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Correlations among the Altar Location, Methods of Binding Columns behind the Altar, and the Size of the Lateral Side of Central Halls in Korean Buddhist Temples

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Abstract

The design of central halls of Korean Buddhist temples includes the location of the altar, which is positioned so as to generate more space in front of it, thus allowing it to be used more comfortably. Changes in the location of the altar from the center of the hall to the rear, are related structurally to the Column behind the altar. The structure of the Column is related especially to the size of lateral side of the hall. Methods of binding the Column behind the altar and components of upper structure show the characteristics of the overall structure and influence the size of the lateral side of the hall. Therefore, understanding correlations among the altar location, methods of binding the Column behind the altar, and the size of the lateral side of the hall are very important in understanding the structural changes in Buddhist architecture in general, as such correlations represented the most important motivation for change during the Chosun Dynasty.

Keywords: central hall; altar location; method of binding columns; size of the lateral side of the hall

1. Introduction

1.1 Background and Purpose

Many Buddhist temples have been constructed in Korea since Buddhism was introduced during the Goguryeo dynasty in the fourth century. The central hall is the most important place in the Buddhist temple, as the Buddha statues and the Buddhist altar[1)] are situated there and because most of the ceremonies are performed there as well. For a long time, worshippers performed ceremonies while facing a statue of Buddha located in the center of the central hall. In this regard, the structures of the central hall focused on Buddha statues.

However, as Buddhist ceremonies[2)] changed with the passage of time, worshippers needed to make more use of the spaces in front of the altar. This trend resulted in an expansion of these spaces, which in turn forced the relocation of the altar in the central hall.

As the location of the altar was changed, the location of columns behind an altar (the Column)[3)] was also changed, and the tops of the Column were connected to the upper units in various ways.

In the planning of the construction of the central hall[4)], the first step is to develop a floor plan that includes the size of the hall and the location of the altar. Once the location of the altar is set, the locations of the Column are determined and, in turn, methods to bind the upper structures with the Column are planned. Thus, the location of the altar is a major variable in determining the floor plan that secures the space in front of the altar and the layout plan of the upper structures.

The change in the location of the altar triggered a great shift in the floor plan and frame layout, which had remained unmodified since the introduction of Buddhism. The space of the hall was used more efficiently and diversely.

Thus far, some studies on the subject of altars and the Column in the halls and the plans of the hall have been carried out respectively. The present study is an investigation of the changes in the floor plan and frame structures that resulted from the change in the altar location in the hall. Furthermore, the study seeks the principle of the architecture of the hall by studying correlations among the location of altar, the methods to bind the Column to upper components, and the size of the lateral side of the hall.

1.2 The range and method

The subjects of this study are 138 central halls among 165 central halls designated as national cultural assets in Korea. Unlike others, these halls did have their own layout drawings, as determined from survey reports which were presented in reports for repair.

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The currently existing halls were built in the period between the later part of the Goryeo dynasty and the twentieth century. In this study, the author attempted to confirm the historical transformations throughout the period when they were built.

The positions of the altar in the 138 halls were investigated. As a factor that determines the floor plan of halls, the location of the altar shows the use of the space in front of the altar as well as the locations of the Column.

The location of the Column changed when the location of the altar was changed. The Column in this study are mainly classified according to their locations and heights, and subsequent minor classification is based on the structural binding methods between the Column and upper components.

An additional point to be considered in the floor plan is the size of the hall. The size of the lateral side of the hall is closely related to the way the Column was joined to upper components. Therefore, this study investigates the length of the lateral side of the hall and the number of lateral bays that exist, as lateral bays are indicators of the lateral size of the hall.

The joining of the Column with the upper components is closely related to the location of the altar and the size of the lateral side of the hall, as these connections should be efficient in terms of economy and structural stability in order to ensure adequate space in front of the altar. In this study, the author counted the combination in each case and compared the results. Such a statistical analysis was utilized to discern any trend related to the joining of the Column and upper components. The results of the analysis will show how the efficient combinations were made and will also determine the significance.

2. Classification of the Planes of Central Halls as Determined by the Location of the Altar

2.1 Criteria of the classification

Sang-Hyun, Kim was the first to use the classification of the planes of the hall as determined by the location of the altar[5]. But, this study will follow the recent classification used by Dai-Whan, An and Sung-Woo, Kim[6].

The first criterion is the position of the back of the altar, which is located in the farthest bay in the back of the hall. The second criterion is the direction in which the back of the altar faces: facing backward or sideways. Hence, authors created four types of halls.

2.2 Center-altar type (CAT)

A CAT is such that the back of the altar is aligned with the Column directly in front of the farthest columns in the back.

