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Re-learning the architectural forms of *Rumoh Aceh*: Opportunities for using shape grammar approach for tectonic form exploration

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ABSTRACT

The implementation of tectonic expression within Indonesian architecture has undergone a marked reduction in recent times. This decline is especially discernible in vernacular structures such as the Rumoh Aceh. As a significant element of cultural heritage, Rumoh Aceh embodies distinctive formal configurations and spatial principles that merit investigation through a tectonic lens. The principal aim of this study is to examine the applicability of the shape grammar method in analyzing the tectonic characteristics inherent in the form of Rumoh Aceh. Employing an explanatory case study as its methodological framework, this research entails a thorough examination of pertinent literature related to the application of shape grammar. The analytical findings indicate that the shape grammar methodology can be effectively utilized to codify the architectural form and tectonic elements of Rumoh Aceh. This methodological approach is anticipated to enrich the spectrum of techniques available for exploring and recording tectonic knowledge within the context of traditional Indonesian architecture, with a concentrated emphasis on Rumoh Aceh.

Introduction

The articulation of tectonic expressions in architectural practice has witnessed a marked decline, as highlighted by Ng and Wong (2018). This tendency is apparent across numerous traditional architectural typologies throughout Indonesia. Illustrative examples include the Limas house in Palembang (Aziz et al. 2021), the traditional Praigoli house of West Sumba (Solikhah and Fatimah 2020), the stilted dwellings of the Korowai tribe in Papua (Kurniawan, Suhanto, and Angelia 2020), the vernacular house of the Talang Mamak tribe in Riau (Faisal and Wihardyanto 2020), the Bugis house (Naing and Hadi 2020), the Ume Bangka (Kurniawan and Nuraeny 2018), the Minahasa traditional house (Gosal et al. 2018), the Batak Toba house (Hanan et al. 2015), and the Minangkabau Gadang house (Noviarti, Irsa, and Masdar 2013).

This declining trend is also evident in the *Rumoh Aceh*, a vernacular house native to Aceh Province, located at the northernmost tip of Sumatra. Cultural evolution, as described by (Hajdad et al. 1984) has led to the gradual acculturation and adaptation of the *Rumoh Aceh* in response to changing contextual and societal demands (Aiyub, Loebis, and Pane 2018; Azzahra and Sahriyadi 2020; Rizky 2022; Meutia and Izziah 2019; Nursaniah 2022).

One prevalent contemporary modification involves the construction of additional rooms or subsidiary "houses" that are either attached to or structurally integrated with the original columns of the *Rumoh Aceh*, as observed by Aiyub, Loebis, and Pane (2018). While some of these extensions remain faithful to traditional timber construction, many employ hybrid materials, combining wood with reinforced concrete. Such modifications raise critical concerns regarding the preservation and longevity of the architectural authenticity of the *Rumoh Aceh*, which continues to serve as an important cultural symbol for Aceh.

Moreover, the transformation of the *Rumoh Aceh* from an embodiment of cultural identity and symbolic tradition into a response to pragmatic spatial and functional requirements reflects a shift in architectural values. In this contemporary reinterpretation, aesthetic appeal has become the dominant design driver, frequently overshadowing the rich symbolic narratives and cultural expressions that originally defined the form. Consequently, the poetic craftsmanship and nuanced tectonic articulation that once characterized the *Rumoh Aceh* are increasingly being lost.

This transformation signals the urgent need for a more refined and scholarly approach to re-examining and re-engaging with the architectural form of the *Rumoh Aceh*. Through tectonic investigation, the foundational structural logic and expressive intent embedded within its architecture may be rediscovered, facilitating the preservation of its cultural essence while enabling its thoughtful reinterpretation within contemporary architectural practice. Looking forward, this approach is anticipated to expand the methodological landscape for examining and documenting tectonic traditions in Indonesia's vernacular architectural heritage.

The phenomenon of *Rumoh Aceh* disappearance and the transformation of the tectonic expression

The long-term sustainability of *Rumoh Aceh* is currently under significant threat. Although it is often cited as an environmentally responsive architectural form, the *Rumoh Aceh* is progressively diminishing and is approaching the brink of extinction (Izziah et al. 2020; Nas 2003). The surviving examples have generally undergone functional transformations, resulting in substantial changes to their construction techniques, formal characteristics, spatial organization, and material composition (Aiyub, Loebis, and Pane 2018) (figure 1).

Figure 1. Transformation of tectonic expression in the architectural forms of *Rumoh Aceh*

Upon closer examination, the threat of extinction extends beyond the physical presence of *Rumoh Aceh* to encompass the architectural knowledge and epistemological frameworks associated with it. Several scenarios can be postulated (figure 2). In the first scenario, where

physical artifacts of *Rumoh Aceh* are preserved but the accompanying knowledge is inadequately documented, the advancement of tectonic studies would remain constrained. In the second scenario, if both the artifacts and their knowledge base are lost, the potential for future research into the tectonics of *Rumoh Aceh* would be virtually eliminated. The third scenario envisions the extinction of physical artifacts, while the knowledge persists through rigorous documentation this would still permit scholarly development in *Rumoh Aceh* tectonic studies. The fourth and ideal scenario involves the preservation of both the tangible architectural heritage and its associated body of knowledge, thus enabling continued development in the study and application of its tectonic principles.

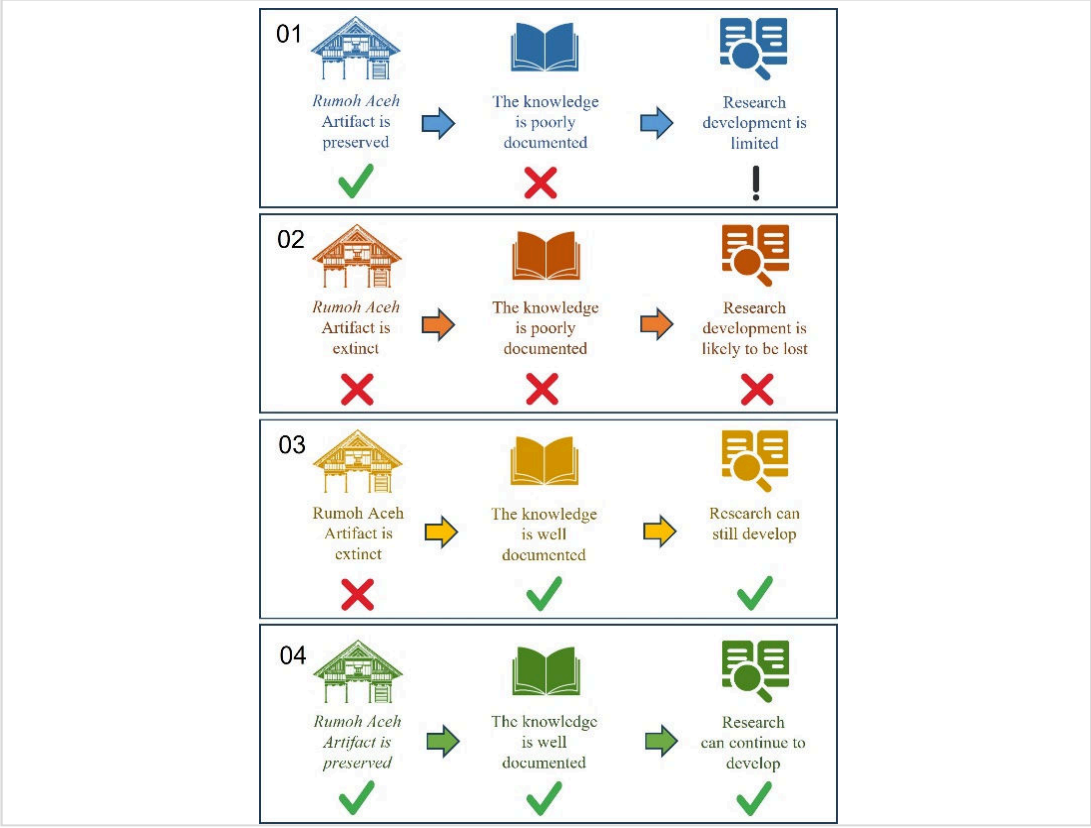

Figure 2. Transformation of tectonic expression in the architectural forms of *Rumoh Aceh*

Shape grammar in architectural design

Shape grammar is fundamentally a procedural system used for the generation and analysis of architectural forms by employing algorithmic rule sets (Garcia and Menezes Leitão 2018; Kwon 2003; Strobbe et al. 2016; Tepavcevic and Stojakovic 2012). The conceptual linkage between architecture and grammar lies in viewing architecture as a "collection of design ideas" organized around "a system of rules" and their applications (Fisher 2015).

