

# A Figurative Study of Louis Kahn's Capitol Complex at Dhaka: Analysis through Shape and Shape Grammars Theory

## Introduction:

An architectural language, whether it belongs to a certain period or to an architect, has some compositional principles. These principles can be defined by a set of rules, which form the grammar of the language. The study presented in this thesis comprises the union of two basic themes:

- Deriving a shape grammar from a corpus of design (viz., Louis I Kahn's Capitol Complex office block being chosen in this very study).
- Generating languages for application in further designs ('contextualism' triumphing over 'globalization').

This study is a first step towards the formulation of a methodology towards using original design principles, viz. shape grammar and shape language, as a tool to use as guidelines for newer designs.

## Overview of Methodology:

The use of shape and shape grammar formalism provides for a series of methodologies. The methodology applied here refers to the method introduced by George Stiny and William J Mitchell in their paper "The Palladian Grammar", published in the *Environment and Planning B* (volume 5) in 1978. The basic theories abide by the shape and shape grammar definitions incorporated by Stiny (1975), (1980), and Gips (1975). The shapes, chosen from the master plan of Louis I Kahn's Capitol Complex at Dhaka, were analyzed in reference to the papers by G. Stiny's "The Palladian grammar" from *Environment and Planning B* 5, 1978; U. Flemming's "The secret of the Casa Giuliani Frigerio" from *Environment and Planning B* 8, 1981, and T W Knight's "The forty-one steps" from *Environment and Planning B* 8, 1981. The rules of analysis pertain to the 'parametric shape grammar' analysis.

The geometry of Kahn's Capitol plan is studied instead of other aspects of his architectural system, for example, the use of different fenestration, because it characterizes the Kahn style in a fundamental sense. Shapes are realized in Cartesian system of coordinates. Instead of shape rules, a parametric *shape rule schemata*, or *schemata* for short; from any such schema a specific shape rule can be derived through an assignment of values,  $g$ , to the parameters in the schema.

## Shape and Shape Grammars:

George Stiny and James Gips invented shape grammars over twenty-five years ago. They were one of the earliest algorithmic systems for creating and understanding designs directly through computations with shapes, rather than indirectly through computations with text or symbols. Over the years, shape grammars have been explored through applications addressing a variety of design problems. Shortly after their invention, Stiny outlined a two-part project for shape grammars. In a 1976 paper in *Environment and Planning B* 3:(187-210), "Two exercises in formal composition", Stiny described two exercises in formal composition. These simple exercises became the foundation for the many applications of shape grammars that followed, and suggested the potential of such applications in education and practice.

## Research Area:

The capitol complex project at Dhaka, designed by Louis I Kahn in the late sixties, and finished in the early eighties exhibits upon closer inspection a host of formal characteristics which are traces of Louis Kahn's innate *geomancy*. An account of the geometrical analysis, with a different approach, of the prismoidal form, the central towering structure, is available in Gast (2001). This study is an attempt to exemplify parts of it. As a test case, the office block plan from the prismatic volume (fig. 01) is taken into consideration. Figure 02 shows the selected parts. The most conspicuous feature of Kahn's plans is their seemingly bilateral symmetry of individual units. The selected building is apparently ten storied, with a basement floor. The prime definition of this building is that it is the house of the legislative assembly, or the parliament building. It has a central core that is used as the sitting for the assembly three hundred members of the parliament (MPs). It also accommodates offices for the ministers and officials, which are referred to as office blocks in this paper. The present study concentrates on the boundary of the office block plans and introduces a grammar, which produces a partial plan of these segments in the form of a horizontal section through their facades. The most available plan view (Fig. 02) of the building from different published sources account to a drawing cut through the building at forty-eight feet from the ground level. However, plans at different levels may vary in accessibility terms, but the fundamental form is repetitive. Therefore, the plan view at forty-eight feet is taken as granted as a representative one for the building block.