Among the methods to combine the Column with upper components for this type, three methods are mainly used, involving a High Column Type, Two High Column Type, or a Queued Column Type. The CAT does not have a 3x2 (3 bays on the front side and

Table 1. Classification of the Planes of Halls as Determined by the Location of the Alter

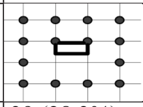
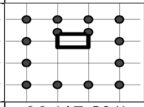
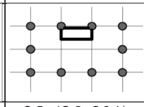
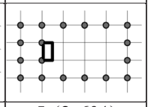
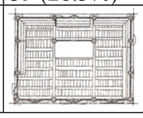
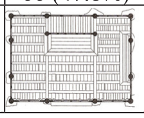
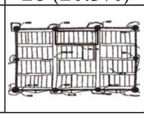
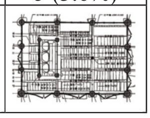
	CAT	MAT	AAT	SAT
TYPE				
Num	39 (28.3%)	66 (47.8%)	28 (20.3%)	5 (3.6%)
EX				

Table 2. Number of Halls According to the Planar Type and the Number of Bays

Lateral bays	1		2	3		4			Total
Whale bays	1x1	3x1	3x2	3x3	5x3	3x4	5x4	7x4	
CAT				24	7	2	4	2	39
MAT			13	42	9	1		1	66
AAT	1	1	19	7					28
SAT				2	3				
Total	1	1	32	75	19	3	4	3	138
	2		32	94		10			

2 bays on the lateral side) bay layout; if the altar is aligned with columns directly in front of the farthest columns in the back, the front space of the altar is smaller than the back space. Therefore, the CAT was mainly used in large halls with 3 or 4 bays on the lateral side. A total of 39 halls (28.3%) employed this type, representing the second most popular type in this study.

2.3 Moved-Altar Type (MAT)

The back of the altar is located further back than columns just in front of the farthest columns in the back of the hall. However, the back of the altar is not attached to the back wall of the hall. Therefore, more space in front of the altar is available for use compared to the CAT. The space in the back of the altar is used as a kind of warehouse. Among the methods to combine the Column with upper components in this type, two methods are mainly used; a Queued-Column Type and Moved-Column Type. The halls that use the MAT have lateral layouts comprised of 2, 3, or 4 bays. Those with 4 lateral bays, however, are quite rare. MAT is most common in this study. (66 halls, 47.8%)

2.4 Attached to the back wall-Altar Type (AAT)

Here, the back of the altar is attached to the back wall so that as much space as possible can be secured in front of the altar. Bowing to the statue of Buddha is the only possible ceremony when this type is used. There are only two methods of combining the Column with upper components in this type ; the use of a Capital-Column Type and the Pyeongbang-Column Type. the AAT Hall can have 1, 2, or 3 lateral bays. This type of structure is common for small halls, especially for those with 2 lateral bays. There are 28 halls of this type in this study (20.3%), which is the third most common.

2.5 Side-Altar Type (SAT)

In this type, the altars are situated on the lateral side. The front space of the altar is narrow and long in shape;

thus, considerable space is available. As a methods to combine the Column with upper components for this type , the Two High Column Type is typically used. To put the altar on the lateral side, the number of lateral bays should be an odd number. Therefore, this type is mainly applied in 3 lateral bay halls. In this study, only five halls adopt this type of altar position.

3. Methods to Combine the Column with Upper Components and their Characteristics

3.1 Criteria for classification

Lee Woo-Jong[7] was the first person to classify methods of combining the Column with upper components. The present study followed the classification used in the recent papers of An Dai Whan and Kim Sung Woo.

The Column was the objective of this study and two standards were used to classify them into their major and minor classifications.

The standard for the major classification is the location and height of the Column. The location of the Column shows the planar characteristics, which are the same as the altar location, whereas the height of the Column shows the characteristics of the upper structure.

A minor classification was made based on which auxiliary item of upper structures was directly bound with the Column and which item was indirectly bound with it. The second item to consider was the existence of a girder on the side of the Column, and the third was whether the Column was vertically centered in the purline.

The classification based on the Column and their binding methods with the main girder along with the rear girder revealed the size of the lateral side of the hall. Moreover, the efficient composition of the lateral size becomes apparent in terms of the location of the altar and the Column and their binding methods.