The shape grammar approach provides a methodological framework for understanding, interpreting, and identifying the formal logic of design. It enables the decomposition of complex architectural forms into their elementary generative patterns, and conversely, the derivation of complexity from basic configurations (Li 2001; Li and Jin-Yeu Tsou 1994). Furthermore, shape grammar allows for adaptation and transformation of architectural designs through the manipulation of rule formats, rule sequences, and the overall grammatical syntax of form (Al-kazzaz and Bridges 2012). The process involves creatively constructing a sequence of shape rules, evolving from initial configurations to defined outcomes (G. N. Stiny 1985) as illustrated in figure 3.

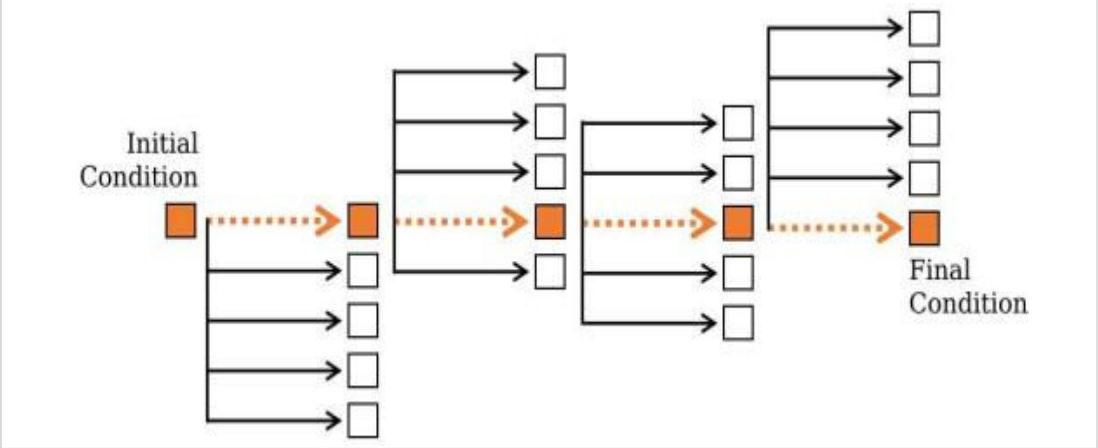

Figure 3. Diagram of the shape grammar design process (adapted from Mitchell 1994)
Source: (Ibrahim 2005)

Shape grammar is composed of four fundamental components (figures 4, 5, 6), as outlined by G. Stiny (1980): (1) shape, referring to a configuration of defined geometrical entities; (2) symbol, a set of markers that constrain or guide the application of shape rules; (3) shape rule, a formalized set of transformational procedures; and (4) initial shape, the foundational form to which the rules are applied.

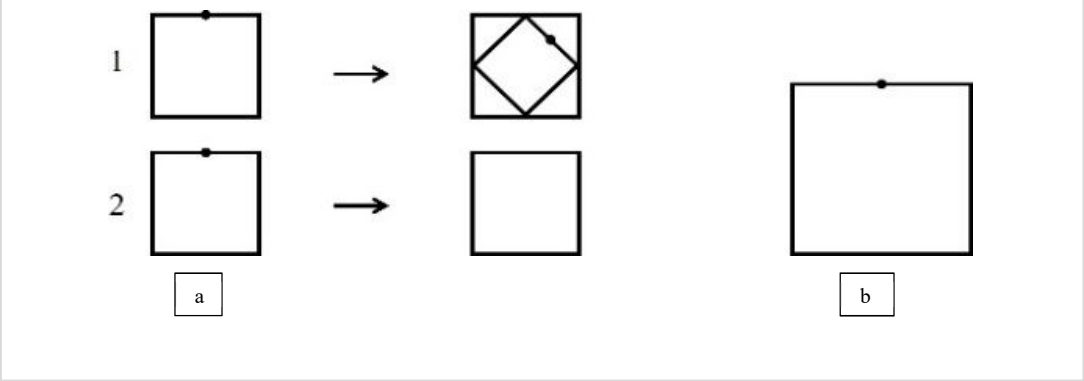

Figure 4. A simple shape grammar that inscribes squares in squares, (a) shape rules, (b) initial shape
Source: (G. Stiny 1980)

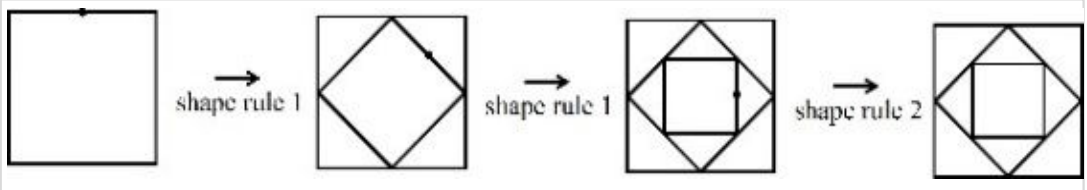

Figure 5. Generation of a shape using the shape grammar of figure 2
Source: (G. Stiny 1980)

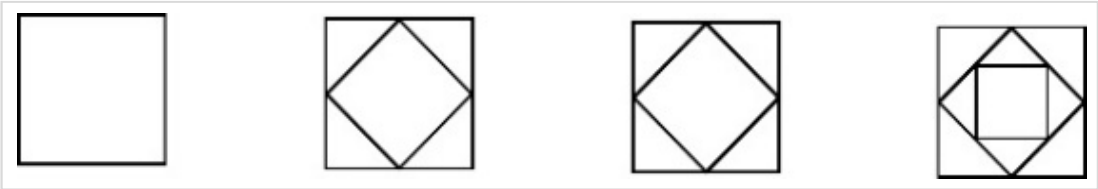

Figure 6. Some shapes in the language are defined by the shape grammar of figure 2
Source: (G. Stiny 1980)

Creativity in the context of shape grammar is rooted in four core attributes of the design process (Knight 2003):

1. *Interaction*, characterized by continual reinterpretation, requires the designer to relearn rules and reimagine outcomes;
2. *Novelty*, through the creation of previously unseen design solutions;
3. *Uncertainty*, involving the ambiguity of rule applications and outcomes;
4. *Ambiguity*, as forms may possess multiple valid interpretations. These four dimensions are integral to the application of shape grammar in exploring the tectonic qualities of *Rumoh Aceh*.

