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Integrating Nutmeg and Clove Motifs into ACP Sunscreens: Developing a Campus Facade Typology for Tropical Educational Architecture

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ABSTRACT

This study investigates how the symbolic and morphological attributes of nutmeg (*Myristica fragrans*) and clove (*Syzygium aromaticum*), two endemic and culturally significant plants of North Maluku, can be translated into contemporary Facade sunscreen systems for tropical campus architecture. Focusing on Khairun University in Ternate, the study examines three building cases: the Integrated Lecture Building, the Engineering Laboratory Building, and the Rectorate Building, representing academic, laboratory, and administrative functions within a single institutional setting. A qualitative, conceptual, and typological design approach was employed through literature interpretation, daytime Facade observation, morphological abstraction of plant forms, digital Facade modelling, and comparative analysis based on Facade porosity, symbolic expression, visual permeability, functional adaptation, and material-fabrication compatibility. The findings show that nutmeg–clove-inspired motifs can be systematically transformed into Aluminium Composite Panel (ACP) sunscreen systems with differentiated architectural expressions. From these existing campus applications, three built typologies are derived: Type A academic screens with medium porosity, Type B laboratory screens with zoned density, and Type C administrative screens with lower porosity and stronger institutional character. Rather than functioning as applied ornamentation, these Facade elements operate as a repeatable architectural language that reinforces campus identity while aligning with contemporary material systems and laser-cut fabrication techniques. The study contributes to the discourse on symbolic-material integration in tropical educational architecture by deriving a preliminary framework for translating endemic flora into Facade-based institutional identity. However, the derived typology remains preliminary and design-based and does not claim verified thermal, daylight, glare, or energy performance. Future studies should validate its environmental and perceptual effectiveness through simulation, field measurement, user evaluation, and construction performance assessment.

1. INTRODUCTION

Educational architecture in tropical regions is increasingly required to provide more than functional accommodation and indoor comfort. It is also expected to represent institutional identity and engage meaningfully with the cultural and environmental character of place [1, 2]. In many contemporary academic buildings, however, Facade design remains dominated by generalized modern expression, often prioritizing material efficiency and visual consistency over contextual specificity. As a result, buildings may perform adequately as educational facilities while lacking a recognizable architectural language that reflects local identity.

This issue is particularly relevant in North Maluku, where nutmeg (*Myristica fragrans*) and clove (*Syzygium aromaticum*) occupy a significant place in regional history, economic life, and collective memory [3, 4]. These endemic spice plants are not only agricultural commodities, but cultural symbols associated with prosperity, local wisdom, and the historical trajectory of the archipelago. Their transformation into architectural expression therefore offers more than ornamental value. It creates the possibility of embedding local symbolism into contemporary educational buildings in a way that is both visually legible and institutionally meaningful [1, 5]. Comparable studies on the transformation of traditional houses and the integration of cultural elements into contemporary design further suggest that local symbolism can remain architecturally relevant when reinterpreted through modern design language [6, 7].

At the same time, advances in material technology and construction systems have expanded the possibilities for integrating traditional symbolic content into modern Facades. Innovative Facade systems and modular construction methods enable local motifs to be reinterpreted within a contemporary architectural language while remaining compatible with current demands for durability, construction efficiency, and environmental responsiveness [8, 9]. In particular, the use of Aluminium Composite Panel (ACP) and laser-cut fabrication provides an opportunity to translate symbolic forms into perforated Facade elements that are precise, repeatable, and constructively feasible [10, 11].

Within tropical architecture, sunscreen or *brise-soleil* systems play an important role in mediating Facade exposure, regulating incoming light, and contributing to visual comfort [10, 12-14]. Studies on perforated screens have shown that such systems can support daylight control and shading performance when pattern density and porosity are carefully considered [15-17]. This makes perforated Facade systems especially relevant for educational buildings, where visual clarity, Facade identity, and the articulation of institutional image must be addressed simultaneously [18, 19]. In this context, the use of nutmeg and clove as perforation motifs offers both symbolic significance and architectural coherence [20-23].

Accordingly, the problem addressed in this paper lies at the intersection of local plant identity, tropical facade response, and campus image. Nutmeg and clove are selected not simply because they are visually recognizable plants, but because their fruit, aril, bud, and petal structures can be abstracted into void-solid patterns suitable for perforated sunscreen panels. In this interpretation, cultural symbolism is linked to a potential environmental response through porosity, screen depth, light transmission, and visual permeability rather than through symbolic meaning alone [24].

Khairun University, located in North Maluku, has increasingly adopted local symbolic expression in its campus architecture through the use of nutmeg–clove-inspired sunscreen panels in several buildings, including the Integrated Lecture Building, the Engineering Laboratory Building, and the Rectorate Building. These existing applications are treated in this study as built campus cases from which a recurring architectural language and three Facade typologies are derived, rather than as newly proposed Facade designs.