## Grammar Formulation:

The grammar itself is formulated as a parametric shape grammar and follows the general model given for such grammars in Stiny (1980) and also is referred to the first chapter of this thesis. The presentation was modeled after the Palladian grammar described by Stiny and Mitchell (1978) and The Secret of the Casa Giuliani Frigerio by Flemming (1981), who divide the design of a plan into distinct stages and rely extensively on labeled points to signal the transition from one stage to the next.



Figure 01: Capitol Complex during construction.

Shapes are realized in a Cartesian system of coordinates, and the symbols  $x$  and  $y$  are used to denote, in the usual way, the coordinates of a point in the system. Instead of shape rules, a parametric shape grammar contains *shape rule schemata*, or *schemata* for short;

from any such schema a specific shape rule can be derived through an assignment of values,  $g$ , to the parameters in the schema. All schemata used in the present grammar are fully parameterized; that is, both the  $x$  and the  $y$  coordinates of the end points of each maximal line in a schema are given as parameters. It seemed unnecessary to describe the parameters explicitly for each case as long as it is understood that any assignment  $g$  must maintain alignments of points parallel to the  $x$ -axis or  $y$ -axis as they are displayed by the graphic specifications of the schemata; exceptions from this principle will be explicitly stated. The plan is rotated from its original juxtaposition in the building plan to satisfy an alignment with the  $x$ - $y$  axis.

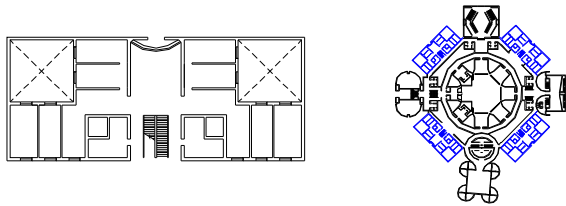


Figure 02: Office block plan (left). Capitol Building plan. (right).

**The Uniaxial Office Plan:**

The plans of all the four office blocks fall in this category, because they are all prototypes of the same plan. These plans may be generated in seven stages which correspond more or less to a natural and intuitive design process. The stages are applied in the following sequence:

1. Grid definition;
2. Exterior-wall definition;
3. Room layout;
4. Interior-wall realignment;
5. Exterior opening;
6. Windows and doors;
7. Termination.

**Preliminaries:**

In plan, all the load bearing shear walls are of the same thickness excepting the interior partition walls. But, for graphical reasons and simplification, the thicknesses are somewhat exaggerated and put to one thickness. The uniaxial office plans are defined in two-dimensional Cartesian coordinate system. Plans are generated with respect to the north-south axis of this coordinate system. (The convention is followed that walls and dimensions parallel to the  $x$ -axis of the coordinate system are 'east-west'; walls and dimensions parallel to the  $y$ -axis are 'north-south'.) For easy reference, the axis is indicated in the initial shape, in the schemata, and in the steps in the generation of office plans by a broken straight line. The initial shape from which all plans are generated by the sequential and recursive application of the schemata specified below is the labeled shape  $(s, \{(0,0): A\})$  shown in figure 03. The initial shape requires that the plans be rooted at the origin of the coordinate system. In the figures showing the schema

or rules for shape generation, the numbers on the left hand side is the index number for the rules. The arrow between two schema stands for the direction of process.

**Stage 1: Grid definition**

The most conspicuous feature of Kahn's office plans here are their bilateral symmetry. These eplans are constructed in terms of labeled rectangular grids with bilateral symmetry relative to the north-south axis of the coordinate system. The grids are generated using the rules specified in figure 03. The grid required for the layout of the ground plan of the office block is shown in figure 05. Every grid generated by the rules in figure 03 consists of a  $(2m+1) \times n$  array of variously dimen-