3.2 The type of the high Column in the hall(HCI)

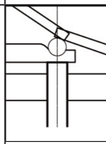
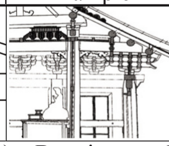
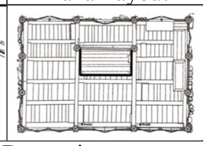
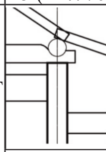
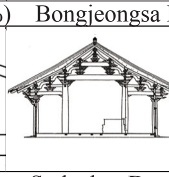
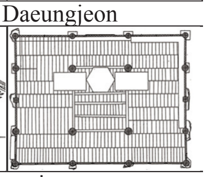
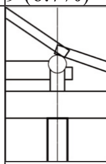
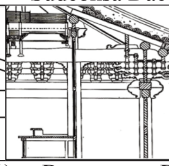
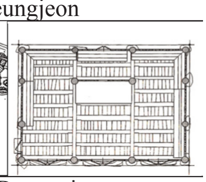
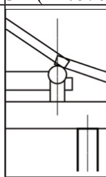
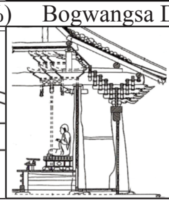
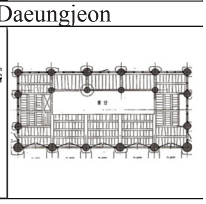
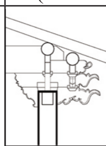
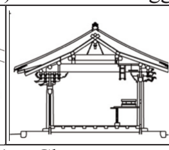
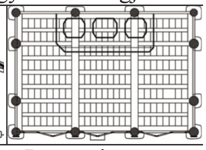
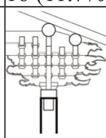
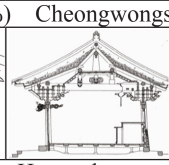
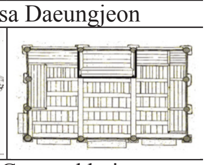
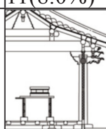
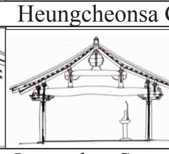
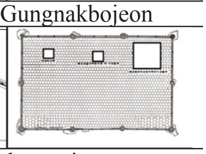
The Column in the HCI is positioned inside the hall. Their height is higher than that of the rear girder, which crosses the back of the Column so that complete binding with the upper structure is as the Column for the purpose of structural stability. This type of column arrangement is very efficient in the construction of a large hall. The CAT and SAT are utilized due to the difficulty of changing the location of the Column.

As a binding method for the Column with a main girder and rear girder, two minor classifications are made: the High-Column Type (HCT) and Two-High Column type (THCT).

(1) High-Column Type (HCT)

Here, the Column extends to the middle purline, and the front and back of columns are crossed with the main girder and rear girder horizontally respectively in line with the Column. Vertically, the centerline of the middle purline coexists with the centerline of the Column.

Table 3. Types of Combination of the Column and Upper Components

Major	Minor	Schematics	Example	Planar layout
High Column in the hall (HCI)	HCT			
		16 (11.7%)	Bongjeongsa Daeungjeon	
	THCT			
		9 (6.7%)	Sudeoksa Daeungjeon	
Column in the hall (CI)	QCT			
		31 (22.6%)	Bogwangsa Daeungjeon	
	MCT			
		48 (35.0%)	Nonsan Ssanggyesa Daeungjeon	
Column attached to the rear wall (CA)	CT			
		16 (11.7%)	Cheongwongsa Daeungjeon	
	PT			
		11(8.0%)	Heungcheonsa Gungnakbojeon	
SACT				
		6 (4.3%)	Janggoksa Sangdaeungjeon	

* Only one hall (Sinansa Daegwangjeon) has two types of combination of column; HCT and QCT. So the number of halls is 138 and the number of the types of combination is 139.

As the lateral size of the hall is determined by the main girder and rear girder, lengthening of the lateral length can be carried out. As large raw material is used as the Column, structural stability can be obtained and can be utilized efficiently in the construction of a large hall. In the case of a small hall, this type is not economical.

In terms of the size of the hall, the Two-High -Column Type (THCT) is used in the largest hall while the HCT is employed in the mid-sized hall. The Queued-Column Type (QCT) is used in a small hall.

There are 16 halls of the HCT (11.5%).

(2) Two-High-Column Type (THCT)

The top of the Column supports the main girder and the rear girder is inserted from the back of the Column.

One end of the main girder is on the top of the Column and the other end is on the front column in the hall. Vertically, the centerline of the middle purline or main purline and the Column coexist.

The lateral size of the hall is determined by the combined length of the rear girder, the main girder and the other rear girder. Hence, at least 3 lateral bays are required in this type. Thus, the largest number of lateral bays is used in this type of hall. The lateral size can be lengthened.

The Column is bound completely to the upper structure and the binding is extended to the front column in the hall so that structural stability is ensured, as is an efficient arrangement of columns for a large hall, whereas a small hall is not suitable for this type because it requires large raw material for the front column in the hall. In addition, the requirement of 3 bays to use this type is not efficient for a small hall.