Although previous studies have examined traditional symbolism in architecture, material expression in contemporary facades, and tropical building-envelope strategies, limited attention has been given to the complete translation chain from endemic flora to repeatable campus facade typology. In particular, few studies explain how local plant motifs can be systematically abstracted into perforated sunscreen geometry, adapted to academic, laboratory, and administrative building functions, and evaluated through transparent design criteria within one university campus. This paper addresses that gap by analysing the symbolic, morphological, material, and typological translation of nutmeg and clove into ACP sunscreen systems at Khairun University. Its originality lies in demonstrating how endemic botanical symbols can be converted into a repeatable institutional facade language while remaining cautious about unverified thermal, daylight, glare, and user-perception claims.

2. METHODOLOGY

This study adopts a qualitative, conceptual, and comparative typological design method. Rather than claiming measured building performance, it examines how symbolic plant forms are translated into facade systems, how those systems are adapted to different campus building functions, and how their potential environmental response can be discussed through design variables such as porosity, screen depth, daylight filtering, and visual permeability.

The research process was organized into four stages. First, nutmeg and clove were interpreted as symbolic-cultural sources within the North Maluku and spice-route context [3, 11, 25]. Second, their morphological characteristics were abstracted into formal principles for perforated facade patterns [5, 20]. Third, the abstraction was translated into ACP sunscreen modules using AutoCAD-based drawings and a simplified SketchUp 1:1 massing model for sun-shadow checking. Fourth, the three case buildings were compared as Type A academic, Type B laboratory, and Type C administrative facade variants.

This sequence allows the study to move systematically from symbolic meaning to formal abstraction, then to material translation, and finally to typological synthesis. The overall analytical sequence of the study is summarized in Figure 1. Table 1 presents the methodological matrix of data sources, analysis steps, outputs, and related figures/tables used in the study.

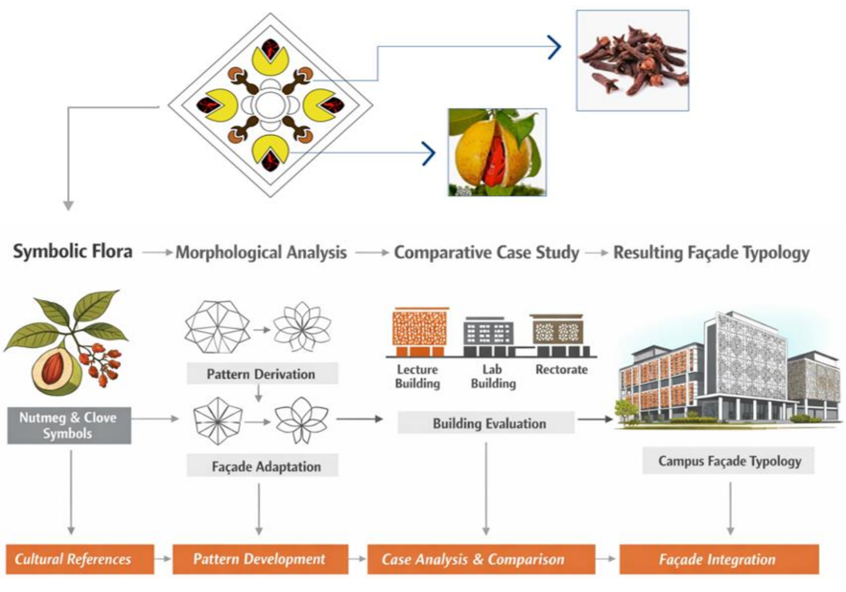

Figure 1. Analytical framework of the symbolic-to-typological design translation process

Table 1. Methodological matrix of data sources, analysis steps, outputs, and related figures/tables

Component	Design-Based Method and Output
Study object	Three Khairun University cases: Integrated Lecture Building, Engineering Laboratory Building, and Rectorate Building.
Stage 1	Symbolic interpretation of nutmeg, clove, North Maluku identity, spice-route memory, and campus image. Output: local identity framework.
Stage 2	Morphological abstraction of fruit, aril, bud, and petal forms into repeatable void-solid geometry. Output: Figure 2 and Table 2.
Stage 3	ACP translation using project drawings, photographs, AutoCAD drawings, and simplified SketchUp 1:1 massing. Decision rule: porosity, screen depth, cavity, and module size. Output: Table 3.
Stage 4	Comparative typological evaluation of Type A, Type B, and Type C as-built typologies derived from existing campus applications using fixed criteria. Scores are author design assessments, not measured performance. Output: Tables 4-5.
Exposure review	Daytime facade reading at 09:00, 12:00, and 15:00, plus equinox/solstice reference checks. Orientation is treated qualitatively through exposed facade planes and time-band exposure.

Notes: The matrix clarifies that the evaluation is a comparative architectural evaluation. It does not replace thermal, daylight, glare, energy, or user-perception testing. ACP: Aluminium Composite Panel.

