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THE DUALITY OF THE PROTRUDING JOINT MEMBER IN KOREAN TRADITIONAL WOODEN ARCHITECTURE

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ABSTRACT: This study examines the interplay between structure and ornamentation by focusing on the projecting ends (ppael-mok) formed at the terminal portions of beams in Korean traditional architecture. Through a typological analysis based on factors such as the thickness of the projecting ends, the types of decorative carving (chogak), and the methods of connection with the bracket system (gongpo), this research investigates how projecting ends are adjusted and transformed between structural necessity and aesthetic intent. The analysis, centered on the projecting ends of beams and transverse beams (chungnyang), reveals a clear contrast between architectural traditions: non-Buddhist architecture emphasizes structural integration, whereas Buddhist architecture tends to prioritize decorative expression. Additionally, a shift toward ornamentation over structure is observed in the late Joseon period, though some Buddhist examples show a concurrent resurgence of structural emphasis. Ultimately, this study demonstrates that projecting ends are not merely residual components but function as deliberate formal devices, offering a renewed perspective on the integrative logic of structure and ornamentation in Korean traditional architecture.

KEYWORDS: ppaelmok, structure, ornamentation, korean, beam

1 – INTRODUCTION

1.1 BACKGROUND AND PURPOSE OF THE STUDY

Traditional architecture in Northeast Asia, which inherits the Chinese lineage of timber-frame construction, exhibits a unique formal characteristic in which structural components themselves function as ornamentation. This feature is particularly prominent in Korean traditional architecture, where various timber members are intricately joined, and most notably in the projecting ends (ppael-mok) formed at the terminal portions of structural members. A projecting end refers to the portion of a structural member that extends outward beyond its joint after intersecting with an adjacent member. It serves not merely as a structural extension but also as a medium for decorative expression through carving (chogak) and wooden finishing techniques (chimok).

Among these, the projecting ends of beams are especially notable for their ornamental character and the diversity of their structural configurations. However, existing studies on Korean traditional architecture have tended to focus primarily on projecting ends found in timber components of the bracket system—such as bracket arms and wings—typically formed in standard sectional width (sujangpok), while offering limited analysis of the broader interaction between structural and decorative functions. Previous typological studies on the joint configurations between beams and brackets include the works of Hun-Duck Jang (2006), Sun-Ah Lee (2018), and Hayoon Park (2024), though none have focused specifically on the structural and ornamental tendencies of beam-end projecting members.

Accordingly, this study aims to typologize and analyze specific cases of projecting ends formed on beams—a primary horizontal structural element in architecture—to clarify how structural necessity and aesthetic intent interact and negotiate within these components. Furthermore, the study seeks to reveal how the structural and ornamental characteristics of projecting ends are differently combined and articulated across historical periods and architectural typologies. An initial version of this research was presented at the 2025 Spring Conference of the Korean Association of Architectural History, held on June 16–17 at the Chuncheon Campus of Kangwon National University. The current paper represents a significantly revised and expanded version of that presentation.

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1.2 OBJECT AND SCOPE OF THE STUDY

This paper represents the first phase of a broader research project aiming to examine the projecting ends formed in the horizontal structural members of Korean traditional timber architecture, including lintels (changbang), flat lintels (pyeongbang), main crossbeams (bo, or daedeulbo), purlin supports (janghyeo), and purlins (dori). In this initial stage, the study focuses specifically on the projecting ends formed on main crossbeams, conducting typological classification and analysis. The main subjects of analysis are the projecting ends of beams within the bracket system and transverse beams (chungnyang) located in the body of the building.

The scope of analysis includes a total of 276 wooden structures constructed from the late Goryeo to the Joseon period, selected among cultural heritage properties designated as National Treasures or Treasures by the Korea Heritage Service, for which structural forms could be verified through available drawings or photographic documentation. Of these, the beam-end analysis covers 237 buildings with a rectangular floor plan employing one of the following bracket system types: column-top complex bracket style (jusimpo), bracket wing style (ikgong), projected bracket wing style (chulmok-ikgong), or multiple complex bracket style (dapo). For each case, the beam connected to the right bracketing unit in the central bay of the front façade was taken as the standard subject of analysis.