The generalization of shape grammar by George Stiny in 1980 laid the groundwork for its interdisciplinary adoption, spanning art, architecture, linguistics, computer science, and mathematics (Cascone et al. 2021; Eilouti 2019). In some domain design (Garcia and Menezes Leitão 2018) has become very varied, namely, architectural design (Li 2001; Hadighi and Duarte 2020; Hussein and Ismaeel 2021), housing design (Duarte and Beirão 2011), rehabilitation and conservation strategies (Castro and Beirão 2019; Eloy and Duarte 2011), design transformation (Eloy 2012; Eloy and Duarte 2011) and product design (Agarwal and Cagan 1998; Garcia and Menezes Leitão 2018).

Notably, shape grammar has become increasingly relevant in the study and preservation of vernacular architecture (Castro and Beirão 2019; Li 2001; Qi et al. 2024; Yousefniapasha et al. 2021), due to its ability to formalize and clarify the implicit rule sets that inform traditional architectural practices. By distilling these architectural principles into a structured grammar, it enables a rigorous interpretation and documentation of inherited design logics.

Given the preceding background, problem formulation, and review of relevant literature, this study hypothesizes that the shape grammar approach offers substantial potential as a method for examining and interpreting the architectural logic of *Rumoh Aceh* through tectonic exploration. The primary aim of this research is to implement the shape grammar approach in the study of *Rumoh Aceh*, with a focus on re-evaluating its rule-based design system. This approach is anticipated to enable more systematic and comprehensive documentation of the partially recorded architectural knowledge associated with *Rumoh Aceh*. The originality and scholarly value of this research lie in employing shape grammar as a means to re-engage with the tectonic dimension of *Rumoh Aceh's* architectural form.

Methods

This study adopts an explanatory case study approach grounded in literature analysis. A case study involves an in-depth exploration of one or more cases, with particular attention to the specificity of the subject and its contextual framework (Neuman 2014). The research proceeds through three key stages, as outlined in figure 7.

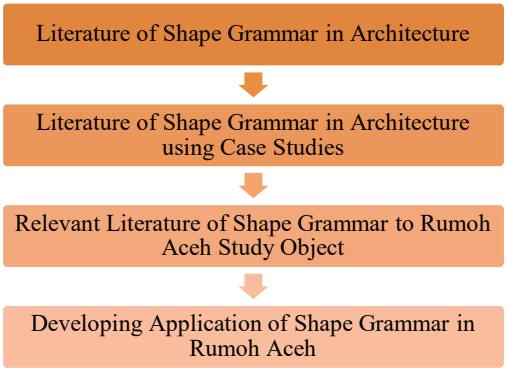

Figure 7. Research stage framework

In the first stage, relevant literature concerning the application of the shape grammar approach in architectural design was systematically collected. This process entailed a targeted review of prior studies closely aligned with the research topic,

resulting in the compilation of 43 pertinent sources discussing shape grammar.

In the second stage, a selection was made from the initial pool, focusing on studies that implemented the shape grammar approach through specific case studies. The aim was to critically examine the methodology and conceptual applications of shape grammar within diverse architectural contexts.

The third stage narrowed the scope further by identifying case studies that directly relate to or can be analogously applied to *Rumoh Aceh*. At this stage, an initial analytical assessment was conducted to evaluate the potential integration of shape grammar principles in the study of *Rumoh Aceh's* architectural form.

The core objective of this case study is to map the epistemological structure, conceptual models, and foundational principles underlying the application of shape grammar in architecture. In this final stage, an overarching model is proposed to reinterpret the architectural composition of *Rumoh Aceh* through an exploration of its tectonic elements.

The research focuses specifically on the *Rumoh Aceh* typology. In Aceh, traditional dwellings generally comprise two main types: *Rumoh Aceh* and *Rumoh Santeut* (Husin dkk., 2003; Nursaniah 2022) (figure 8). *Rumoh Aceh* is distinguished by its elevated and varied floor levels in the central zone, whereas Rumoh Santeut features a uniform flat floor layout (Husin dkk., 2003). Moreover, the dimensions and ownership of a *Rumoh Aceh* structure are determined by the number of "ruweueng" (spaces between structural columns), typically aligned along an east–west orientation (Sahputra et al. 2020) (figure 9).