There are nine halls employing this type (6.5%).

3.3 The type of the Column in the hall (CI)

This type of the Column is positioned inside the hall and extends to the bottom of the main girder so that it's height is lower than the type of the high Column in the hall (HCI). Thus, using this type of column arrangement is economically efficient.

When the upper part of the Column takes a main girder-rear girder formation, the Column serves a structural function. The lengthening of the lateral side is possible through this column arrangement. Upper structures and their loads are vertically loaded and transmitted to the Column through many units. So a heavy load cannot be applied onto this type. Thus, this type is not suitable for a large hall in comparison with the HCI.

When only the main girder is used as an upper structure of the Column, the structural function of the Column is reduced. If a main girder is used to lengthen the lateral size, a long piece of raw material is needed for the main girder. Thus, it is not efficient.

Changing the location of the Column is easy, and sufficient space can be secured in front of the altar. So the MAT often employs this Column arrangement.

(1) Queued-Column Type (QCT)

Vertically, the centerline of the middle purline coexists with the centerline of the Column. In the main girder-rear girder formation, upper structural loads are applied onto the centerline of the Column, allowing this type to handle a heavy load on the Column in comparison with the Moved-Column Type (MCT). The lateral size can be determined via the upper structural arrangement of the Column. The upper structural arrangement is either a main girder-rear girder composition or involves the use of only the main girder.

There are 31 halls that use this type (22.3%)

(2) Moved-Column Type (MCT)

Vertically, the centerline of the middle purline and the centerline of the Column do not coexist. Thus, the Column is moved to the back of the hall.

When the upper structure of the Column has the main girder-rear girder arrangement, there is eccentric loading on the Column. Hence, a heavy load can be a problem in comparison with other types of column arrangement. Thus, this type is not efficient for a heavy load. There is an example of an efficient column arrangement that uses a small cross-sectional column and employs only the main girder on the lateral side so that the Column does not serve as the main structural support column. The size of the lateral side is either the main girder-rear girder arrangement or involves the use of a main girder only, as with the upper structure of the Column.

There are 48 halls that adopt this type (34.5%).

3.4 The type of the Column attached to the rear wall (CA)

In this case, the Column and the back column of the hall are the same. The Capital or Pyeongbang is placed on the upper part of the Column.

Mostly, there are no columns inside a hall employing this type of column arrangement. The main girder determines the lateral size. The structural aspects of the bracket set along with the efficient utility of the lateral side do affect the length of the lateral side. Therefore, the type of the Column attached to the rear wall (CA) is efficient given the small lateral size.

The AAT is mainly employed, as the altar is attached to the back of the Hall.

(1) Capital Type (CT)

The capital is placed on the top of the Column and a bracket arrangement is used. The loading from only one bracket is applied on the Column. This type is used in the hall using Ik-gong (a bracket with an orthogonal projection) and Jushimpo (the capital's center bracket). This type is structurally simple and more advantageous in terms of economy in comparison with the Pyeongbang Type (PT).

There are 16 halls that adopt this type (11.5%).

(2) Pyeongbang Type (PT)

The Pyeongbang is placed on the top of the Column and brackets are set. The loads from many brackets are distributed into many columns. This type is used in the hall with Dapo. Thus, numerous types of materials are used along with complicated structural arrangements in this type, but its structural stability is good. It is typically used in a hall with a large lateral side in comparison with CT.

There are 12 halls that adopt this type (8.6%).

3.5 Specially Arranged Column Type (SACT)

There are five halls in which the Column has no binding arrangement with the upper structure and where two types of column arrangement exit, each having a unique column arrangement.

When columns show no binding arrangement with the upper structure, the lateral side size is small, as when a Column is attached to the rear wall (CA). This arrangement is efficient in the small hall.

There are 7 halls that adopt this type (5%).

3.6 Chapter conclusion

Table 4. Types of the Column Plane and General Composition Methods for Lateral Sides

Order	Major	Minor	Principal plane	Composition methods for lateral sides
1	HCI	HCT	CAT	Rear girder+Main girder (RG) (MG)
2	HCI	THCT	CAT/SAT	RG+MG+RG
3	CI	QCT	CAT/MAT	MG+RG / MG
4	CI	MCT	MAT	MG+RG / MG
5	CA	PT	AAT	MG
6	CA	CT	AAT	MG
7	SACT		CAT/SAT	MG

General correlations among the binding methods for the Column with the upper structure, the location of the altar and the size of the lateral side of the hall were discussed in chapters 2 and 3. The data are tabulated and presented in Table 4. When the binding methods of the Column are the THCT, the CAT and the SAT are mainly used in the hall. Therefore, a large hall can utilize the lateral side of the hall with the rear girder-main girder-rear girder arrangement. Moreover, this setting is used to enlarge the front space of the altar. The binding method of the Column is the CT, where the size of the lateral side of AAT is determined by the main girder. Therefore, a small hall can use this type of column arrangement so that the maximum space can be secured in front of the altar.