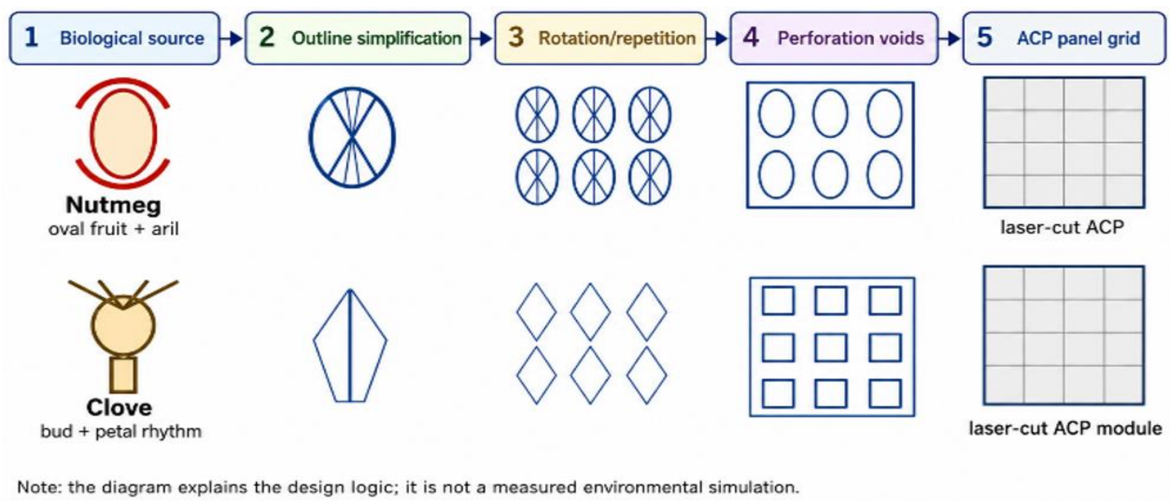

Figure 2. Derivation of nutmeg and clove forms into repeatable Aluminium Composite Panel (ACP) perforation and sunscreen modules

Figure 1 summarizes the analytical logic of the study, beginning with the symbolic-cultural interpretation of nutmeg and clove, followed by morphological abstraction, material translation into ACP sunscreen systems, and comparative case analysis across three campus buildings. This framework clarifies that the study does not treat the Facade as an isolated design object, but as the result of a sequential transformation from local symbolic source to institutional architectural typology.

To ensure analytical consistency across the three case studies, the comparison was structured around four criteria: symbolic legibility, morphological abstraction, material-constructive integration, and typological adaptability. Symbolic legibility refers to the extent to which the Facade remains identifiable as a nutmeg–clove-derived design language. Morphological abstraction refers to the consistency of the transformation from biological form into architectural pattern. Material-constructive integration evaluates the compatibility between symbolic design intent and ACP laser-cut fabrication. Typological adaptability refers to the extent to which the same motif system can be adjusted to different building functions while maintaining campus-wide visual coherence.

The analysis was conducted using project drawings, facade renderings, built-condition photographs, and visual documentation compiled for this study. Daytime facade reading was structured around three exposure bands: morning (09:00), noon (12:00), and afternoon (15:00), and around equinox/solstice reference dates in the simplified digital shadow review. Because no geodetic survey or calibrated environmental measurement was conducted, facade orientation is discussed qualitatively through major exposed facade planes and time-band exposure rather than exact azimuth values. This procedure enabled the study to move from descriptive observation to cross-case interpretation, design-variable estimation, and typological synthesis.

3. SYMBOLIC AND MORPHOLOGICAL BASIS OF THE FACADE CONCEPT

3.1 Symbolic meaning of nutmeg and clove in North Maluku

Plant symbolism has long played an important role in traditional architecture and visual culture as a carrier of identity, social value, and environmental knowledge [11, 21-23]. In this context, nutmeg and clove are particularly significant in North Maluku because they represent not only biodiversity but also the historical memory of the spice trade and the region's cultural position within the wider Indonesian archipelago [3, 11]. Their translation into educational Facades therefore enables the building envelope to function as a cultural sign as well as a physical boundary [24, 25].

Within the present architectural interpretation, nutmeg is associated with fragrance, prosperity, and the symbolic heritage of the spice route, while clove is associated with endurance, regional continuity, and historical trade identity. Beyond these symbolic associations, both species are also recognized in scientific literature through their distinctive fruit and bud characteristics, reinforcing their status as identifiable and regionally specific flora [12, 13]. These combined symbolic and biological associations make both plants suitable as generative references for a Facade system intended to strengthen campus identity.

3.2 Morphological abstraction of endemic flora

The transformation of endemic flora into Facade language is based not on literal pictorial imitation, but on morphological abstraction. Nutmeg is characterized by an oval layered body and the mesh-like geometry of the red aril, while clove is characterized by compact form, bud structure, and repetitive petal rhythm. These biological features can be translated into perforated modules, layered screens, and repetitive Facade grids without becoming direct botanical illustrations.

This transformation is consistent with abstraction-based approaches in architectural design, where the objective is to derive formal, tectonic, and visual principles from natural sources rather than reproduce them literally [5, 20]. The translation of biological characteristics into repeatable perforation patterns also resonates with parametric approaches in which ornamental systems are generated through rule-based geometric abstraction [31]. Through this process, endemic flora becomes a formal and symbolic generator of architectural language, allowing local biological identity to be integrated into contemporary Facade design in a controlled and architecturally legible manner.