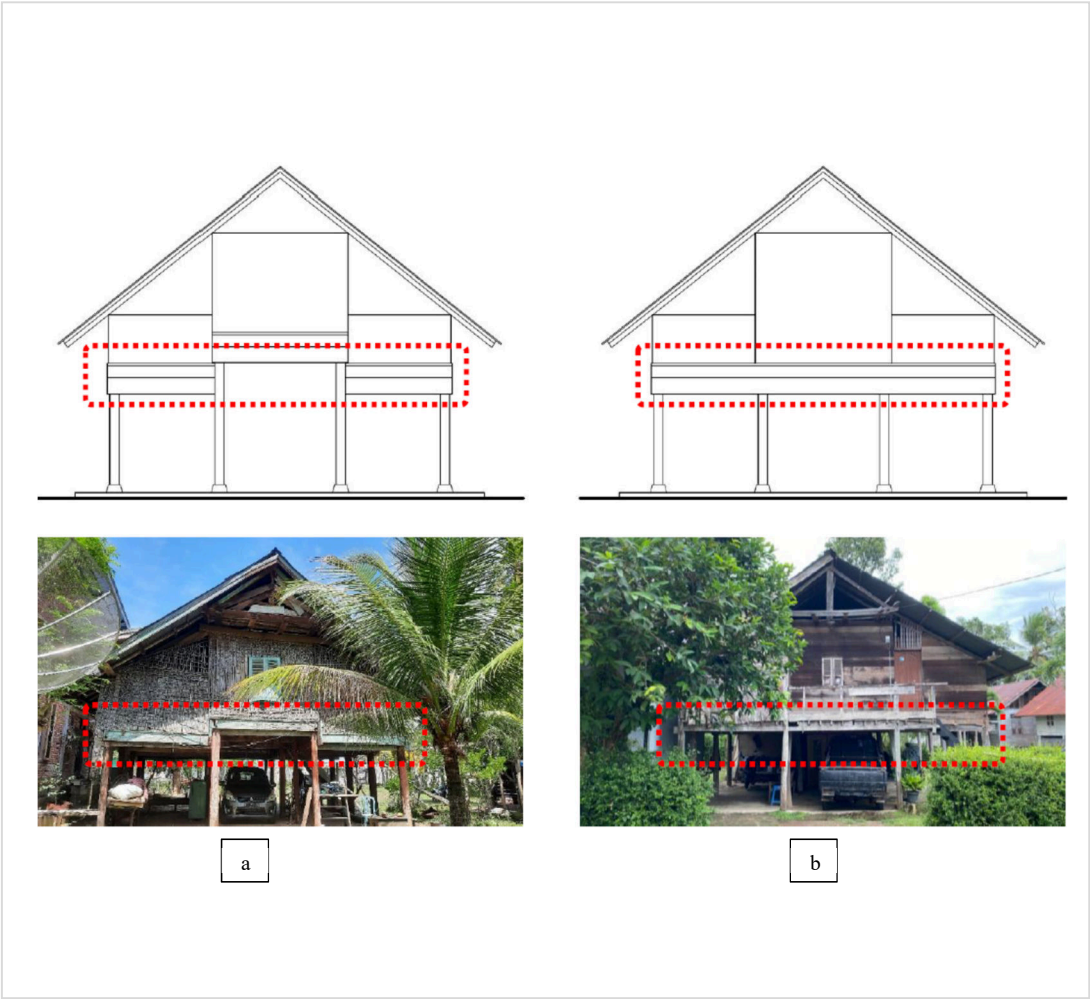

Figure 8. (a) *Rumoh Aceh* (b) *Rumoh Santeut*

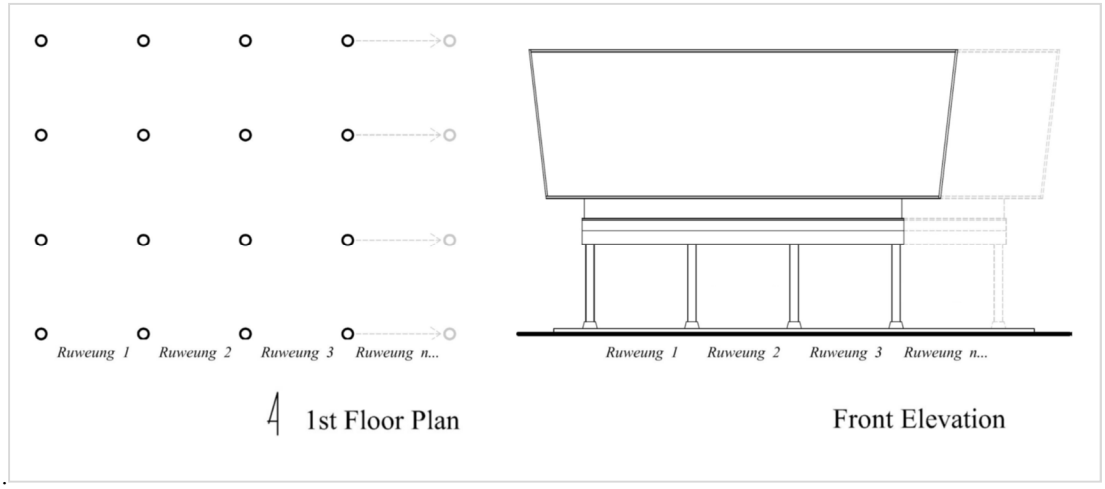

Figure 9. Space configuration of *Rumoh Aceh*

Results and discussion

Tectonics principles and constructability of *Rumoh Aceh* as a case study

According to the literature, *Rumoh Aceh* is a timber stilt house (figure 10), typically elevated above the ground as a cultural and environmental adaptation (Fathiyyah, Idris, and Huzaim 2022; Izziah et al. 2021; Meutia et al. 2020; Mirsa 2013).

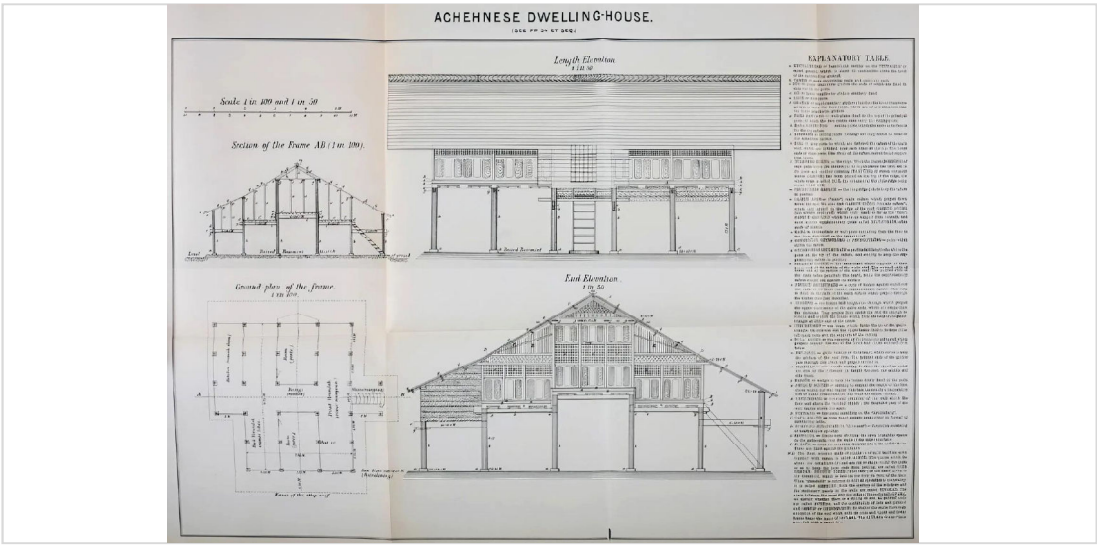

Figure 10. *Rumoh Aceh* image archive

Horizontally, *Rumoh Aceh* is divided into three principal spaces (figure 11): (1) the front porch (*Seuramoe keu*) or commonly referred to as the staircase porch (*Seuramoe rinyeuen*), (2) the middle porch (*Seuramoe teungoh*), and (3) the back porch (*Seuramoe likot*) (Aiyub, Loebis, and Pane 2018; Azzahra and Sahriyadi 2020; Izziah et al. 2021; Sahputra et al. 2020; Meutia and Izziah 2019; Nursaniah 2022).

On the other hand, vertically, the house is categorized into three hierarchical sections: (figure 9): (1) the lower part/legs/foundation of the house (*Yup moh*), (2) the middle part/body of the house (*Rumoh*), and (3) the upper part/head/roof of the house (*Ubong*).

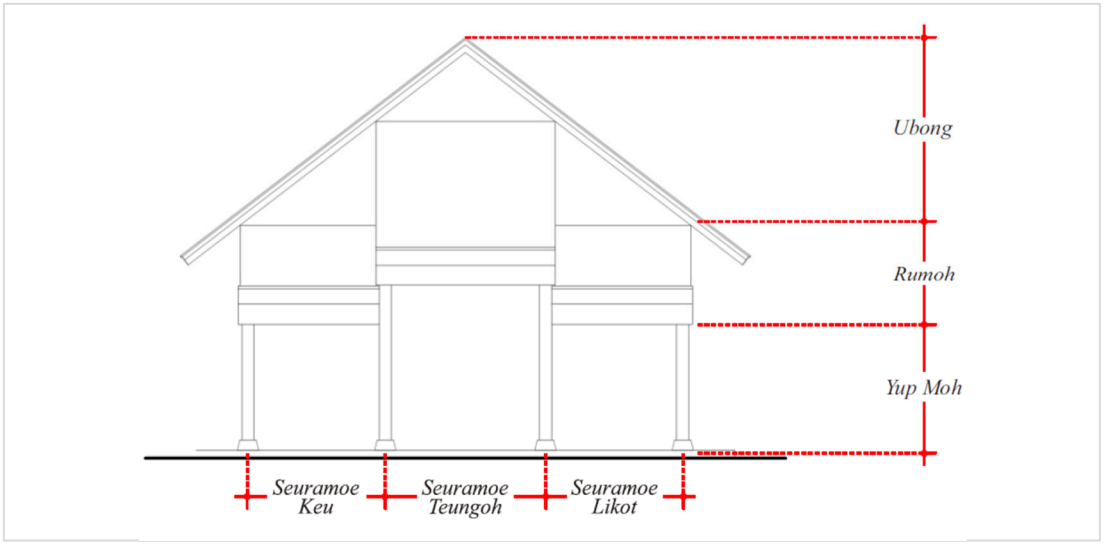

Figure 11. Hierarchical photographs and sections of *Rumoh Aceh*

Tectonic traditions form a critical aspect of architectural progression (Frampton 1995). The architecture and construction of *Rumoh Aceh* (figure 12, 13, 14, 15, and 16) reflect a distinctive tectonic and artistic culture that is fascinating to explore (Azhar Abdullah Arif 2018). Notably, its construction employs joinery techniques without nails, using wooden pegs and palm-fiber ropes (Leigh Barbara 1989), highlighting both craftsmanship and seismic adaptability.