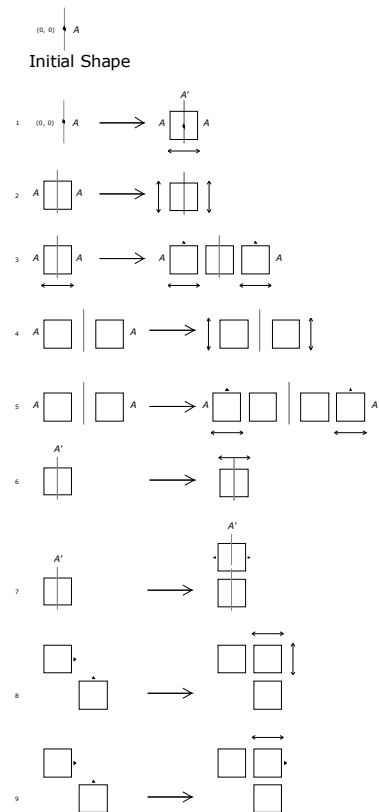


Figure 03: Rules for generating grids with bilateral symmetry

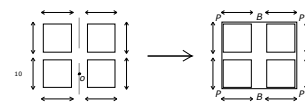


Figure 04: Rules for generation of exterior walls.

sioned rectangles along the  $x$ -axis and  $2m \times n$  array in the  $y$ -axis, where  $m$  and  $n$  are integers such that  $m \geq 0$  and  $n \geq 0$ . In each grid, the central column of rectangles is bisected by the north-south axis of the coordinate system. Each rectangle to the left of the axis has a corresponding reflection to the right of the axis. Adjacent rectangles in the grid are separated by a fixed distance of one wall thickness; their parallel edges are the same length. The dimensions of these rectangles are determined by the assignments used to apply the rules that generate the grid. The line segments, with arrowheads at their end points, surrounding the grid

are used to record the original dimensions of its component rectangles. In order to ensure bilateral symmetry, to fix wall thickness at a constant value, and to incorporate proportioning rules simultaneously, it is necessary to associate parameters and parametric expressions with the grid generation rules and with the rules specified in the following stages. The parameterization of rules in this first stage is the most critical. Once a grid has been generated, it constrains all subsequent applications of rules in such a way that their associated variables are forced to assume the correct values. Any consistent well-defined set of dimensioning and proportioning rules can be incorporated into this grammar by parameterizing its rules.

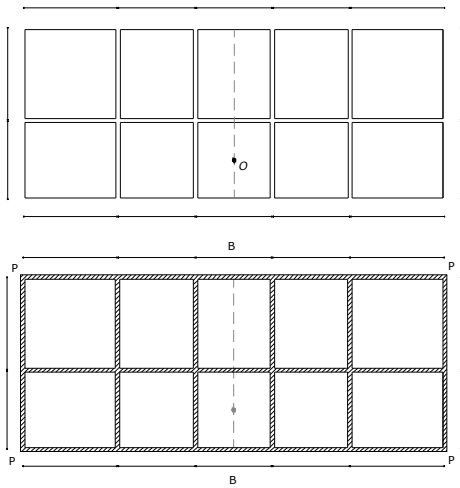


Figure 05: The underlying grid and wall pattern for the office block.

**Stage 2: Exterior-wall definition:**

Once a grid is generated, it is circumscribed by a rectangle to form an exterior wall. This operation is performed by the rule specified in figure 04. The underlying wall pattern generated for the office plan by applying this rule to the grid is shown in figure 05.

The walls in this drawing are hatched.

**Stage 3: Room layout:**

The interior spaces in Kahn's chosen office plans may be rectangular, I-shaped or partially L-shaped. Rooms with these shapes are formed by recursively concatenating the spaces in the wall pattern generated for a villa, in accordance with the rules specified in figure 06. Applications of these rules preserve the symmetry of the plan. It is to be noted that a plan can have at most one nonrectangular space and that this space cannot be bisected by the north-south axis of the coordinate system. The generation of the room layout for the office is given in figure 08. The drawing in this figure is produced by applying schema 11, 12 and 13 to the wall pattern in figure 08.

**Stage 4: Interior-wall realignment:**

North-south and east-west shifts of internal walls away from the underlying grid are used by Kahn to make minor adjustments to room layouts. The rules specified in figure 06, produce these wall realignments in all cases;

they apply to room layouts generated in stage 3. The application of these rules preserves the symmetry of the plan. Figure 08 shows resultant interior room layout and wall alignment for the office plan with the application of schemata through 11 to 16. Schema 17 and 18 account for a special kind of treatment used by Kahn in his designs. Schema 17 shows the choice of space to create the 'hollow column' in the plan, extensively used in plans through out Kahn's design in the east. These hollow columns prevents the use of direct exterior windows to be placed on the façade directly.