4. Correlations among the Altar Location, Binding Methods of the Column, and the Size of the Lateral Side of the Hall

4.1 Center-Altar Type (CAT)

In the lateral side of a hall with 3 bays, the QCT is mostly used (Table 5.ⓐⓑ)[8], while the THCT is mostly used in the lateral side with 4 bays (Table 5.ⓓ). The length of the 3 lateral bays is nearly identical between the HCT and the QCT, whereas the SACT is short (Table 6.ⓐ). In the lateral side of a hall with 4 bays, the length of the lateral side is similar between the HCT and the QCT, whereas the THCT has the longest lateral length (Table 6.ⓑ).

First, a lateral side with 3 bays of the CAT is similar in terms of the lateral length in the cases of the QCT and HCT. The QCT is used as an efficient and more economical means of binding the Column. As in the lateral side with 3 bays, the larger 5x3 bay hall is more efficient when using the HCT for the sake of structural stability over the 3x3 bay hall.

Secondly, the lateral size composition of the HCT is the main girder-rear girder composition, while the QCT is the main girder-rear girder composition or a main girder only. Thus, the similar lateral length between the HCT and the QCT in the lateral side with 3 bays is found in the composition of the main girder-rear girder combination in the construction of the lateral side of the QCT, as in the HCT. In addition, the lateral length in the QCT is longer than that of the SACT, where only a main girder is used to create the lateral side (Table 6.,ⓐ).

Thirdly, the THCT shows the greatest structural stability along with the longest lateral length in a lateral side with 4 bays in the hall.

Fourth, the hall with the 4 bay lateral side shows a longer lateral length in the case of the HCT compared to when the QCT is present. Thus, the longer the length of the lateral side, the more efficient the HCT becomes over the QCT. The QCT is not efficient in terms of structural stability due to the heavy loadings in a large hall in comparison with that of the HCT. There is no difference between the HCT and the QCT in the case of a 3 bay lateral side, but a difference is revealed in the case of a 4 bay lateral side, given the associated loading problem.

Fifth, the hall with a 3 bay lateral side combines well for efficient use with the QCT, whereas the 4 bay lateral side is well suited for the THCT.

Table 5. Correlations Among the Altar Location, Number of Bays and Methods to Combine the Column with Upper Components

	LB	WB	HCI		CI		CA		SACT	Total	No
			HCT	THCT	QCT	MCT	CT	PT			
CAT	3	3x3	7		14				3	24	ⓐ
		5x3	4	1	3					8	ⓑ
	4	3x4	1	1						2	ⓒ
		5x4		3	1					4	ⓓ
		7x4	1	1						2	ⓔ
	Total		13	6	18	0	0	0	3	40	ⓕ
MAT	2	3x2	1		3	8			1	13	ⓖ
	3	3x3	1		6	35				42	ⓗ
		5x3	1	1	4	3				9	ⓘ
	4	3x4				1				1	ⓙ
		7x4				1				1	ⓚ
	Total		3	1	13	48	0	0	1	66	ⓛ
AAT	1	1x1						1		1	ⓜ
		3x1					1			1	ⓝ
	2	3x2					12	6	1	19	ⓞ
	3	3x3					3	4		7	ⓟ
	Total		0	0	0	0	16	11	1	28	ⓠ
SAT	3	3x3						1	1	2	ⓡ
		5x3		2					1	3	ⓢ
	Total		0	2	0	0	0	1	2	5	ⓣ

* LB is Lateral bay and WB is Whole bay

Table 6. Correlations Among the Altar Location, Lengths of Lateral Sides and Methods to Combine the Column with Upper Components

	LB	HCI		CI		CA		SACT	No
		HCT	THCT	QCT	MCT	CT	PT		
CAT	3	8,173	6,660	8,198				6,827	ⓐ
	4	10,426	12,686	9,500					ⓑ
MAT	2	7,700		7,087	5,908			7,707	ⓒ
	3	9,394	9,198	9,611	7,321				ⓓ
	4				12,675				ⓔ
AAT	1					3,100	3,930		ⓕ
	2					4,854	5,273	5,278	ⓙ
	3					5,119	6,574		ⓗ
SAT	3		10,080				5,850	9,260	ⓘ