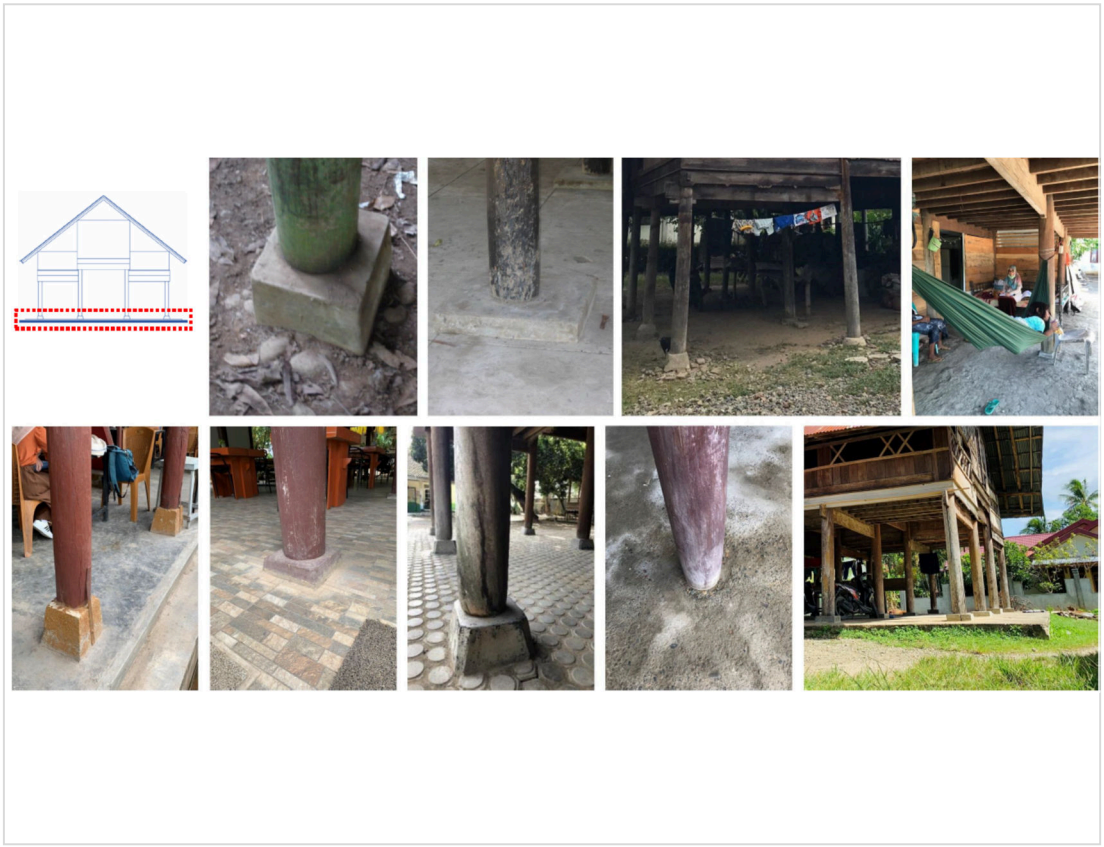

Figure 12. Documentation of the tectonic foundation column in *Rumoh Aceh*

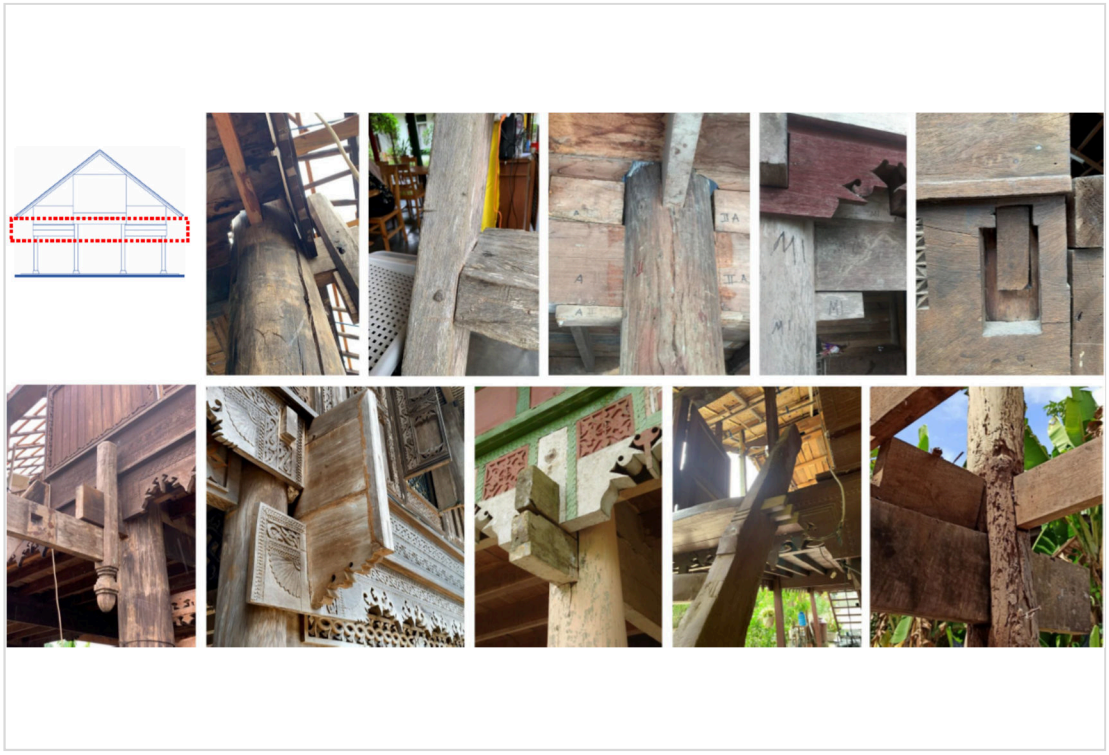

Figure 13. Documentation of the tectonic column and beam connection in *Rumoh Aceh*