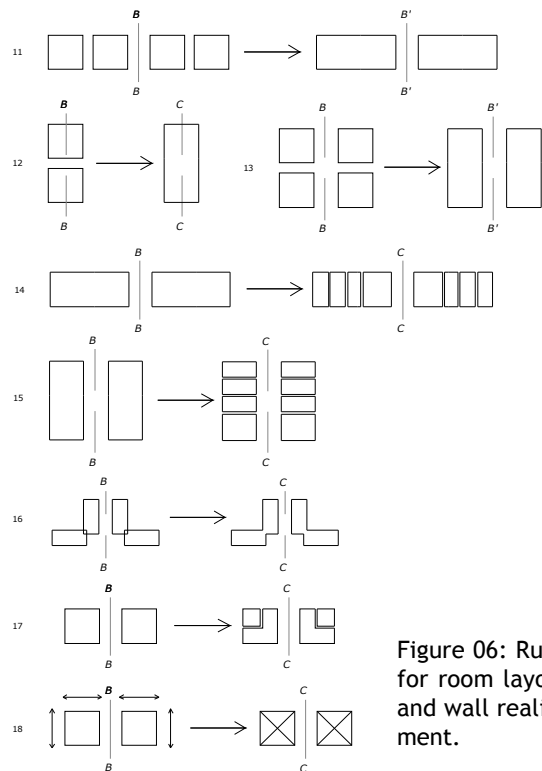


Figure 06: Rules for room layout and wall realignment.

**Stage 5: Exterior opening:**

As explained in the previous paragraph, Kahn's use of hollow columns prevented from openings to direct exterior from room interior. In all his precepts, Kahn has used some sort of curtain to create a buffer between the two. A more detailed understanding is possible if exterior façade is taken into consideration for analysis. Due to limitations, I am concentrating on the opening on the far end of the y-axis. This treatment is exemplified in the schemata 20 through 22. The use of an arch shaped window is though unique only in this case of the plan, but not in the drawings of the whole complex.

**Stage 7: windows and doors:**

Schemata 30 through 33 specified in figure 07 fix the conditions under which doors can be inserted in the office plan. These doors occur on both sides of but not on the plan's axis of symmetry. One such opening is inserted in each nonaxial interior-wall segment corresponding to a north-south or east-west dimension of one of the original rectangles in the underlying grid for the plan. Exterior walls are distinguished by occurrences of the label P; the line segments, determine

their component parts with arrowheads at their end points, surrounding the plan. Typically, doors are located at one end of its length, probably from functionalist approach, only with the exception of the door near the entrance. Rules 34 through 37 in figure 07 allow for nonaxial interior windows to be located in a plan symmetrically so that they line up with previously inserted doors in a right angle form of formation with each other. A door can be placed in a wall just in the case when it is not a direct exterior wall. Windows can open up along the inner wall of a hollow column or the interior wall (with respect to the building plan). Windows are placed centrally on the length of an interior wall segment. It can be noticed that the central axes of the doors and windows are never aligned and always intersect at right angles. In this way, the characteristic *enfilade* is produced. (Figure 33)

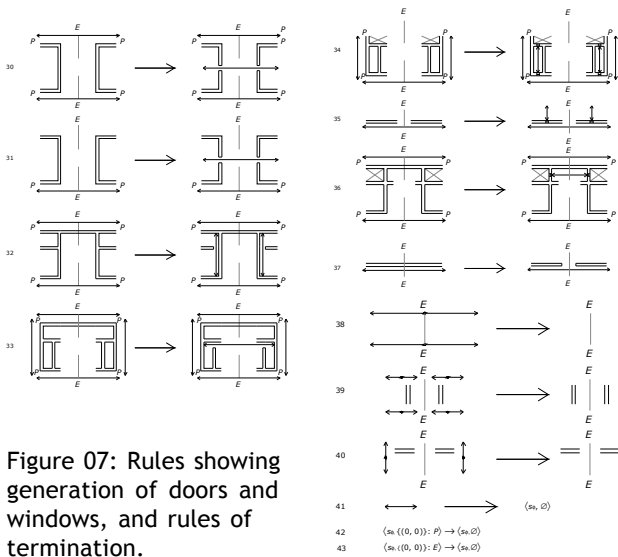


Figure 07: Rules showing generation of doors and windows, and rules of termination.