The transverse beam analysis focuses on 126 buildings featuring hip-and-gable (paljak) roofs, in which transverse beams are present. The transverse beam located on the right side of the front elevation was selected as the primary reference. In principle, analysis was conducted on the standard reference member, but in cases where the designated location lacked a projecting end or another location was judged more representative, an alternative projecting end was analyzed.

Through this method of case selection and analysis, the study establishes a framework for comparing the structural configurations of projecting ends across different architectural types and historical periods.

2 – TYPOLOGICAL CLASSIFICATION OF PROJECTING ENDS IN BEAMS

2.1 CLASSIFICATION OF PROJECTING ENDS IN BEAMS WITH PROJECTION IN THE BRACKET SYSTEM

Before analyzing the structural and ornamental roles of the projecting ends in beams and transverse beams, this section presents a typological classification based on how the projecting ends are integrated with the bracket system. Projecting ends are first categorized by whether the bracket system includes projection (chulmok) or not. Among the 162 buildings with projected brackets, the projecting ends in beams can be further divided into seven types (Table 1), according to the following criteria:

A) Type of purlin supported by the projecting end (central or outer),
B) Relationship between the projecting end and the outer purlin support member,
C) Thickness of the outer purlin support member,
D) Presence of additional non-structural decorative elements.
Based on these criteria, the seven types are as follows:
1) Support type (fig. 1): The projecting end supports the outer purlin but is located below the outer purlin support member, shaped in standard sectional thickness (sujangpok), and contains no decorative elements (non-structural). This type was identified in 4 out of 162 cases.
2) Bracket-head type (fig. 2): The projecting end supports the outer purlin and is directly joined to it, functions as a support member, is shaped in standard sectional thickness, and includes no decorative elements (non-structural). A total of 48 examples were found.
3) Standard beam-head type (fig. 3): Structurally similar to the bracket-head type, but the projecting end is thicker than the standard sectional width. This type was found in 52 buildings.
4) Decorative beam-head type (fig. 4): Structurally identical to the standard beam-head type, but with a non-structural decorative element attached to the end of the projecting member. Only 3 examples were identified.
These four types all involve projecting ends that support the outer purlin.
The following three types involve projecting ends that only support the central purlin and terminate within the bracket system:
5) Extension type (fig. 5): The projecting end supports only the central purlin and is horizontally aligned with a separate structural member supporting the outer purlin. In this case, the outer purlin support is a bracket head (chogong) of standard sectional thickness, and there is no decorative element (non-structural). A total of 21 cases fall under this category.
6) Standard layered type (fig. 6): Structurally similar to the extension type, but the separate member supporting the outer purlin is located below the projecting end and functions as a bracket wing (jegong). A total of 33 cases were identified.
7) Decorative layered type (fig. 7): Structurally identical to the standard layered type, but with a non-structural decorative element attached to the end of the bracket wing supporting the outer purlin. Only one case—Daeungjeon Hall of Bulhoesa Temple in Naju (1799)—was found.

2.2 CLASSIFICATION OF PROJECTING ENDS IN BRACKETED BEAMS WITHOUT PROJECTION

The 75 structures without projection (chulmok) in the bracket system (mu-chulmok gongpo) can be categorized into four types based on the way the projecting ends are connected to the bracket system (Table 2). The classification criteria are as follows:

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B) the relationship between the projecting end and the central purlin (jusimdori) support member,
C) the thickness of the central purlin support member, and
D) the presence of additional non-structural decorative elements.
Since there is no outer purlin (oechulmokdori) in bracket systems without projection, the outermost purlin supported in all cases is the central purlin.
Based on these criteria, four types are identified:
1) Support type (fig. 8): The projecting end supports the central purlin but is positioned below the central purlin support member and has no additional decorative elements (non-structual). While this type is similar to the support type found in bracket systems with projection, it shares some characteristics with the extension type, in that the beam terminates directly at the bracket arm, and the supporting member for the bracket arm is a separate piece of standard sectional thickness (sujangpok). This type was identified in only one case: Hoejeonmun Gate of Cheongpyeongsa Temple in Chuncheon (1557).
2) Bracket-head type (fig. 9): The projecting end directly connects to and supports the central purlin, is shaped in standard sectional thickness, and includes no additional decorative elements. A total of 12 examples were identified.
3) Standard beam-head type (fig. 10): Structurally identical to the bracket-head type, but the projecting end is thicker than standard sectional width. This type was found in 49 buildings.
4) Decorative beam-head type (fig. 11): Structurally the same as the standard beam-head type, but with a decorative element attached to the end of the projecting member that serves no structural function. This type was identified in 13 cases.