For transparency, the motif derivation was organized into five steps: identifying the biological source, simplifying the outline, rotating and repeating the simplified form, converting selected areas into perforation voids, and assembling the result into an ACP panel grid. Nutmeg contributes oval outlines and aril-like mesh geometry, whereas clove contributes bud compactness and rhythmic petal repetition. Figure 2 illustrates this abstraction process before the forms are assigned to different facade typologies.

3.3 Design translation matrix

To clarify this transformation, the morphological logic of each plant may be summarized in relation to the derivation process in Figure 2 and Table 2.

Table 2. Morphological translation of nutmeg and clove into Facade design

Plant Source	Morphological Characteristic	Design Translation	Facade Application	Symbolic Value
Nutmeg (*Myristica fragrans*)	Oval layered fruit; mesh-like aril	Organic and semi-transparent perforation pattern	Layered sunscreen panel	Prosperity, fragrance, spice-route identity
Clove (*Syzygium aromaticum*)	Compact bud form; rhythmic petal repetition	Modular and repetitive geometric screen	Repeated Facade grid / double-skin logic	Resilience, trade history, regional continuity

Table 2 indicates that nutmeg and clove do not function merely as visual references but as distinct formal generators within the Facade design process. Nutmeg contributes layered, organic, and semi-transparent characteristics, whereas clove contributes repetitive, modular, and rhythmically ordered geometry. The combination of these two symbolic sources enables the development of a Facade language that is both culturally rooted and architecturally adaptable.

3.4 Design translation into Aluminium Composite Panel sunscreen systems

In tropical humid climates, sunscreen systems are relevant not only as shading devices but also as visual mediators between interior and exterior. In this study, environmental action is not attributed to the cultural symbol itself, but to its translation into perforated ACP geometry. The void-solid ratio, porosity, screen depth, and ventilated cavity are treated as design mechanisms for solar filtering, daylight moderation, visual permeability, and potential heat response [14, 17-19]. These mechanisms are discussed as potential environmental responses rather than verified performance outcomes.

The translation of nutmeg and clove into facade systems is made feasible through ACP and laser-cut fabrication. The working assumption used in the design review is a 4 mm ACP panel based on standard 1200 × 2400 mm sheet modules, fixed to a secondary metal subframe with screw or rivet connections, a ventilated cavity of approximately 100-200 mm, and expansion gaps of about 3-5 mm between panels. For humid tropical applications, fire-retardant ACP cores, protected edges, corrosion-resistant fixings, rainwater drainage, and cleaning access should be specified before construction.

The design logic of the proposed system may be summarized into four criteria. First, the symbolic criterion requires that the motif remain legible as a local plant-derived form [21, 23-25]. Second, the morphological criterion requires that abstraction be formally consistent rather than merely decorative [5, 20]. Third, the constructive criterion requires compatibility between motif geometry and ACP fabrication, panel assembly, fixing method, ventilation cavity, and expansion tolerance [2, 9]. Fourth, the typological criterion requires that the same motif system be adaptable across more than one building function while maintaining visual coherence [26-28]. Because no calibrated simulation, field measurement, or user survey was conducted, the following evaluation is a design-based comparative assessment.

3.5 Comparative case analysis at Khairun University

This section presents a comparative analysis of three existing campus applications at Khairun University: the Integrated Lecture Building, the Engineering Laboratory Building, and the Rectorate Building. Based on a typological reading of these built applications, the cases are classified as Type A (academic), Type B (laboratory), and Type C (administrative). Each built typology is examined in terms of Facade composition, Facade placement, porosity strategy, intended function, and material-construction assumptions.

Figure 3 provides a comparative visual overview of the three existing case-study buildings analysed in this paper: the

Integrated Lecture Building as Type A, the Engineering Laboratory Building as Type B, and the Rectorate Building as Type C. Together, these built applications demonstrate that the same symbolic facade language has been implemented across different institutional functions while allowing different porosity and density strategies.

Table 3 reports the main design variables used to compare a hypothetical no-screen reference condition with the three built typologies derived from existing campus applications. The values are preliminary estimates derived from drawings, photographs, and simplified digital modelling; they are not field-measured data.

Integrated lecture building	Faculty of engineering laboratory building	Rectorate Building
(A)	(B)	(C)

Figure 3. Typologies of nutmeg-clove-inspired Aluminium Composite Panel (ACP) sunscreen systems at Khairun University: (A) Type A academic, (B) Type B laboratory, and (C) Type C administrative buildings

Table 3. Preliminary design variables and decision rules for built ACP sunscreen typologies

Type/Case	Preliminary Design Variables and Decision Rules
Hypothetical no-screen reference condition	Hypothetical reference condition without a secondary ACP sunscreen, used only for comparative design assessment; it does not represent the actual existing condition of the three case buildings.
Type A Academic	Built Integrated Lecture Building application. Medium porosity; estimated open area 35-45%; screen depth 150-200 mm; 4 mm ACP; 1200 × 2400 mm module; balances openness, recognizability, and daylight filtering.
Type B Laboratory	Built Engineering Laboratory Building application. Zoned density-gradient screen; estimated open area 25-40%; screen depth 200-300 mm; 100-200 mm ventilated cavity; denser panels for light-sensitive rooms and more open panels for circulation/ventilation zones.
Type C Administrative	Built Rectorate Building application. Lower porosity; estimated open area 20-30%; screen depth 250-300 mm; formalized grid; stronger institutional expression; fire-retardant ACP core and cavity barriers recommended.