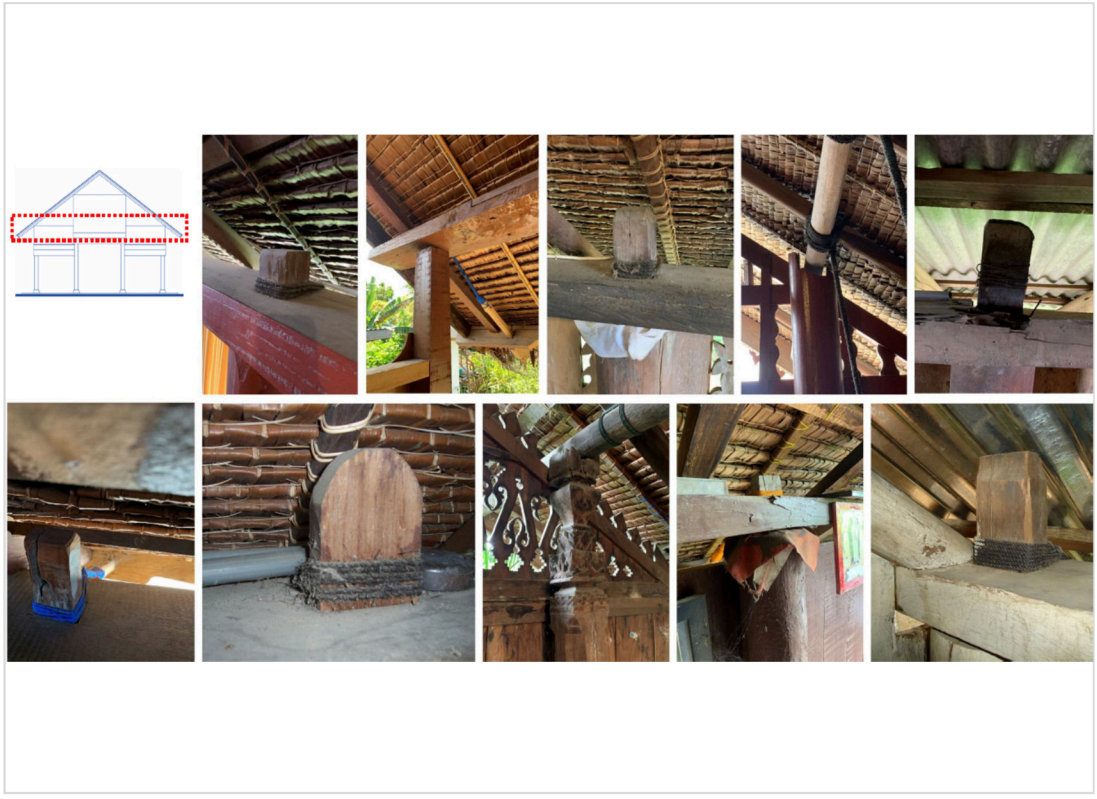

Figure 14. Documentation of beam and roof construction in *Rumoh Aceh*

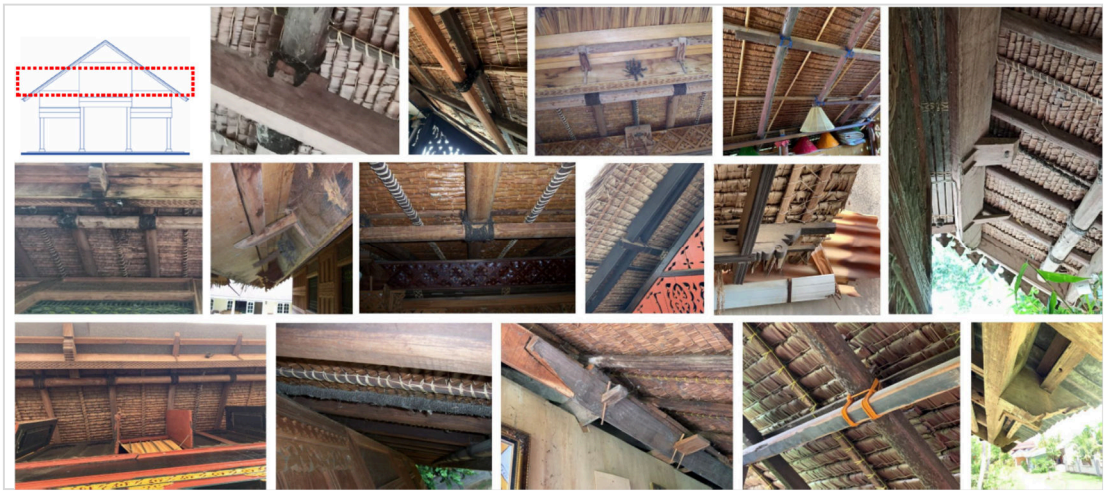

Figure 15. Documentation of connection on roof frame construction in *Rumoh Aceh*

Figure 16. Roof frame construction documentation in *Rumoh Aceh*

The structural flexibility of *Rumoh Aceh* was notably demonstrated during the 2004 Aceh earthquake and tsunami. According to Izziah et al. (2020), the damage to *Rumoh Aceh* was not visible; only the house columns were slightly shifted around 1.5 cm from their original location. This incident proves that the *Rumoh Aceh* construction structure is safe from large-scale earthquake forces (Husin, TA, and Syafrizal 2003) because the structure is rigid and elastic, following the rhythm of the earthquake.

Figures 12 to 16 depict the tectonic documentation of *Rumoh Aceh*, which has the potential to be a subject of study in the conducted research.

The potential of the shape grammar approach for *Rumoh Aceh* tectonics research

The implementation of shape grammar in Indonesian traditional architecture remains underexplored. A notable exception is (Primanizar 2021), who employed shape grammar to derive generative rules for Lumbung Sasak structures via parametric simulation. Consequently, *Rumoh Aceh* offers a promising research avenue for advancing the application of shape grammar in architectural tectonics (figure 17).

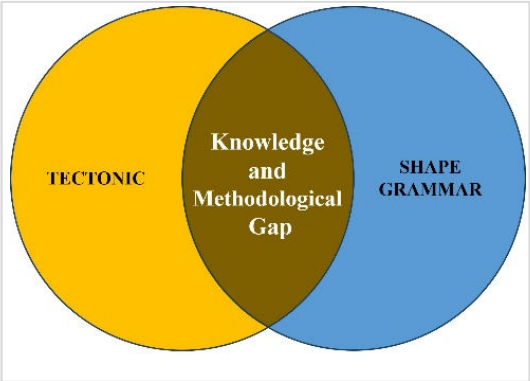

Figure 17. Research gap in the tectonic research of *Rumoh Aceh*

Case study of shape grammar application

These case studies aimed to comprehend the application and exploration of grammatical models to establish an initial illustration for developing a grammatical methodology for the study object of *Rumoh Aceh*. The identification results show that based on the 43 works of literature collected, there are only 8 literature that explain the use of the shape grammar approach with case studies.

Case study #1

A shape grammar approach to contextual design: A case study of the Pol houses of Ahmedabad, India (Lambe and Dongre 2019).

This research begins by addressing a pressing issue: the proliferation of new residential buildings that lack contextual harmony with the surrounding traditional settlements. The study seeks to resolve spatial discordance through the implementation of a shape grammar approach. The grammar developed captures the formal qualities of the Pol houses, while its syntax articulates socio-spatial dynamics. The method is applied as an analytical tool capable of generating novel designs based on the embedded grammatical structure of historical architectural forms. It frames contextual understanding as a socio-cultural phenomenon, interpreted through rule-based design strategies responsive to contemporary societal demands.

To streamline this process, the authors categorize activity zones and outline a series of procedural stages. These stages comprise thirteen distinct phases, each governed by one or more formal rules (Lambe and Dongre 2019)

Case study #2:

Adapting modern Architecture to a Local Context: A Grammar for Hajjar's Hybrid Domestic Architecture (Hadighi and Duarte 2018).

This investigation aims to examine the spatial organization of William Hajjar's residential architecture using shape grammar as a computational design methodology. Here, the grammar serves to validate and describe modern architectural influences by contrasting the grammar rules derived from Hajjar's work with those of other architectural systems.

Case study #3:

Using grammars to Trace Architectural Hybridity in American Modernism: The Case of William Hajjar's Single-family House (Hadighi and Duarte 2019)

Following a similar trajectory to Case Study #2, this research further evaluates the efficacy of shape grammar in revealing hybridity within architectural design. The grammar model of Hajjar's residential forms is critically compared with the conventions of traditional American architecture.

Case study #4:

Local adaptation of the International Style Contextualizing Global Architecture between East and West (Hadighi and Duarte 2020).

Aligning with the methodologies of Case Studies #2 and #3, this study illustrates how shape grammar can be employed to identify and articulate the fusion of local architectural expressions with modern design paradigms. The research applies a consistent and detailed rule-based process to all case study objects, allowing for the comparative analysis of grammatical structures. This demonstrates shape grammar's potential as a tool for synthesizing traditional and modern architectural vocabularies.

Case study #5:

Shape grammars as a Support Instrument for Heritage Safeguard Planning, from A Vernacular Language to A Contemporary Materialization (Castro and Beirão 2019).

Within the same theoretical framework, this study employs shape grammar as a strategic planning tool to safeguard historic urban environments. It focuses on Aljezur, a Moorish settlement in southern Portugal characterized by vernacular residential architecture. The grammar

developed in this study centers primarily on two-dimensional spatial analysis.