Table 1

Types of Projecting Ends in Bracketed Beams with Projection (162 cases)							
Type							***Classification Criteria***
Types supporting the outer purlin (oechulmokdori)				Types supporting the central purlin (jusimdori)			A. Type of purlin supported (central or outer)
1. Support type (4)	Matching support type			5. Extension type (21)	Layered type		B. Relationship between the projecting end and the outer purlin support member
-	2. Bracket-head type (48)	Beam-head type		-	-		C. Thickness of the outer purlin support member
-	-	3. Standard beam-head type (52)	4. Decorative beam-head type (3)	-	6. Standard layered type (33)	7. Decorative layered type (1)	D. Presence of purely decorative (non-structural) elements

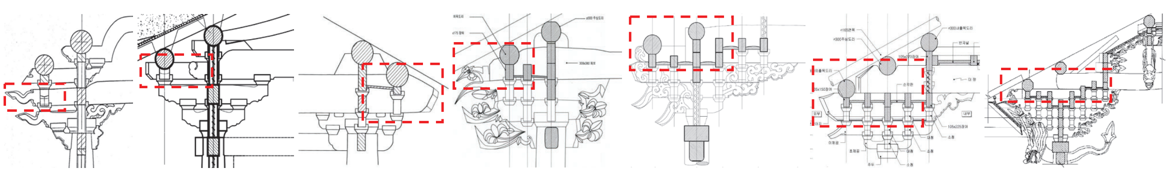

Figure 1. Support type: Daeungjeon Hall, Sudeoksa Temple, Yesan (1308)
Figure 2. Bracket-head type: Geungnakjeon Hall, Bongjeongsa Temple, Andong (1363)
Figure 3. Standard beam-head type: Jukseoru Pavilion, Samcheok (1403)
Figure 4. Decorative beam-head type: Daeseongjeon Hall, Jangsu Hyanggyo (1685)
Figure 5. Extension type: Daeungjeon Hall, Gaesimsa Temple, Seosan (1484)
Figure 6. Standard layered type: Daeungjeon Hall, Bongjeongsa Temple, Andong (1435)
Figure 7. Decorative layered type: Daeungjeon Hall, Bulhoesa Temple, Naju (1799

Table 2

Types of Projecting Ends in Bracketed Beams without Projection (75 cases)				
Type				***Classification Criteria***
-				A. Type of purlin supported (central only)
1. Support type (1)	Matching support type			B. Relationship between the projecting end and the central purlin support member
-	2. Bracket-head type (12)	Beam-head type		C. Thickness of the central purlin support member
-		3. Standard beam-head type (49)	4. Decorative beam-head type (13)	D. Presence of purely decorative (non-structural) elements

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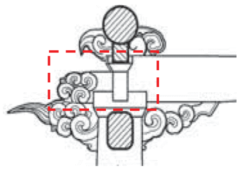
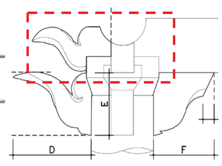



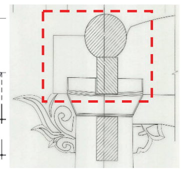
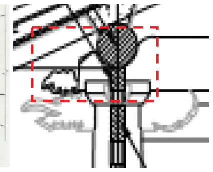



Figure 8. Support type: Hoejeonmun Gate, Cheongpyeongsa Temple, Chuncheon (1557)
Figure 9. Bracket-head type: Wontongjeon Hall, Gaemoksa Temple, Andong (1459)
Figure 10. Standard beam-head type: Gwangajeong House, Yangdong Village, Gyeongju (1514)
Figure 11. Decorative beam-head type: East Wing, Gangneung Hyanggyo (1623)

2.3 CLASSIFICATION OF PROJECTING ENDS IN TRANSVERSE BEAMS

Although the transverse beam (chungnyang) is commonly defined as a lateral beam with one end joined to the side bracket system and the other resting on a main beam (daedeulbo), this study adopts a broader definition. In this context, any lateral beam whose rear end connects to a main beam, a child post (dongjaju), a principal column (goju), or a bracket base (judu) is classified as a transverse beam.

