.
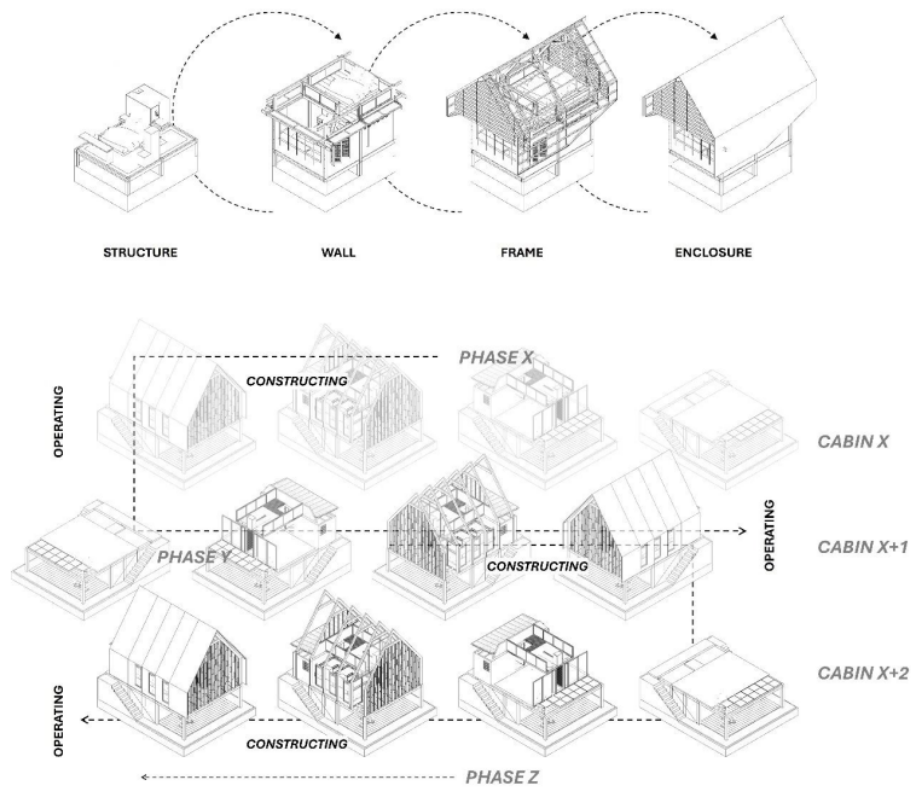

Figure 6. Construction and operation as a parallel process (Image by authors)

Re-repetition variation: Whole as part

The third reflection on the exploration of modularity in the project highlights the idea of repetition by seeing architecture as part of the whole and the wholeness of the project as part of the larger-scale master plan of the lodge complex. The material element of the lodge design can be configured differently according to how it represents the particular expression that needs to be presented as a whole. "With intermodal architecture, where

the addressable grid governs the layout, system kitchens can be integrated seamlessly in varied arrangements into the larger whole" (Wallance, 2021, p. 237). Repetition exists as a rule (Alexander, 1977; Pollio, 1914), allowing each part to be creatively composed to construct the whole altogether. The possible configurations which form the visual image of the modules as the whole design block in *Radika* Paradise and *Drini Hills #1* are very varied. From the macro perspective, the whole lodging unit becomes part of a masterplan arrangement in the design block and creates visual attraction. Opportunities for variation and adaptation are also present in the phased construction process. The possibility for expansion is significant to create a varied and dynamic configuration. Repetition within repetition becomes a mechanism that has the potential to bring variation within it. It can be seen that the modules are not only related to similar repetition but can also present the possibility of difference.

Moreover, the act of repetition in modular design presents an opportunity to define visual identity and specific aspects of locality and culture. This aligns with the statement from Wallance (2021), "the authenticity of intermodal modular components created on the Small Grid satisfies our need for identity, and the variety of those components allows us to differentiate ourselves" (p. 240). The combination of materiality in modularity indirectly becomes an attempt to maintain the nature-based of local materials, parallel to its efficiency with the more sustainable industrial materials. Architects have the opportunity to present a material composition that has references from the surrounding local wealth.

This idea of material composition in modules aligns with the possibilities of material tectonics (Frampton, 2001), where each modular element can be varied according to the designer's creativity, seen from the micro perspective. Tschumi (1996) also addresses the