Note: ACP: Aluminium Composite Panel.

Table 4. Preliminary comparative scoring matrix for the hypothetical no-screen reference condition and Type A-C built sunscreen typologies

Criterion	Design-Based Comparison Score
Shading potential	No-screen reference = 1; Type A = 3; Type B = 4; Type C = 4. Higher score means stronger potential shading.
Light transmission/view	No-screen reference = 4; Type A = 4; Type B = 3; Type C = 2. Higher score means greater openness and view/light transmission.
Symbolic legibility	No-screen reference = 1; Type A = 4; Type B = 4; Type C = 5. Higher score means stronger visible cultural-symbolic reading.
Construction complexity	No-screen reference = 1; Type A = 3; Type B = 4; Type C = 3. Higher score means greater construction complexity.
Maintenance risk	No-screen reference = 2; Type A = 3; Type B = 4; Type C = 4. Higher score means greater cleaning, staining, fixing, and durability risk.

The comparative evaluation in Table 4 uses fixed criteria to avoid presenting built typologies without an evaluation basis. Scores are preliminary author assessments. For shading potential, light/view, and symbolic legibility, 1 indicates weak and 5 indicates strong. For construction complexity and maintenance risk, 1 indicates low risk/complexity and 5 indicates high risk/complexity.

Table 4 is a design-based comparison only between a hypothetical no-screen reference condition and built Type A-C sunscreen typologies; it does not report measured temperature reduction, illuminance, glare index, energy demand, or user-perception scores.

3.6 Integrated Lecture Building

The Integrated Lecture Building is categorized as Type A (academic). It presents the most introductory and pedagogically accessible application of the nutmeg-clove facade language. The motif functions as a visual campus identifier and as a medium-porosity light-filtering layer, balancing openness, symbolic legibility, daylight moderation, and visual permeability [29, 30].

The application of laser-cut ACP panels indicates that the motif is not merely decorative, but has been translated into a buildable secondary skin. In Type A, the design rule favours medium open area and moderate screen depth so that teaching spaces remain visually accessible while direct solar exposure is filtered. This makes the lecture building the clearest example of an academic facade type within the Khairun University campus.

Figure 4 shows how the nutmeg-clove motif is applied to the Integrated Lecture Building as a Type A medium-density sunscreen layer. The facade expression emphasizes openness, recognizability, and balanced visual filtering, making it appropriate for academic space. In typological terms, this figure illustrates the most introductory and accessible expression of the campus facade language.

Figure 5 clarifies the constructive logic of the Type A sunscreen system applied to the Integrated Lecture Building. The technical drawing demonstrates how symbolic abstraction is translated into panel composition, perforation arrangement, facade placement, and buildable ACP module logic rather than remaining a decorative graphic.

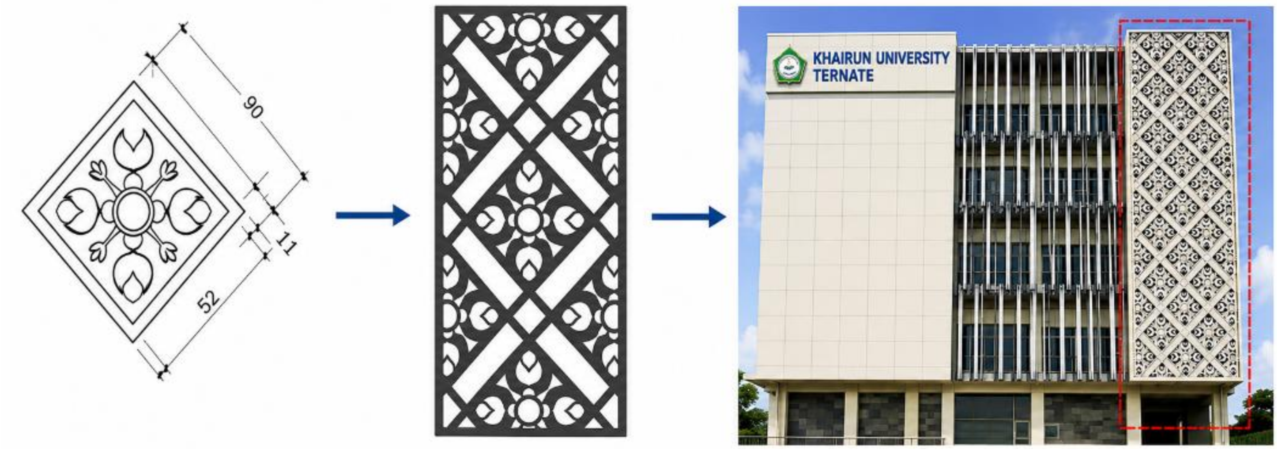

Figure 4. Type A academic sunscreen: Nutmeg-clove motif as a medium-porosity light-filtering facade element in the Integrated Lecture Building

