The Representation of Design Constraints for the Building Product Model of Korean Traditional Buildings

Differences in Applying Physical constraints vs. spatial constraints

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A Korean traditional building has both canonical methods of building up structural framework and typical rules of spatial arrangement. The uniqueness of its building style results from these canonical methods of physical elements as well as those typical rules of spatial elements. Both canonical methods and typical rules can be represented as the constraints among physical and spatial elements. This study aims to investigate the design process of Korean traditional building with respect to physical and spatial constraints.

Keywords. Korean Traditional Building; Design Process; Product Model; Design Constraint

Design Process of Korean Traditional Buildings

A Korean Traditional building has both canonical methods of building up structural framework and typical rules of spatial arrangement. The uniqueness of its building style results from those canonical methods of physical elements as well as those typical rules of spatial elements. Both canonical methods and typical rules can be represented as the constraints among physical and spatial elements.

The purpose of this study is to represent the design process of Korean traditional building with respect to physical and spatial constraints. A data model of design process will show the relations of physical and spatial constraints. Case study on a house of Cho-sun dynasty, Yi Py? ktong Residence of Hongmun-dong, Seoul (architect Lee, Sung-eup), is done to test the reliability of this model.

Physical Constraints

Korean traditional building is an assembly of wooden components. Physical constraint is about how the dimensions of each component are determined and about where a component is located in relation to other components.

The physical framework of Korean traditional building is post-and-lintel construction. The most important composition of physical components is a transverse section of a building. A transverse section of a building is composed of column, beam and strut, and this transverse section is
repeatedly arranged along the longitudinal axis of a building.

The composition of a transverse section and its deployment along the longitudinal axis of a building are influenced by location constraints and dimension constraints of physical elements.

**Location constraints**

Location constraint is about where each component is located in relation to other components. Beams and lintels are laid out on the top of columns, and struts are on the beams supporting gabled roof. Vertical components such as column and strut are placed on specific spots, but horizontal components such as beam, lintel, and purlin are placed between two points: the start point and the end point of a component. So location constraint has two subtypes: spot and linear. Each type has different attributes for its location information.

**Dimensional constraints**

Dimension constraint is about how the dimensions of each component are determined in relation to other components. Dimensional relations of physical components can be explained in terms of dimensional ratios. And they are categorized into 3 groups: the ratios among the parts of a component (internal ratio), the ratios between components (external ratio) and the layout ratios.¹

The dimensions of a component are constrained by internal ratios. For example, a ratio exists between the diameter and the height of a column.

One component may have several external ratios among their different dimensions such as column diameter and height as well as mortise width and depth of column head. Moreover, the assembly of wooden components has a fixed rule in the connection between joining components, and a ratio of one component is related to that of another component in a sequential manner. Thus, the change of one component’s dimension results in that of joining component’s dimension. Reciprocally, the unknown dimension of a component may be derived from the given dimension of joining component when the interrelated dimensional ratios of joining components are known.

The ratios also exist between the spacings of physical components both in sectional layout and in planar layout. For example, the dimensional relation between the height of a building proper and that of its roof is a sectional layout ratio and the dimensional relation between transversal column spacing and longitudinal column spacing is a planar layout ratio.

**Spatial Constraints**

The composition of a Korean traditional building is constrained by the typical rules of ‘spatial layout’, which determines the deployment of physical components and the arrangement of space units. The rules of spatial layout operate at the starting phase in design process.

The house of upper class in Cho-sun dynasty, for example, is composed of different quarters.

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¹ Kim(2000) and Bae(2002) demonstrates the specific details of internal ratios, external and layout ratios.

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**Figure 1. Physical Constraints of Components**
such as a Courtyard Quarter, a Master’s Quarter, a Servants’ Quarter, a Shrine. Each quarter is composed of a courtyard and its surrounding building. And the locations of these quarters in a site are defined in relation to each other. Usually a Master’s Quarter is located near to the entrance of a house and a Courtyard Quarter is placed more far away from the entrance, etc.