Table 7. Construction According to the Century

	LB	WB	Before 16C	17C	18C	19C	20C	Not Known	Total	No
CAT	3	3x3	1	13	6	4			24	ⓐ
		5x3		3	3		1		7	ⓑ
	4	3x4	1		1				2	ⓒ
		5x4		3		1			4	ⓓ
		7x4		2					2	ⓔ
	Total		2	21	10	5	1		39	ⓕ
MAT	2	3x2		4	5	2	1	1	13	ⓖ
	3	3x3	3	16	11	9	1	2	42	ⓗ
		5x3		4	4	1			9	ⓘ
	4	3x4		1					1	ⓙ
		7x4					1		1	ⓚ
	Total		3	25	20	12	3	3	66	ⓛ
AAT	1	1x1		1					1	ⓜ
		3x1						1	1	ⓝ
	2	3x2	2	3	9	4	1		19	ⓞ
	3	3x3		2		4	1		7	ⓟ
	Total		2	6	9	8	2	1	28	ⓠ
SAT	3	3x3		2					2	ⓡ
		5x3	1	2					3	ⓢ
	Total		1	4					5	ⓣ

* LB is Lateral bay and WB is Whole bay

Table 8. Change in the Methods to Combine the Column with Upper Components

	Method		Before 16C	17C	18C	19C	20C	Not Known	Total	No
CAT	HCI	HCT		6	5	1	1		13	ⓐ
		THCT	1	3	1	1			6	ⓑ
	CI	QCT		10	5	3			18	ⓒ
	SACT		1	2					3	ⓓ
	Total		2	21	11	5	1		40	ⓔ
MAT	HCI	HCT	1		1			1	3	ⓕ
		THCT				1			1	ⓖ
	CI	QCT		9	3	1			13	ⓗ
		MCT	2	16	15	10	3	2	48	ⓘ
	SACT				1				1	ⓙ
	Total		3	25	20	12	3	3	66	ⓚ
AAT	CA	CT	2	2	5	5	1	1	16	ⓛ
		PT		3	4	3	1		11	ⓜ
	SACT			1					1	ⓝ
	Total		2	6	9	8	2	1	28	ⓞ
SAT	HCI	THCT	1	1					2	ⓟ
	CA	PT		1					1	ⓠ
	SACT			2					2	ⓡ
	Total		1	4					5	ⓢ

4.2 Moved-Altar Type (MAT)

There are 48 MCT and 13 QCT in the case of a comparatively small hall, as well as a few HCT and THCT (Table 5.ⓘ). For a 2 bay lateral side, the MCT is employed most (Table 5.ⓖ). When the lateral length is extremely long in a 2 bay lateral side, the QCT is preferred over the MCT (Table 6.ⓒ).

Among the 3 bay lateral side designs, the hall with a 3x3 bay arrangement employs the MCT, whereas the hall with a 5x3 bay arrangement typically employs the QCT (Table 5.ⓗⓘ). For the three bay lateral side, the lateral length of the MCT is drastically shorter than those of the HCT, THCT, and the QCT (Table 6.ⓓ). In

Table 9. Change in the Lengths of the Lateral Sides of the Halls

	Method		Before 16C	17C	18C	19C	20C	Not Known	No
CAT	HCI	HCT		8,916	8,327	7,933	7,700		ⓐ
		THCT	10,777	12,371	6,660	15,540			ⓑ
	CI	QCT		8,745	7,806	7,465			ⓒ
	SACT		7,942	6,270					ⓓ
MAT	HCI	HCT	8,827		9,960			7,700	ⓔ
		THCT				9,198			ⓕ
	CI	QCT		9,359	7,690	10,069			ⓖ
		MCT	6,527	7,221	7,776	6,394	9,565	6,475	ⓗ
	SACT				7,707				ⓘ
AAT	CA	CT	4,998	5,245	4,951	4,701	4,860	3,100	ⓙ
		PT		5,331	5,038	6,032	7,620		ⓚ
	SACT				5,278				ⓛ
SAT	HCI	THCT	11,521	8,639					ⓜ
	CA	PT		5,850					ⓝ
	SACT			9,260					ⓞ

the 4 bay lateral side of the hall, the MCT is used even with a lateral side with a long length (Table 6.ⓔ).

First, for the MAT hall with a 2 bay size lateral side, the main girder is sufficient to ensure sufficient length of the lateral distance. In addition, the Column can be moved to the back of the hall without taking into consideration the upper structure, so that enough space can be secured in front of the altar with the MCT.

The length of the lateral distance can be presented in an increasing order of length, as follows: MCT<QCT<SACT<HCT. The MCT has an extremely short lateral distance. The short lateral distance of the MCT was made intentionally considering the relatively long length of the lateral distance in the SACT. Most QCT halls compose their lateral distance using the main girder-rear girder composition, whereas the MCT employs only the main girder for its lateral distance.