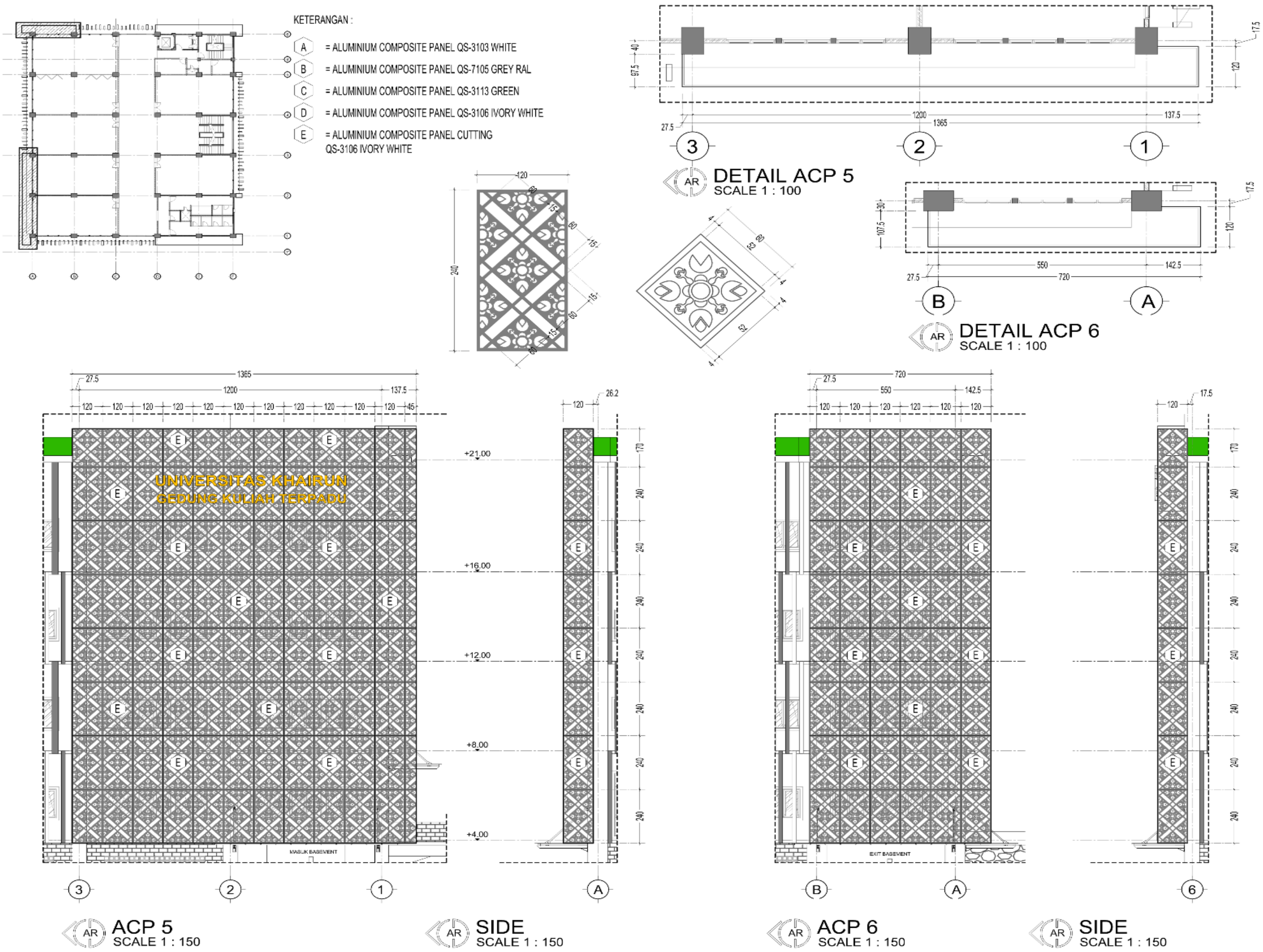

Figure 5. Type A academic sunscreen technical drawing showing Aluminium Composite Panel (ACP) panel composition, perforation arrangement, facade placement, and buildable module logic

