Generative Design Approach for Modeling a Rhythmic Façade
(Case Study: Colonial Building in *Kota Lama*, Semarang)

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1. Introduction

Kota Lama is a historic area in Semarang City with characteristics of Colonial Building with various styles and facades. The similarity of architectural façade character is related to the image of the city (1). In the context of historic buildings, Historical patterns can lose the character and identity of their historical structures as changes in the urban environment. New buildings should be integrated harmoniously with their surroundings through observation of cultural heritage buildings in *Kota Lama* of Semarang by looking for formal elements of the structure in the modelling of this study to reference the new façade design.

Designing for the 21st century is a perspective that demonstrates the intersection of transdisciplinarity with the cutting edge digital technology used to design and manufacture. Society 5.0 is proposed in the 5th Science and Technology Basic Plan as a future society (2). In the transdisciplinary collaboration, we could appreciate how the natural, social, and cultural environment influence on the structural and conceptual solution of the design.

With the phenomenon that occurs in the field, the research question is formulated*: How generative design approaches can analyze the facade of a colonial building in 'Kota Lama' Semarang?*. The objectivity of this research is to determine the dominance of formal structure theory in *Kota Lama* Semarang by using a generative design approach so that formal elements of the dominant structure can be found as a reference for new façade designs.

1.1. GENERATIVE DESIGN THEORY

Generative Design is a design model in which the exploration of design is described as a series of transformations from a new initial data to a large number of possible knowledge-integrated designs, which have high qualities that meet the design requirements in the best possible way (3). An explanation regarding GDA's framework (4) (see Figure.1.):
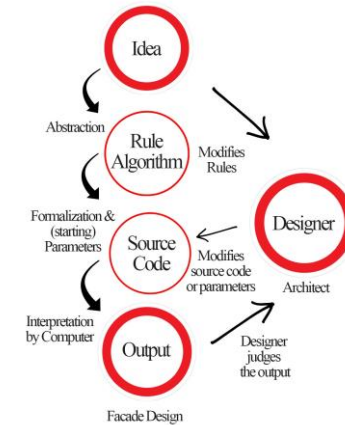

Figure.1. Re-drawing GDA's Framework by Lazzeroni, 2009. (Author, 2020)

1.2. FORMAL STRUCTURE THEORY

Rafael Moneo, 1979 (5) explained that the design process is a way to bring elements from a typology in which it has a formal structure that gives its characteristics of architecture. In the modelling of this research, five variables will be chosen to find façade typology in *Kota Lama* Semarang with the following illustration (see Figure. 2):

Figure. 2. Illustration of Formal Structure element as the observation variable (Source: Author, 2020)

- Proportion is a consideration of the solid-void relationship in the overall image of the region
- The scale is concerned with the dimensions of the building to its perception relative to the elements around.
- The balance element is the relationship between different areas of the structure and imaginary centre lines.

- Rhythm is the organization and size of the façade components which are usually in the repetition's form (Both Vertical or Horizontal)
- Material Can be defined to construct significant visual characteristics so they can manifest colours.

1.3. BUILDING FAÇADE THEORY

Aesthetic diversity in urban areas plays a role in the structure of buildings that are side by side with each other in different periods, and the 'musical' style produces a unique environment. Aesthetic value includes some sense sensitivity features on several criteria that include attention to material, texture, structure, colour, and shape (6). The main variables that make up the character of the region are mass asymmetry, facade rhythm, facade configuration, vertical and horizontal connections between facade elements (7).

From the theory above, it is explained that form and structure are part of the aspects that need to be considered in building façade characters. One form of the building element is openings such as doors and windows, while the structure is the columns that appear on the exterior of the building facade that forms specific patterns and rhythms.

2. Study Area and Data

2.1. KOTA LAMA SEMARANG AS HERITAGE SITE

Semarang is a colonial city which established in the 17th century, *Kota Lama* Semarang is a preserved colonial city with remarkable testimony of critical historical phases of human civilization in economic, political, and social. Even though it is now a sprawling metropolis of 1.2 million population, *Kota Lama* maintains a group of buildings with various architectural styles derived from medieval, baroque, and modern style especially in façade. The unique urban landscape shows a development of a fortified city that grew into an international and cosmopolitan port city in its age (8).