In addition to the locational characteristics of different quarters, the building of each quarter has its own typical rule of space arrangement. The typical plan configuration of Courtyard building, for example, has a shape of ¥, which is a concatenation of rectangular space units, called ‘kan’. The main body of Courtyard building is located on the north part of this ¥ configuration. The depth (ay) of the main body is 2.0-2.5 kan and the depth of other parts of Courtyard building is generally 1.0 kan.
Space Units
The space unit of Korean traditional building is a ‘kan’ defined by four columns at four corners. A kan is the spatial module of a building and the dimensions of a kan is constrained by planar layout ratio. The total number of kans in a residence indicates its size. For example, the size of a spatial layout shown in Figure 3 is 21 kan.

There exist three kan types; earth floor kan, ondol kan and wooden floor kan. (Shon, 1989) The earth floor kan is normally used for service space, such as kitchen, gate, storage or stable. The ondol kan is equipped with floor panel heating system and normally used for multi-purpose bedroom. The wooden floor kan is used for various living spaces such as Daechung (a big living room) as well as for the services such as corridors and storage.

Section
The transverse section of an upper class building normally consists of columns, beams, struts, five purlins and two rafters. There are two typical section types; three columns including a high-column and two columns only. The former section type has two columns in the front and backside of the building and one high-column in-between while the other section type has two columns only in the front and backside of the building.

Building layout
The Courtyard building is the main building of a residence from which other building types are generated. A Courtyard building is composed of several kinds of rooms; ondol rooms², a daechung³, veranda, a kitchen, storage, etc.

According to the typical rules of spatial layout, the main ondol room for the Mistress is located next to the kitchen. This main ondol room is adjacent to a kitchen in order to be panel-heated from the firebox in the kitchen. The kitchen is normally located on side parts of a Courtyard building and the kitchen has an direct entrance to a Courtyard. The ondol rooms can be connected upto three in maximum. And the maximum depth of a building is two kans excluding circulation space of wooden floor.

The half kan of wooden floor (maru) may circulate around a building attached to ondol rooms and daechung excluding the kitchen.

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² Ondol is a system of heating peculiar in Korean Architecture. The room with the ondol floor is the ondol room. It is the room mainly for sleeping and for living in cold whether as well. Ondol room is made of panel floor.

³ Daechung is a kind of maru. Maru means the wooden flooring and also represents the space with the wooden flooring. Daechung is the largest maru of the house usually located next to the main ondol room. It is the major living space of the house, especially in summer.
The main body of a Courtyard building faces south or southeast in consideration of building orientation.

A Courtyard building constructed in this paper follows the spatial rules specified in the above. The grid of 2.4 m * 2.4 m is chosen as a kan module and the transverse section with a high-column is also chosen. As a characteristic variation, the main body of the Courtyard building is extended to the north and the west side with an additional kan attached as shown in Figure 3.

**Infill Wall**

A infill wall is usually inserted between two columns, and sometimes between other infill walls, but it never stands alone. There are four types of infill walls; a wall type, a wall + door type, a wall + window type and a full door type. A particular type of infill wall is chosen according to the character of joining edge between adjoining spaces. For example, the wall+door type or the full door type is generally used between a ondol kan and a wooden floor kan. And the wall type is rarely used for the wall planes facing the Courtyard.

**Differences in Applying Physical constraints vs. spatial constraints**

The physical constraints of a Korean traditional building are tightly interwoven as the elements of its physical structure are integrated into a comprehensive whole. And the physical constraints are canonical methods, which determine the dimensions of wooden components and their assembly, i.e. the locations of the components.

On the other hand, the spatial constraints are...
typical rules, which govern the room locations of a building, and a room is composed of kans each of which is derived from the physical constraints in plan. The infill wall in-between depends upon the characters of two adjoining spaces.

In design process a spatial layout, which is implicitly suggested by layout ratio, is laid down as a datum layer. Then the kans in a spatial layout may be occupied by the required rooms, and additional kans may be attached to extend the spatial layout, or preexisting kans may be deleted. Once a building layout is completed, the physical components are accordingly positioned under the explicit control of physical constraints. The physical constraints and the spatial constraints of a Korean traditional building play different roles and take different parts in distinctive phases of design process.

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**References**


Chu, Nam Chul. Residential architecture of Korea, Il Ji Sa, Seoul, 1980 (Korean Text)