Secondly, the QCT is employed most in conjunction with a 3 bay lateral side hall with the MAT. In particular, more QCT are used with the 5x3 bay in the hall compared to the use of the MCT. Thus, when the size increases, the QCT is more efficient in supporting the load than the MCT in the case of heavy loading.

Thirdly, the MCT is used in the hall with a 4-bay lateral side, though there are few halls with 4 bay sized lateral sides. When the size of the hall is enlarged in conjunction with the use of the MAT, the MCT can use the main girder-rear girder composition. The MCT can lengthen the maximum length of the lateral distance while securing the maximum space arrangement in front of the altar.

4.3 Attached to the back wall-Altar Type (AAT)

There are 16 halls with the CT and 11 halls with PT (Table 5.ⓠ). There was one hall with a 1-bay lateral side with the CT and one with the PT (Table 5.ⓜⓝ). There are 12 halls with a 2-bay sized lateral side with the CT, whereas there are 6 halls with a 2 bay sized lateral side with the PT (Table 5.ⓞ). There are 3 halls with a 3 bay size lateral side with the CT, whereas there are 4 halls with the PT (Table 5.ⓟ).

The PT has a longer lateral distance than that of the CT for any type of lateral side (Table 6.ⓕⓖⓗ).

First, the CT was more commonly used in the case of a hall with a 2 bay lateral side, whereas the PT was mainly used in a hall with a 3 bay lateral side due to the heavy loadings on the larger lateral sides of the hall. Thus, the PT is suitable for a large lateral side with an AAT, whereas the CT is well suited to a small lateral side with an AAT hall.

Secondly, an AAT hall is mainly employed in small halls where the CT is used due to the economical use of raw materials and simple structure.

4.4 Side-Alter Type hall (SAT)

The THCT and SACT are employed most in this case, while the PT is rarely used. The lateral distance is the longest in the THCT followed by the SACT. The shortest length is shown in the PT. There are few SAT halls; thus, it is difficult to make a statistical generalization. An intention to lengthen the lateral distance is discerned in the THCT utilizing the rear girder-main girder-rear girder composition because the altar is positioned on the lateral side of the hall.

5. The Evolution the Altar Location, Binding Methods of the Column, and the Size of the Lateral Side Over Time

5.1 Center-Altar Type hall (CAT)

With the CAT hall, it is rather difficult to secure space efficiently in front of the altar. Hence, the number drastically decreased as time passed (Table 7.ⓕ). Moreover, the number of 3 bay lateral side used in the hall increased as the number of bays decreased (Table 7.ⓐⓑ).

The QCT is more widely employed for the binding methods for the Column (Table 8.ⓐⓑⓒ). The length of the lateral distance of the HCT and the QCT shows a shortening trend (Table 9.ⓐⓒ).

The number of THCT showed a decrease, while the lateral distance was lengthened (Table 9.ⓑ).

First, the number of lateral bays decreased as time passed, and the QCT became the more preferred column type along with the shortening of the lateral distance.

Second, the construction of large halls occurred randomly with the THCT for structural stability with the lengthening of the lateral distance. Thus, a different trend arose between a large size with the THCT and a small size with the QCT.

Third, the number decreased, as it was not possible to secure space in front of the altar. In a large hall, secured space in front of the altar is possible. Therefore, the THCT and the HCT are efficient in the CAT hall.

5.2 Moved Altar Type hall (MAT)

The number decreased as time passed (Table 7.ⓛ). The number of halls with the 3 bay lateral side increased along with the use of the MCT (Table 7.ⓖⓗⓘ, Table 8.ⓗⓘ); the length of the lateral distance did not show any trend, but it did show a variety in its range (Table 9.ⓖⓗ).

First, as halls with 3 bay sized lateral sides became more common, the MCT was employed in order to secure the front space of the altar more easily, and the lateral distance was drastically shortened. As the MAT is more efficient in a small hall, the CAT hall was replaced with the MAT hall.

Second, as the number of MAT halls with the two bay lateral side decreased in number, the AAT hall became more numerous because it allowed sufficient space in front of the altar and was more efficient.

Third, there was an attempt to pursue economy in planning the lateral side of the hall and in the binding methods of the Column to secure the space in front of the altar in an MAT hall. The lateral distance showed no specific trend in the MAT hall. Thus, there must have been numerous attempts to acquire efficiency in terms of the structural aspects and efficiency in the search for the correct lateral distance.

5.3 Attached to the back wall-Altar Type (AAT)

In the AAT, both the 2 bay and 3 bay sized lateral sides of the hall increased in number (Table 7.ⓞⓟ). The CT is more numerous than the PT (Table 8.ⓛⓜ). The lateral distance is lengthened in the PT, whereas the CT shows the opposite trend (Table 9.ⓙⓚ).