2.2. SAMPLE OF BUILDING'S LOCATION

Buildings sample can be seen in (Figure 3), and a three-dimensional perspective from the main street of Kota Lama can be seen in (Figure 4). The reason for determining the 12 building samples is the consideration in observing the existence of old buildings that are still in use with functions that have changed according to the times but still retain their original facades.
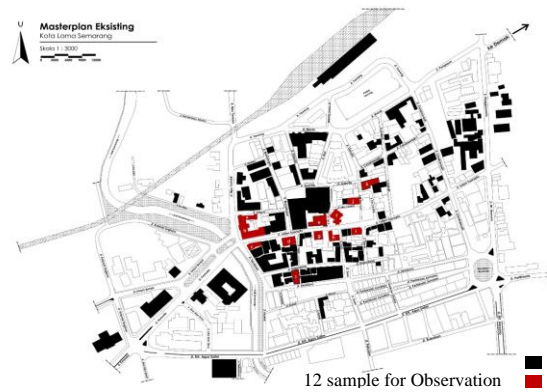

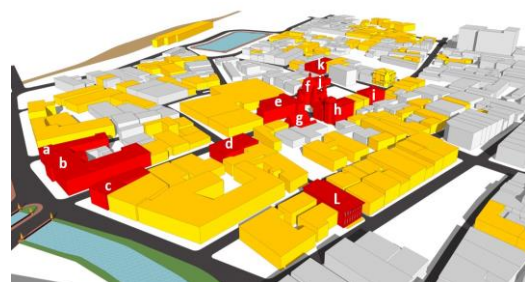Figure. 3. *Kota Lama* Semarang in 2D Map as Locus of Research (Source: Author, 2020)

Figure. 4. *Kota Lama* Semarang in three-dimensional perspective as Research location (Source: Author, 2020)

The *Kota Lama* Semarang is a visual image that presents the grandeur of European architecture in the past. Many exotic ancient buildings and magnificent relics of Dutch Colonial (9). See (Figure. 5):

Figure. 5. 12 Building Sample in *Kota Lama* Semarang (Source: Author, 2020)

Explanation of the functions of samples (see table 1):

Table 1. 12 Building Sample (Author, 2020)

Sample	Name of Building	Build By Years	Function (Now)
Sa	Jakarta Loyd	1930	Office
Sb	*Bank Mandiri*	1908	Office
Sc	*Reflecta* Redaction Ofiice	1908	Office

Sd	*UMKM* Gallery	1925	Gallery
Se	*PPI* Building	1939	Office
Sf	*Blenduk* Church	1753	Church
Sg	*Ikan Bakar* Cianjur	1851	Restaurant
Sh	*Jiwasraya*	1916	Office
Si	*Marba*	1894	Office
Sj	*Out de Trap*	1834	Convention
Sk	Semarang Contemporary Art	1937	Gallery
Sl	*Monod Huis*	1921	Convention

3. Methodology

3.1. SOLID-VOID IN BUILDING FAÇADE AS DATA

Refer to Burra Charter (6); there are several factors where the scientific and research value of place depends on several things, such as the importance of data compilation, representativeness, or quality, in terms of their unique and how much is essential future information. The data complication, in this case, is the regular arrangement of the façade, selected, tabulated, and grouped systematically according to the purpose of analysis rather than the data itself. The design process of interactive facades combines three-dimensional modelling digital tools physical models for examination and experimentation (10).

Data complication refers to the collected facades aimed at identifying what patterns make up the old city building facade network from 12 samples of observed buildings that have different shapes with certain complexities such as rectangle, arch, and circle shapes. Once found the shape of the building elements that will identify specific patterns, then the coding of the facade form elements in each building can be formulated, which will serve as a guide in the array to parametric modelling design.

3.2. MIX-METHODS IN PARAMETRIC APPROACH

Design Problems with varying requirements force designer to explore multiple alternatives between problem space & solution space of a design task (2). In this study, a mixed-method approach was chosen (quantitative and qualitative) to facilitate the simulation of the repetition element design found in the building facade.

4. Results

4.1. FAÇADE ANALYSIS

Façade analysis will use the principle of the decision matrix. Decision matrix elements represent decisions based on specific decision criteria. The matrix is useful for looking at multiple decision variables and assessing the relative significance of each. Based on formal structure theory, elements that can be linearly symbolized and found in almost all building samples are balance, rhythm, and material. In (Table 2), a red table shows to have a pattern '1', and the grey table is shown to have no pattern '0':

Table 2. Decision Matrix Analysis (Author, 2020)

S	X1	X2	X3	X4	X5
Sa	0	0	1	1	1
Sb	0	0	1	1	1
Sc	0	0	1	1	1
Sd	0	0	1	1	1
Se	0	0	0	1	1
Sf	0	0	1	1	1
Sg	0	0	1	1	1
Sh	0	0	1	1	1
Si	0	0	0	1	0
Sj	0	0	0	1	1
Sk	0	0	0	1	1
Sl	0	0	0	1	1