Case study #6:

Regenerating the traditional houses' facades of old Mosul city by Shape Grammar (Hussein and Ismaeel 2021).

Mosul's old city suffered substantial destruction during military operations between 2016 and 2017, resulting in damage to approximately 80% of its 15,000 housing units. In the absence of formal restoration guidelines, efforts to rebuild led to deformations and unauthorized interventions.

This study has three objectives: (1) analyze the structural composition of facades by identifying element boundaries, (2) formalize local architectural language to reflect the traditional identity of housing typologies, and (3) develop a foundational knowledge system for the future adaptation and evolution of Mosul's housing.

The methodology includes: (1) data collection, (2) classification of architectural components using syntax principles based on mass, space, and surface, (3) genotypic and relational analysis of elements, (4) interpretation of derivational rules, (5) rule application, and (6) implementation in selected case studies (Hussein and Ismaeel 2021). Mosul's old city suffered substantial destruction during military operations between 2016 and 2017, resulting in damage to approximately 80% of its 15,000 housing units. In the absence of formal restoration guidelines, efforts to rebuild led to deformations and unauthorized interventions.

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Case study #7:

Customizing Mass Housing: A Discursive Grammar for Siza's Malagueira Houses (Duarte 2005).

This study utilizes discursive grammar to address the customization of mass housing designs. "Discursive grammar" here encompasses programming grammar, which converts user requirements into a design brief, and design grammar, which translates the brief into architectural form.

The Malagueira project is structured around geometric manipulations involving rectangles, governed by rules for cutting, connecting, expanding, and functionally modifying these shapes. Duarte (2005) research is notable for its detailed extraction of independent and dependent variables from grammatical design principles.

Case study #8:

A Shape Grammar for Teaching the Architectural Style of the Yingzao Fashi (Li 2001).

In this study, shape grammar is employed as a pedagogical tool to teach the architectural language documented in the Yingzao Fashi a historic manual of building standards. The study underscores the role of users in determining and organizing grammar-based architectural shapes.

According to criteria by G. Stiny and Mitchell (1978), users are essential in: (1) generating new forms through grammar, (2) evaluating the acquisition of design knowledge, and (3) perceiving design similarity.

Rather than relying on empirical case studies, A. Li adopts a generative definition approach rooted in textual analysis of the Yingzao Fashi. The grammatical definitions are structured to allow students to evaluate and engage with them directly, promoting active learning.

One particularly noteworthy feature is the detailed graphical representation of grammar rules, which includes floor plan derivations for various building scales, sectional perspectives detailing beam arrangements, elevation drawings, and roof construction guidelines (Li 2001).

From the comparative analysis of all eight case studies, it is evident that those labeled #1 through #5 and #7 primarily utilize shape grammar in two-dimensional spatial analysis, often lacking comprehensive codification of rules and their derivations. Conversely, case studies #6, #7, and #8 offer more advanced applications of shape grammar, with robust methodologies that

define architectural elements, rules, and derivative transformations in greater detail. These latter approaches present a valuable foundation for adapting the shape grammar methodology to *Rumoh Aceh*, albeit with necessary modifications to suit its unique context.

Shape grammar approach for tectonic form exploration of *Rumoh Aceh*

Rumoh Aceh, a long-standing representation of Indonesia's vernacular architecture, has survived for centuries. Wright (1954) describes that every house that can be regarded as a work of art possesses its grammar. As a cultural heritage artifact, *Rumoh Aceh* is believed to embody a distinct architectural grammar deserving of thorough scholarly investigation.

Historically, the construction of *Rumoh Aceh* adhered to established norms and community values. Given its unique structural characteristics, the architecture of *Rumoh Aceh* necessitates a deeper grammatical analysis.

Based on insights gained from the case studies reviewed, two primary approaches can be applied to *Rumoh Aceh* using shape grammar. First, the methods from Case Studies #1 through #5 and #7 provide reference models for analyzing spatial configurations. Second, Case Studies #6 and #8 offer frameworks for examining more complex tectonic aspects through grammatical formalization.

Preliminary analysis of *Rumoh Aceh's* tectonic form can begin by interpreting construction components as part of a rule-based framework that reflects the building's holistic composition. Drawing from literature and relevant case study findings, an initial five-stage framework for applying grammatical analysis to *Rumoh Aceh* is proposed (figure 18):

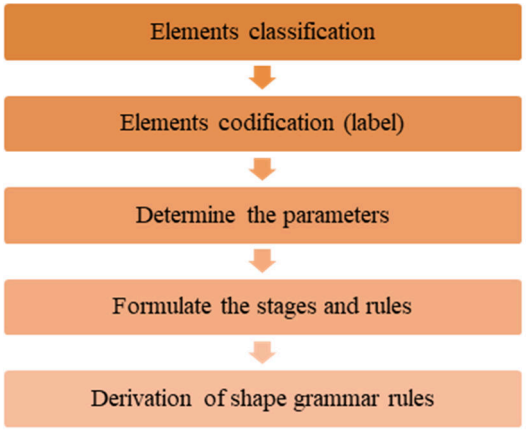

Figure 18. Formulation and application stage framework

Due to *Rumoh Aceh's* modular construction, which allows for disassembly (Meutia et al. 2020) (figure 19), Stage 1 involves morphological classification of construction elements based on exploded views (figure 20).

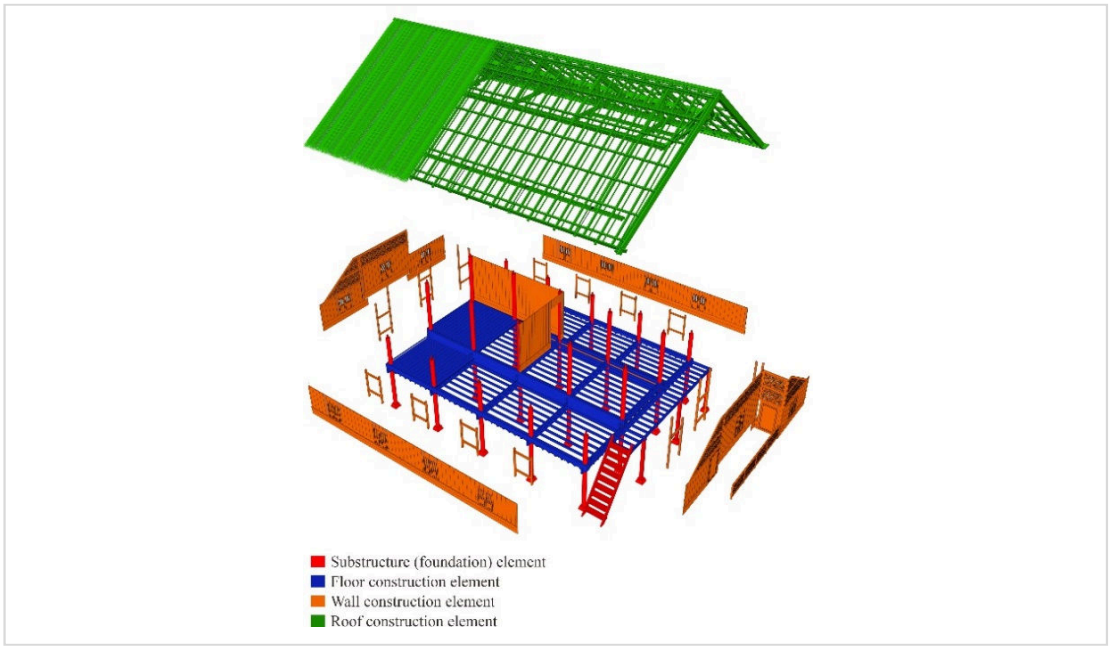

Figure 19. Exploded diagram of *Rumoh Aceh* construction

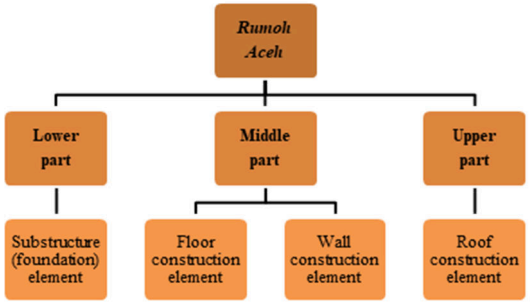

Figure 20. Morphology diagram of *Rumoh Aceh* based on an exploded diagram of the construction form

Stage 2 involves the codification of elements through the systematic breakdown of construction subcomponents. Each sub-element is labeled to form the foundation for rule creation (figure 21).