In the 126 examples examined, the projecting ends of transverse beams were classified into four types, based on how the rear end of the beam connects to the main crossbeam (daedeulbo) or other beams, or to a column (Table 3).

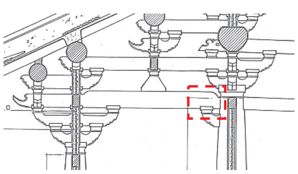
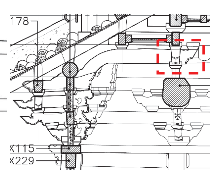
A) Presence or absence of a projecting end,
B) Connection to other structural components,
C) Presence of additional non-structural decorative elements.

According to these criteria, the four types are:

1) No projecting end type: The rear end of the transverse beam is inserted into the main crossbeam (daedeulbo) or other beams, or into a column, and no projecting portion exists. This type was found in 56 out of 126 cases.
2) Combined type: The projecting end absorbs the function and form of other structural components, but includes no decorative elements. A total of 7 examples were identified.
3) Standard projecting end type: The projecting end exists independently, does not incorporate other structural functions, and includes no decorative elements (non-structual). Found in 43 cases.
4) Decorative projecting end type: Structurally identical to the standard type, but with a non-structural decorative element attached to the end. A total of 22 cases were identified.

Table 3

Types of Projecting Ends in Transverse Beams (126 cases)				
Type				***Classification Criteria***
1. No projecting end type (56)	Projecting end type			A. Presence or absence of a projecting end
-	2. Combined type (7)	Standard type		B. Connection to other structural components
-	-	3. Standard projecting end type (43)	4. Decorative projecting end type (22)	C. Presence of purely decorative (non-structural) elements

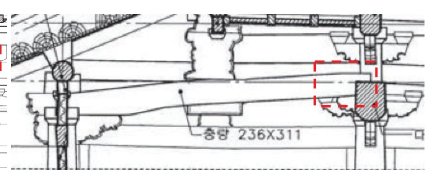
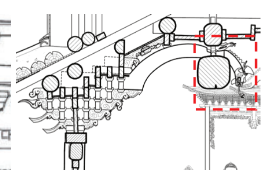



Figure 12. No projecting end type: Muryangsujeon Hall, Buseoksa Temple, Yeongju (1376)
Figure 13. Combined type: Daeungjeon Hall, Gosansa Temple, Hongseong (1626)
Figure 14. Standard projecting end type: Imcheonggak, Andong (1519)
Figure 15. Decorative projecting end type: Daeungjeon Hall, Jeondeungsa Temple, Ganghwa (1621)

3 – STRUCTURAL AND ORNAMENTAL CHARACTERISTICS BY TYPE

3.1 ANALYSIS OF PROJECTING ENDS IN BEAMS WITH PROJECTION IN THE BRACKET SYSTEM

Based on the typologies presented in Chapter 2, this chapter analyzes how the structural and ornamental functions of the projecting ends in beams and transverse beams are distinguished across different types.

In the case of projecting ends in beams with projection (chulmok), they can be categorized into two groups: those that function both as structural and ornamental components, and those that serve purely structural roles (Table 4). In the former, the projecting end supports the outer purlin (oechulmokdori), extending beyond the building façade, and is often decorated at its tip through wood shaping (chimok), painting (dancheong), or carving (chogak).

In the latter, the projecting end supports only the central purlin (jusimdori), and is not exposed outside but terminates internally within the bracket system. In such cases, the function of supporting the outer purlin and serving as an exterior decorative element is instead performed by either a short bracket wing (chogong) aligned horizontally with the beam, or a bracket wing (jegong) located below it. These bracket wings may thus be understood as complementary components that partially inherit the role of the projecting end.