S = Sample; X = Independent Variable

Nmax = 12 Building Samples
$$(Sa + Sb + ..., + Sl) \quad (1)$$

1 Building Sample = Observed by 5 Independent Variables (Formal Structure) (2)

5 Variable = X1. Proportion; X2. Scale; X3. Balance; X4. Rhytm; X5. Material (3)

- Primary Element = X4. Rhythm

Buildings in *Kota Lama* Semarang have a steady rhythm with repetition element and can be observed concretely in all building façade (windows, doors, columns, and vertical ornament)

- Secondary Element = X1. Material; X2. Balance; X3; Proportion; X4. Scale. With the interpretation as follows, see (Table 3):

Table 3. Variable interpretation (Author, 2020)

Variable	Interpretation
X1. Material	Buildings in the Old City of Semarang are dominated by solid material and white colour.
X2. Balance	Buildings in *Kota Lama* do not have the same balance aspect.
X3.	Buildings in *Kota Lama* Semarang mostly

Proportion	have proportions that are in harmony with the neighbourhood.
X5. Scale	Buildings in the *Kota Lama* Semarang have a different scale relationship with the human scale. Some have anthropometric measurements, while others use large scales.

4.2. MODELLING WITH GENERATIVE DESIGN

Repetition Rhythm Forming Algorithm

From the 12 building samples in this research modelling, all buildings that were the object of research in *Kota Lama* Semarang that unite the character of buildings built in different eras are the rhythm factor in the form of repetition, both in the form of windows or doors. It can also be found on vertical columns of structures and decorative elements of buildings.

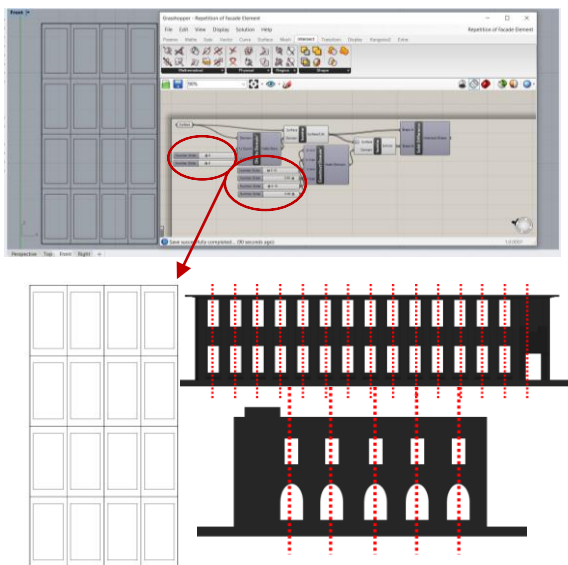$$Nmax = 12\ Samples\ (Sa + Sb +…, + Sl) = X4.\ Rhythm\quad (4)$$

Figure 6. Algorithm for Parametric Facade Modeling with customized sliders (Source: Rhinoceros 6 + Grasshopper plug-in, 2020)

Parametric modelling here focuses on the idea of the relationship between design elements, which is solid-void elements in a system to perform a task. The slider in Grasshopper plug-in, both vertical and horizontal points, explains the area that has a repetitive rhythm. Grasshopper is based on several scripts that implement the façade design process within a parametric modeller in an interval (in this simulation set in interval < 20 = 16). Various simulation tools can improve the speed of design, especially in repetitive form.

5. Discussion and Conclusions

The Building Façade in *Kota Lama* forms a unique identity as a relic of the Dutch colonial era and a famous tourist destination in Semarang. Various attempts were made to be able to maintain the authenticity of the facade. Architects and Researchers make various efforts to be able to identify the pattern so that it can be studied and become a reference for future designs, especially those related to artificial intelligence and computational design.

Parametric design tools are flexible, adaptive, and accurate to the solution of complex problems in architecture as well as facade issues (10). Generative Design will help architects to formulate patterns that can be seen through the contextual outer space, in this study case is building façade. From the overall modelling of observation building samples, it can be found algorithmically that the shape of the repetition pattern dominates of building façade. Parametric modelling and simulation are quickly done with a sliding bar that presents different results based on metric adjustments by the user (Architect as a designer).

With parametric-based Generative Design Approach (GDA), research related to building facades that have repetition rhythm will be easier to do with parametric modelling. This finding will be a booster for Architect and researchers to develop algorithmic intuitions that can easily be captured with human eyes, and then it can be simulated with specific formulas. It will make easier for architects to design building facades from simple to complex form.

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