opportunity for modules to be assembled differently, with unusual connections, juxtapositions, and disrupted grids. Venturi et al. (1977) also emphasise the possibility of embracing the ability of a module to be embedded with local or historical references. In this sense, the repetition of modules in modular design is present in multilevel hierarchies, occurring in a micro-to-macro mechanism as a way for the architecture to adapt creatively. Figure 7 illustrates the continuum of part to whole and whole as part of such multilevel hierarchies, and the possible material representation of certain aspects of the composition.
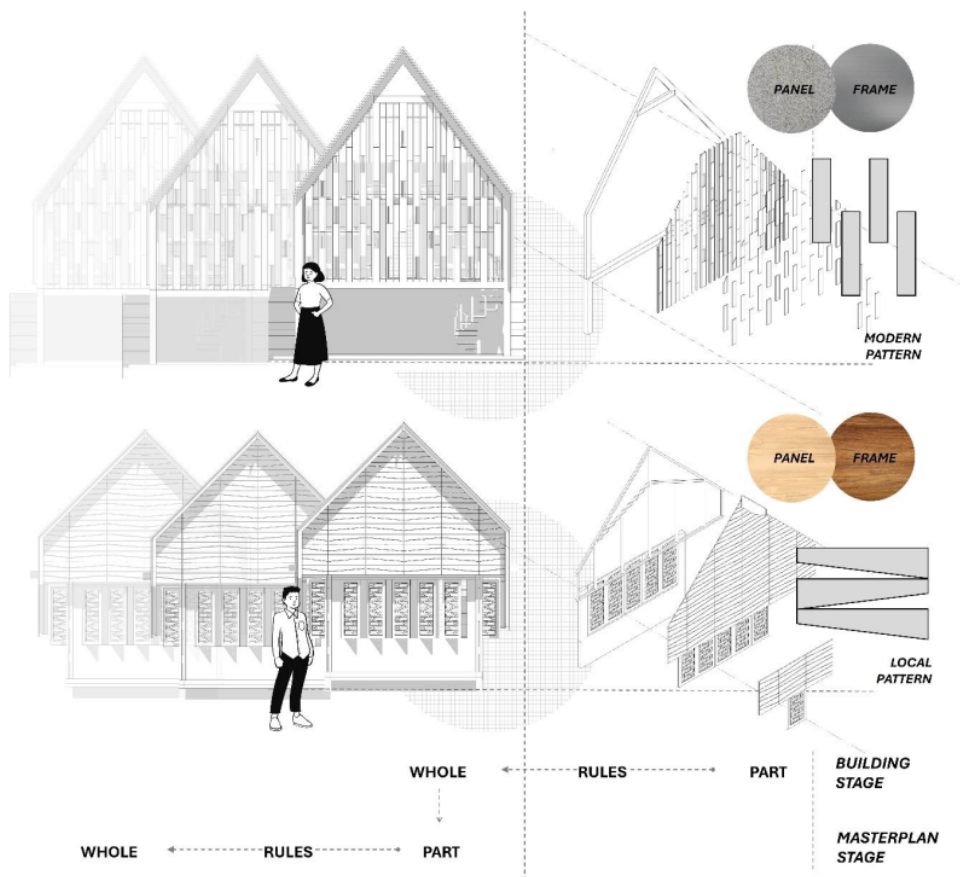
Figure 7. Re-repetition part to whole on design system (Image by authors)

Inside-outside: Local site sustainability

The fourth reflection of the design focuses on the inside-out combination of the module, which plays a role in supporting local environmental sustainability. Modularity itself has been a response to sustainability needs and one aspect of environmental sustainability that architecture can respond to is minimum intervention (Redyantanu, 2021) and preservation of natural local site conditions. Such minimum intervention must consider the overall developmental patterns and phases, as discussed below:

> We are headed down a path of mutually assured environmental destruction if we do not get our house in order, or more accurately, our housing—beginning at the base of the energy pyramid by first and foremost considering the location and density of our development patterns. (Wallance, 2021, p. 186)

The partial presence of lodging units creates a different experience of architecture through its existence as fragments. The central circulation in the design is not present in the built space but instead is open and merges with the environment, creating a more significant experience of closeness to nature. The spatial composition of the project leaves more open space, creating better rainwater infiltration. With the application of the stilt system to the lodge design, it is possible for the built-up area to still have infiltration at the bottom as well.

Another aspect of sustainability is the possibility for incremental development of the overall lodge blocks, which can be constructed in stages and still be highly adaptive to market demands and needs (Smith, 2011). Blending outdoor and indoor spaces with architecture as a boundary space (Atmodiwirjo & Yatmo, 2019; Boettger, 2014) demonstrates maximum land use efficiency as a whole. Modularity is also part of the design action associated with the preservation of karst topography that characterises the geology and geography of the

site, giving specific outdoor and indoor experiences. Figure 8 illustrates the inside-outside