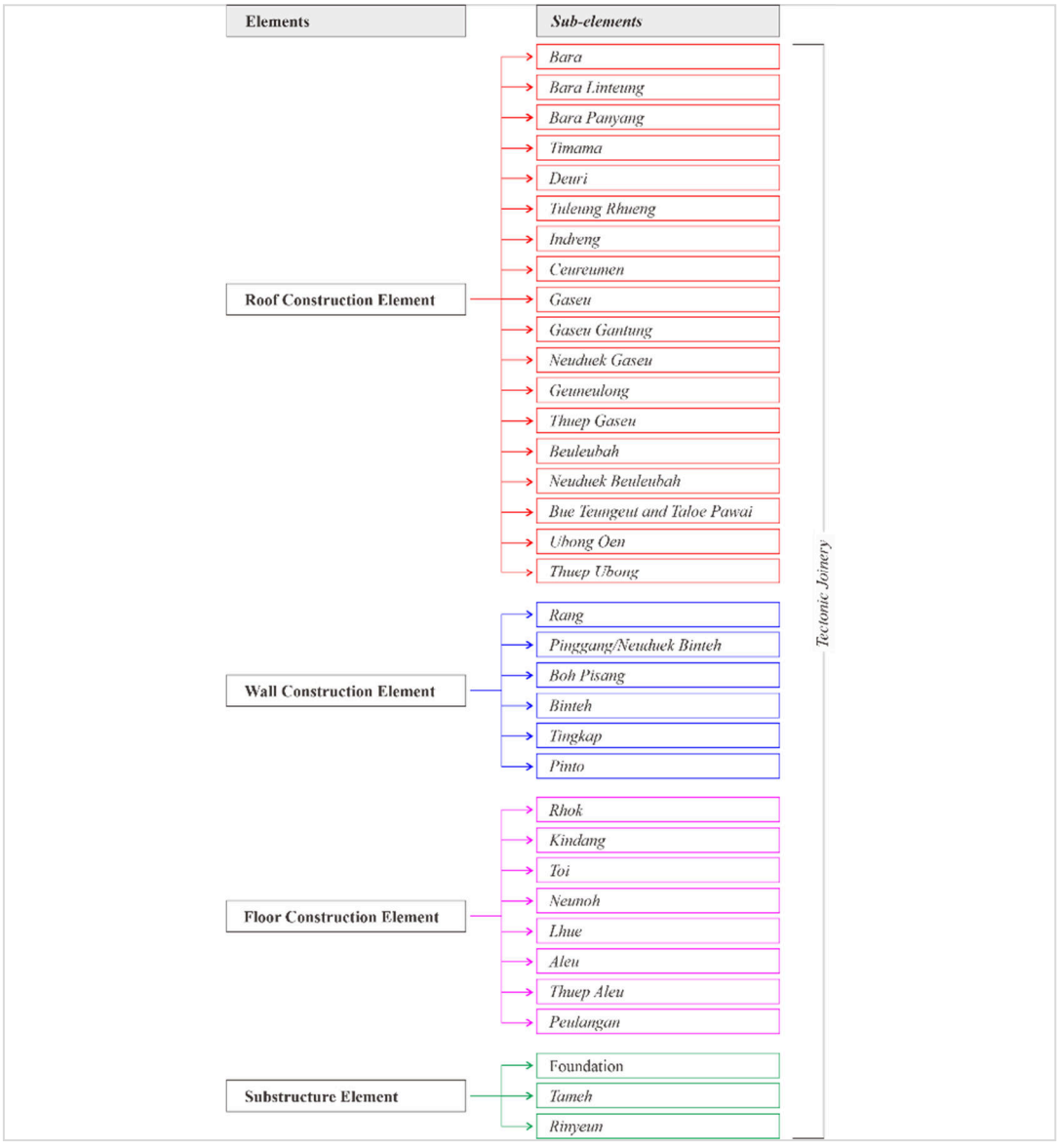

Figure 21. Breakdown example of elements and sub-elements of the *Rumoh Aceh* construction

In Stage 3, parameters for each codified element are defined, including shape, quantity, and dimensional attributes.

Stage 4 focuses on formulating composition stages and syntactic rules that govern *Rumoh Aceh's* construction grammar.

Stage 5 entails derivation of form grammar, construction logic, and optional rules, allowing for additions, modifications, or eliminations as needed.

The syntactic properties of *Rumoh Aceh* facilitate its integration into a rule-based grammatical system. Within this research, shape grammar functions as a framework for reinterpreting existing design rules and discovering new, previously undefined tectonic principles.

Texts, documents, and building manuals serve as codified rule references, construction processes embody these rules, and built structures manifest their application (Li and Jin-Yeu Tsou 1995). Similar to Li (2001) use of the Yingzao Fashi to analyze Chinese architectural rules; this study employs shape grammar to uncover the knowledge embedded in *Rumoh Aceh's* tectonic system. It is crucial to recognize that modern instances of *Rumoh Aceh* may deviate from these traditional rules, often displaying variations even when following conventional guidelines.

Therefore, an investigation into the tectonic knowledge of *Rumoh Aceh* is essential to identify references to its legitimate architectural rules. This inquiry should encompass various knowledge sources, including explicit knowledge, tacit understanding, and physical artifacts associated with *Rumoh Aceh*.

Conclusions

This study is devoted to investigating the potential application of the shape grammar approach to the tectonic configuration of *Rumoh Aceh*, a traditional Acehnese architectural form. Although the scope is constrained to examining this theoretical possibility, the analysis demonstrates that shape grammar possesses significant potential in codifying not only the architectural language but also the tectonic articulation embedded within *Rumoh Aceh*. The results suggest that this methodology is capable of systematically capturing and formalizing the intrinsic structural logics and stylistic principles that define the traditional architectural vocabulary, thereby positioning it as a promising instrument for future reinterpretation and adaptation within contemporary architectural contexts. Nonetheless, empirical validation remains necessary to substantiate the practical viability of this approach.

The shape grammar framework may thus serve as an analytical, generative, and adaptive tool, facilitating the re-examination and reinterpretation of *Rumoh Aceh's* architectural typology through a tectonic lens. To achieve this, however, it is essential to refine the operational framework and methodological constructs with greater specificity to reflect the unique cultural and contextual parameters of the intended design application. This endeavour demands a comprehensive and nuanced understanding of architectural design knowledge.

Crucially, the value of the shape grammar paradigm does not lie primarily in the production of final design outcomes or case-specific solutions, but rather in its capacity to elucidate and encode the foundational principles that govern the configuration and articulation of architectural elements and building components.

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Zulhadi Sahputra contributed to the research concepts, preparation, methodologies, investigations, data analysis, visualization, articles drafting and revisions.

Dewi Larasati contributed to research concepts, literature reviews, methodology, data analysis, supervision, and validation.

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