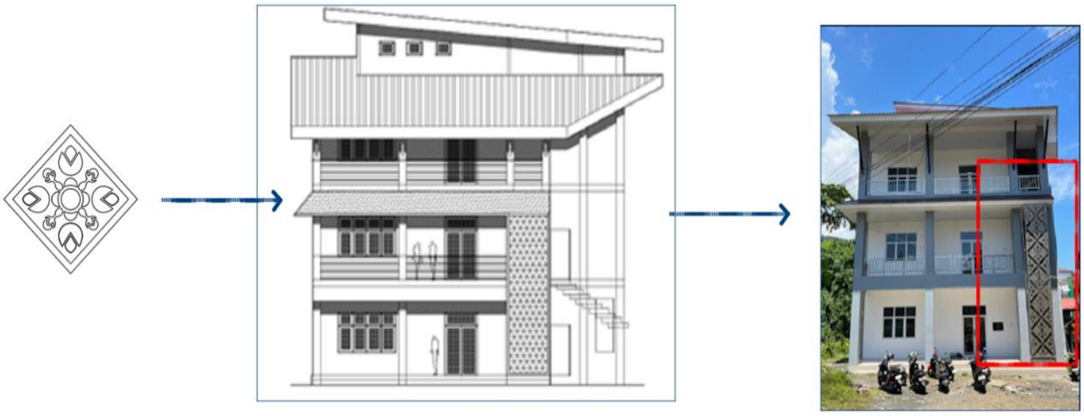

Figure 6. Type B laboratory sunscreen: Nutmeg-clove motif with zoned-density light-filtering and ventilation response in the Engineering Laboratory Building

3.7 Engineering Laboratory Building

The Engineering Laboratory Building is categorized as Type B (laboratory). It presents the most functionally differentiated use of the nutmeg-clove system because the facade employs a density-gradient strategy. More open patterns are assigned to circulation and ventilation zones, while denser motifs are associated with laboratory spaces requiring stronger visual and daylight control [28].

This case demonstrates that the nutmeg-clove language is not simply copied from one building to another. The motif is modulated according to facade function, producing a laboratory facade typology characterized by zoned porosity, stronger enclosure, and programmatic response. Type B, therefore, provides the strongest evidence that symbolic continuity can coexist with functional differentiation.

Figure 6 illustrates the facade application of the nutmeg-clove motif in the Engineering Laboratory Building as a Type B laboratory screen. Compared with the lecture building, the laboratory facade shows a stronger degree of enclosure and visual control. This figure supports the argument that the symbolic language is adjusted in response to circulation, ventilation, and light-sensitive laboratory zones.

Figure 7. Type B laboratory sunscreen technical drawing showing density variation, internal zoning response, and Aluminium Composite Panel (ACP) module assembly

Figure 7 demonstrates the technical articulation of the Type B laboratory sunscreen system, particularly the use of density variation in relation to internal zoning. More open areas correspond to circulation and ventilation needs, whereas denser patterns are associated with spaces requiring greater visual control. This figure, therefore, represents the clearest example of programmatic adaptation within the three case studies.

3.8 Rectorate Building

The Rectorate Building is categorized as Type C (administrative). It adopts the nutmeg-clove facade language in a more formal and representative manner. Lower-porosity motifs respond to office and administrative requirements by creating stronger visual order, a more solid institutional character, and clearer symbolic presence [29-31].

Figure 8 shows how the nutmeg-clove motif is translated into a Type C facade composition characterized by lower porosity, stronger visual order, and a more formal representational expression. In contrast to the lecture and laboratory buildings, the rectorate facade emphasizes institutional presence and administrative authority as a symbolic design intention, not as verified user-perception evidence.

Figure 8. Type C administrative sunscreen: Nutmeg-clove motif with lower porosity and stronger institutional facade order in the Rectorate Building

Figure 9 explains the constructive and compositional logic of the Type C sunscreen system in the Rectorate Building. The technical drawing indicates a more formalized facade arrangement, showing how symbolic abstraction is resolved into an ordered institutional envelope with clearer placement and construction assumptions.

Figure 10 highlights the visual transformation of the Rectorate Building before and after the installation of the nutmeg-clove-inspired sunscreen system. The comparison demonstrates an architectural image change; however, it should be read as visual and symbolic evidence rather than as proof of measured environmental or user-perception performance.

3.9 Campus facade typology

The repeated use of nutmeg-clove-inspired ACP sunscreens across multiple building types indicates that the facade system can be read as an emerging campus-wide typology. This typological reading remains preliminary because it is based on visual, architectural, and design-based evidence rather than post-occupancy evaluation. Nevertheless, the motif is applied consistently across educational, laboratory, and administrative buildings, and its use has extended to additional campus projects still under construction. This allows the cases to be synthesized into three typological groups, as shown in Table 5.

The typological classification demonstrates that the repeated use of nutmeg-clove-inspired sunscreen panels does not result in uniformity, but in controlled variation. The same symbolic source generates distinct facade responses according to programmatic demand: Type A emphasizes academic openness, Type B emphasizes density-based laboratory control, and Type C emphasizes administrative formality. This indicates that the facade language operates typologically rather than merely decoratively, while its environmental and perceptual effectiveness still requires validation.

Figure 11 indicates that the nutmeg-clove-inspired facade language is not limited to the three completed case-study buildings, but is continuing to inform newer campus developments. This extension strengthens the typological argument, while wider campus replication should still be preceded by simulation, post-occupancy feedback, and construction validation.