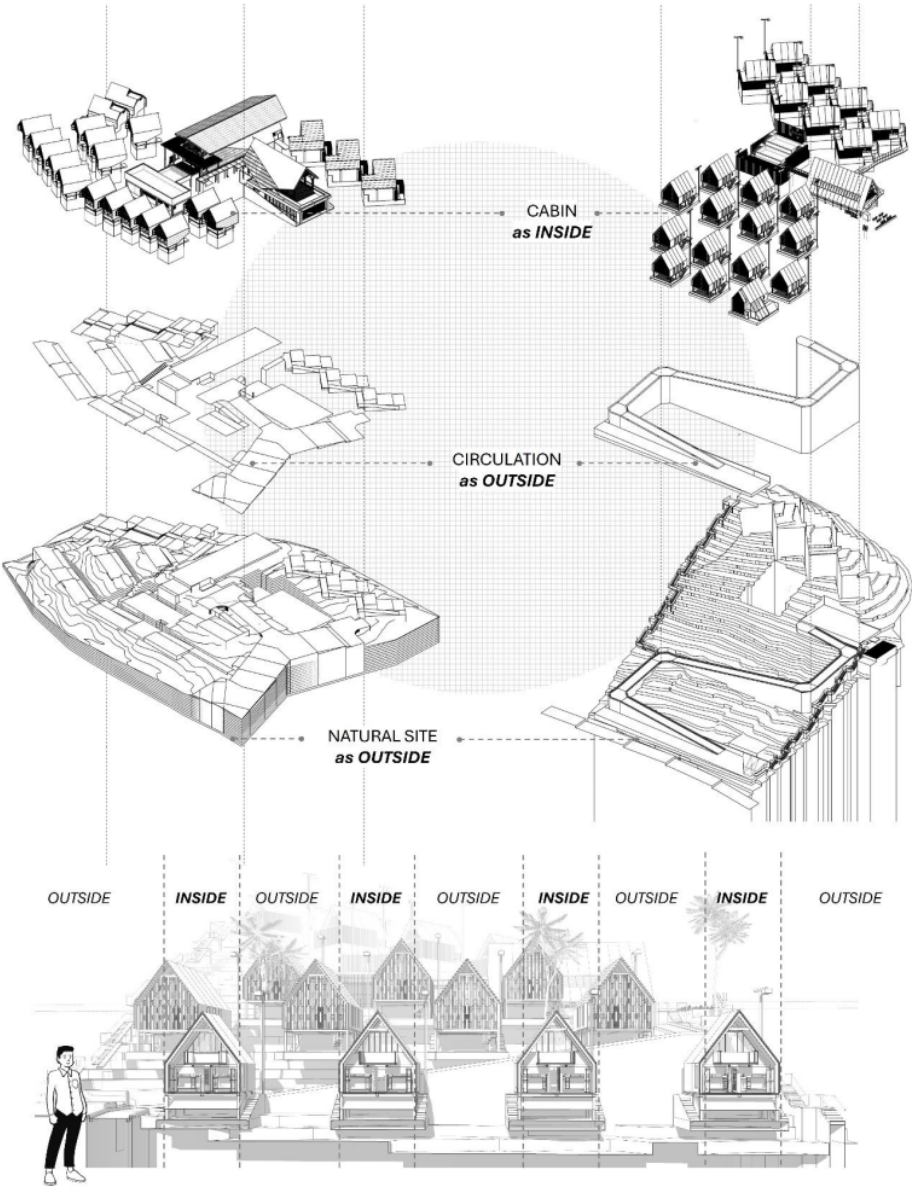combination related to site preservation and environmental sustainability.

Figure 8. Site preservation with outside circulation system (Image by authors)

Conclusion

This study aims to rethink the idea of modularity in the design method, using design project reflections of a lodge architecture. Modularity is often discussed as an approach related to the form development of architecture without considering other contextual forces. As discussed by Plowright (2014), a design framework that focuses on the forms and their variations is often seen in opposition to a design framework that is more contextual-driven (Plowright, 2014). This study argued that the notion of modularity has the potential to complement the consideration of form in response to various contextual needs. Four design reflections of two lodge projects are highlighted, showing lessons learned regarding how modular forms can be developed to respond to various spatial, economic, and sustainability needs.

The first design reflection addresses how modularity allows potential redefinition of the form and role of architectural elements. Through such redefinition, the act of repetition in modular design is more than just a way to organise and configure elements but is a way of creatively finding varied configurations of programmatic needs. Secondly, the application of modularity accommodates the efficiency and effectiveness of design construction and the operation of architectural programs, especially in a commercial context. By dividing its construction into phases, modularity allows the construction process and operation of the program to take place in parallel conditions. This parallel condition demonstrates how architecture can operate in fragments. In this sense, the architects are not just designing a standalone object but also various programmatic operation and construction schemes, so that the fragments of architectural modules can still operate swiftly without disruption.

Thirdly, the notion of modularity repositions architecture in a hierarchy of micro and macro elements. Modularity creates iteration of module pattern variation, enabling adaptation to the dynamics of the existing context. Iterations of variation can be organised to create a configuration of the whole that brings attraction to the visitors. Fourthly, the use of modularity as a design strategy creates inside and outside patterns in the space between one module to another. Spaces between modules are also significant for sustainability efforts, especially nature conservation as it minimise intervention in the site. Strategies for bringing more spaces that are not built are also relevant to provide access to nature, for absorption or other natural needs.

This study is limited in its modular reflection to two specific lodge design projects. Further study is needed to see further expansion of the idea of modularity in other types of architecture. Modularity is a valuable tool in architecture, yet the decision of whether to use a modular approach needs to consider the specific needs and goals of its users. This paper's reflections on the idea of modularity provide expansion on its limited focus on repetition and uniformity, demonstrating a progressive potential in design to address modularity as a way of responding to context. It can be concluded that applying modularity does not necessarily limit creativity but instead can trigger a broader exploration of a responsive and contextual design method.

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