**Stage 8: Termination:**

Termination rules are specified in figure 07. For the most part, these rules provide for the erasing of the labels and labeled line segments (line segments with arrowheads at their end points and possibly the symbol • at their midpoints) used to guide the plan generation process. Notice that the labeled line segments, with arrowheads at their end points, which surround a plan, can be erased if and only if there is an interior-wall segment associated with them (schemata 39 and 40). These rules ensure that some part of each wall in the underlying wall pattern generated for the offices (stages 1 and 2) remains in the final plan. For this condition to be satisfied, the grid for the plan must be minimal. Only plans which have been correctly generated in the previous six stages can have all of their labels erased. These unlabeled plans are in the language of office plans (in the Capitol building) defined by the parametric shape grammar given here.

**Discussion:**

The results achieved here portray a matrix of rules or schema Kahn has used in the design of the office block in the capitol building. The grammar presented here expresses principles through schemata, which are simple in double sense: (1) each schema defines only a very

limited range of properties, and (2) it influences only a small portion of a shape.

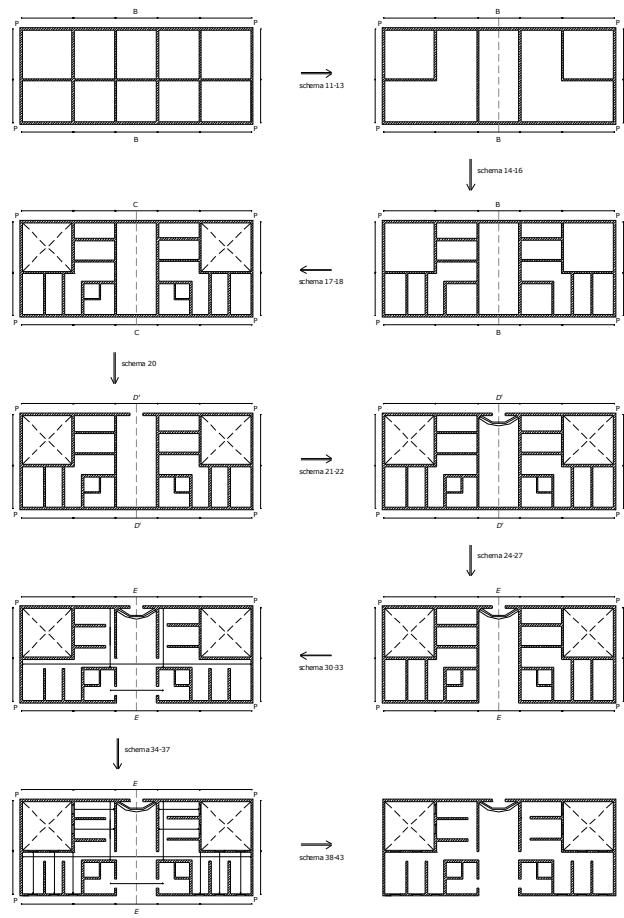


Figure 08: Process of generation of the plan.

**Conclusion | Observations:**

The results show us a newer fabric woven into the design of Kahn, in a partial way. A more elaborate study can evolve newer aspects in the works of the master. The study conducted here is analytical. It breaks up the design plan into standardized piecemeal to find out the skeletal form. This process helped us understand the beauty in Kahn’s approach in design. “Order is.” Was the definition of Kahn when asked to define ‘order’. The answer is explicit and evident when we analyze his works, just as this study conducted here.

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