Figure 9. Type C administrative sunscreen technical drawing showing formalized Aluminium Composite Panel (ACP) panel composition, fixing logic, and facade placement

Figure 10. Rectorate Building before and after the installation of the Type C nutmeg-clove-inspired Aluminium Composite Panel (ACP) sunscreen system

Table 5. Preliminary typology of nutmeg-clove facade applications at Khairun University

Typology	Building Function	Design Character	Dominant Facade Logic	Symbolic Role
Academic typology	Lecture and faculty buildings	Open and moderately dense	Balanced filtering and readability	Introductory academic identity
Laboratory typology	Laboratories and research facilities	Zoned and denser	Density-gradient screening	Scientific-local identity
Administrative typology	Rectorate and office buildings	Formal and representative	Lower-porosity institutional screen	Institutional authority and campus image

Figure 11. New campus buildings under construction, adopting the nutmeg-clove sunscreen language

4. DISCUSSION

The main value of this study lies in showing that symbolic endemic flora can be transformed into a consistent architectural facade language without being reduced to superficial ornament. Nutmeg and clove are translated through symbolic reading, morphological abstraction, material construction, and typological adaptation. In this framework, environmental action is not produced by the symbol itself, but by the way the symbol is converted into perforated geometry, porosity, screen depth, and ventilated facade layering [5, 6, 24, 25].

The first research question asked how nutmeg and clove could be translated from cultural and biological symbols into facade geometry. The findings indicate that this translation is achieved through abstraction rather than literal imitation. Nutmeg contributes layered and semi-transparent characteristics, while clove contributes modular and rhythmically ordered geometry. Together, these sources form a perforated motif grammar that can be applied to ACP screens [25, 32, 33].

The second research question asked how these motifs are adapted across different building functions. The comparative analysis demonstrates that the same symbolic source is not applied uniformly. Type A emphasizes openness and recognizability, Type B introduces density-based differentiation for laboratory use, and Type C expresses formal administrative representation. This supports the argument that symbolic continuity can coexist with functional variation.

The third research question asked to what extent these applications form an emerging campus facade typology. The results indicate that the repeated use of nutmeg-clove-inspired ACP sunscreen systems across academic, laboratory, and administrative buildings has generated more than isolated facade treatments. However, this typology should be understood as preliminary and design-based, not as evidence of verified environmental performance or confirmed user perception [32].

Compared with common horizontal louvers, the proposed ACP sunscreen typology offers stronger symbolic specificity because its perforation grammar is derived from regional plant imagery rather than from a generic shading profile. However, louvers can be easier to optimize for solar angle and may provide more predictable shading behaviour when their depth, spacing, and orientation are quantitatively modelled. The nutmeg-clove system, therefore, adds cultural legibility while still requiring simulation to confirm daylight, glare, and heat-response performance [14, 26].

Compared with generic perforated panels and double-skin systems, the proposed typology is simpler and more directly tied to campus identity because it uses fixed laser-cut ACP modules and a recognizable botanical source. Its limitation is that fixed screens cannot adapt dynamically to seasonal or hourly solar variation. Compared with regional ornamental facades, the proposal shifts ornament into a functional envelope layer, yet cultural legibility remains an author assessment until tested through user questionnaires, expert review, or post-occupancy interviews [25, 29, 34].

The practical use of ACP in a humid tropical campus also requires caution. Rain exposure, salt-laden air, ultraviolet weathering, surface staining, corrosion at fixings, panel-edge deterioration, thermal movement, joint stress, and cleaning access can affect durability. Fire safety should be addressed through fire-retardant core selection, cavity barriers, safe subframe detailing, and compliance with applicable facade regulations. Drainage paths, inspection access, replaceable panels, and maintenance scheduling should therefore be incorporated before wider campus replication.

Nevertheless, the study has several limitations. First, it does not include calibrated simulation-based or measurement-based environmental performance evaluation; therefore, the findings remain architectural, typological, and preliminary. Second, the analysis focuses on three buildings within a single institutional context, which limits broader generalization. Third, no student, staff, visitor, expert, or facility manager survey was conducted; therefore, claims about campus identity are limited to symbolic legibility and visual coherence. Fourth, the scoring matrix is an author-designed assessment and should be validated through annual daylight simulation, thermal measurement, glare analysis, user-perception surveys, maintenance observation, and construction performance assessment [14, 26, 29].

5. CONCLUSIONS

This study derives, rather than newly proposes or verifies, a preliminary ACP sunscreen typology based on nutmeg and clove imagery for tropical educational architecture at Khairun University. Through symbolic interpretation, morphological abstraction, ACP material translation, and comparative typological evaluation of existing campus applications, the study shows how endemic symbolic flora can be converted into a repeatable institutional facade language. Type A academic screens emphasize openness and medium porosity, Type B laboratory screens emphasize zoned-density control, and Type C administrative screens emphasize lower porosity and formal institutional expression. The derived system indicates possible roles in solar filtering, daylight moderation, visual permeability, and symbolic legibility, but these roles are design intentions and potential responses only. The study does not claim verified thermal, daylight, glare, energy, or user-perception performance. Before wider campus replication, the typology should be tested through annual daylight and glare simulation, field thermal measurement, user and expert evaluation, maintenance monitoring, fire-safety review, and construction validation. These further studies would strengthen the applicability of culturally grounded facade design in tropical educational environments seeking to integrate local identity with contemporary architectural practice.

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