First, the AAT hall is the planar type that is used in a small hall. The size of the hall became smaller as time passed, and the CT was used more extensively due to its efficiency in a small hall.

Second, the PT was used in a large hall with lengthening of the lateral distance, whereas the CT shows a different development trend.

Third, as AAT halls became more numerous, this trend allowed the securing of space in front of the altar more efficiently. It also showed different compositions, in some cases facilitating use as a small hall.

5.4 Side-Altar Type hall (SAT)

The SAT hall was used before the 16th century and again in the 17th century. Therefore, it is difficult to trace the changes over time.

6. Conclusions

As the front space of an altar became an important space in the hall, moving the location of the altar toward the back of the hall was initiated to secure the space in front of the altar. The changing location of the altar meant that the floor plans and all the structural construction planning had to be altered. The variety of compositions and the efficiency of these forms are shown in the construction of halls after the Chosun period.

The changing location of the altar initiated changes such as changing planar types, changing the binding methods of the Column behind the altar, and changes in the size of the hall. All changes were correlated in terms of securing the space in front of the altar, and a variety of compositions for securing this space evolved. Table 10. shows the efficient types of altar, column arrangements and compositions of the lateral side that evolved. The main themes are as follows; a method to secure the space in front of the altar, the transmission of loadings of the upper structure toward the lower part, and the manner of ensuring a larger lateral area of the hall using a rear girder and main girder combination.

Thus, the CAT hall/SAT hall with the THCT compositions was the most efficient composition to support heavy loadings, where the lateral side of the hall uses the rear girder-main girder-rear girder composition. In addition, adequate space in front of the altar can be secured so that there is no need to change the altar location. This arrangement is mainly used with the CAT hall. The AAT hall with the CT composition is the most efficient composition in a small hall with a smaller lateral side due to its economic advantage.

In the 17th century, a variety of compositions already existed. As time passed, the size of the hall became smaller, which triggered a number of efficient combinations to secure the space in front of the altar. Various combinations drove the changes in the types of the floor plan, the composition of the structures, and the types of roofs used.

As time passed, preferred compositions arose, such as the CAT hall with the QCT, the MAT hall with the MCT, and the AAT hall with the CT. In addition, the use of a larger CAT hall and MAT hall configuration decreased in number, whereas the use of smaller AAT halls increased in number. Various attempts were made to secure the space in front of the altar as the size of the lateral side of the hall became smaller. In a random fashion, a large hall employed the THCT to lengthen the lateral distance and secure structural stability.

This study shows the correlations among the altar locations in the floor plan, the size of the lateral area, and the structural plan in connection with the binding methods of the Column. To secure the space in front of the altar under the constraints of the size of the hall, a variety of combinations and compositions were attempted. The developed combinations and compositions to secure the front space of the altar for a given hall size shows advantages in terms of economy and structural integrity. This study reveals that the system for building Buddhist central halls is very comprehensive, encompassing the floor plan, a structure plan, and the planning of the roof. Therefore, the location of the altar and the binding methods of the Column greatly influenced the construction of the hall. This influence played an important role in various architectural developments and helped to bring about efficient methods of construction in the Chosun period.

Table 10. The Trend of Compositions Based on Efficiency and their Order in Terms of Lateral Size (The Largest Size Appears First in a Descending Order of Size)

Order	Plane Type	Combination method	Composition methods for lateral sides
1	CAT/SAT	THCT	RG+MG+RG
2	CAT	HCT	MG+RG
3	CAT	QCT	MG+RG
4	MAT	QCT	MG+RG
5	MAT	MCT	MG
6	AAT	PT	MG
7	AAT	CT	MG

Notes

1 The altar addressed in this study refers to a main altar on which a statue of Buddha is placed. Auxiliary altars are located on the right and left sides of the main altar.

2 There are two types of Buddhist ceremony. One is performed with people circling around the altar and the other is performed in front of the altar. As time passed, the latter was emphasized.

3 The columns in front or on the sides of an altar are outside the scope of this study, as their locations are not affected by the altar's location. In this study, 'Column' means 'column behind the altar'.

4 In this study, 'hall' means 'central hall'.

5 The study of Sang-Hyeon, Kim is Reference 2).

6 The study of Dai-Whan, An and Sung-Woo, Kim is Reference 4).

7 In Lee Woo-Jong's paper (Reference 3), the classification was made on a one story central hall in terms of the column inside the hall. They included the High-Column Type, the Queued-Column Type, the Moved-Column Type, and Column Type of halls.

8 All rows are numbered in the Table and the explanation is expressed as "(T3ⓐ)".

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