Table 4

Structural and Ornamental Functions by Type of Projecting Ends in Beams with Projection		
Type	***Note***	***Primary Function***
Standard beam-head type	Outer purlin-supporting type	Structural + Ornamental
Decorative beam-head type		
Bracket-head type		
Support type		
Extension type	Central purlin-supporting type	Structural only
Standard layered type		
Decorative layered type		

The degree of structural contribution of each type of projecting end within the bracket system can be understood as shown in Table 5. Generally, the outer purlin-supporting types exhibit a higher level of structural engagement compared to other types, as the beam is embedded deeply into the bracket system and supports both the central purlin (jusimdori) and the outer purlin (oechulmokdori), thereby bearing a greater structural load within the system.

Among these, the beam-head type and bracket-head type are structurally more significant than the support type, as their projecting ends are directly joined to the outer purlin (Table 1). In particular, the beam-head type features a thicker projecting end compared to the bracket-head type, providing a larger contact surface with the purlin, which enables more stable support and resistance against horizontal displacement. For these reasons, it can be regarded as the most structurally robust among all types.

In contrast, the central purlin-supporting types contribute less structurally, as their projecting ends do not extend to the outer purlin, but instead terminate internally within the bracket system, and the outer purlin is instead supported by a short bracket wing (chogong) or a bracket wing (jegong).

Within the central purlin-supporting types, extension types and layered types can be distinguished as follows. The extension type features a support for the outer purlin located on the same horizontal line as the beam, thus partially supplementing the role of the projecting end; the beam is horizontally disconnected but still somewhat functionally integrated. On the other hand, in the layered type, the support for the outer purlin is located below the beam, which means that the beam's role is not only horizontally but also vertically isolated. Therefore, among all types of projecting ends in beams with projection (chulmok), the layered type is considered to contribute the least structurally.

Table 5

Structural and Ornamental Functions by Type of Projecting Ends in Beams with Projection		
Type	***Note***	***Degree***
Standard beam-head type	Beam-head type	a
Decorative beam-head type		
Bracket-head type	-	b
Support type	-	c
Extension type	-	d
Standard layered type	Layered type	e
Decorative layered type		

Structural significance decreases from a (highest) to e (lowest).

The ease of decorative carving in each type of projecting end in beams with projection (chulmok) appears to follow the trend shown in Table 6, assuming that carving becomes easier when the decorative member is closer to the standard sectional width (sujangpok) and when the structural role is minimal.

In the decorative types, the decorative elements used are purely ornamental and entirely independent of any structural function. These are typically carved into members of standard sectional width and then either attached to the projecting end (as in the decorative beam-head type) or affixed to the bracket wing (jegong), as in the decorative layered type. Because these decorative elements are separate from the structural members, they can be carved in advance and then attached, making them arguably the easiest type to construct from a carpenter's perspective.

In the support type, bracket-head type, extension type, and standard layered type, the members that receive carving—such as the beam, short bracket wing (chogong), or bracket wing (jegong)—are generally shaped to the standard sectional width, offering a high degree of freedom in carving. However, since these components also serve a structural function in supporting the outer purlin, the carving must be carefully considered alongside structural performance and require preliminary shaping work based on load-bearing requirements.

Finally, the standard beam-head type directly supports the outer purlin and is composed of a thicker beam end, making it less suitable for detailed carving. In fact, while decorative elements of standard sectional width are almost always carved, only 28 out of the 52 examples of the standard beam-head type (54%) show decorative carving (Table 1).

Table 6

Relative Ease of Decorative Carving by Type of Projecting Ends in Beams with Projection		
Type	***Note***	***Degree***
Decorative beam-head type	Decorative type	a
Decorative layered type		
Support type	Standard sectional width	b

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Bracket-head type		
Extension type		
Standard layered type		
Standard beam-head type	Thicker than standard width	c

Decorative carving becomes more difficult from level a to c.

An examination of the types of decorative carvings (chogak) by projecting end type shows that the standard layered type, where the bracket wing (jegong) replaces the beam as the decorative element, exhibits the greatest variety with seven distinct forms. This is followed by the bracket-head type with six, and both the standard beam-head type and the extension type with four each.

By contrast, only two, one, and one type were identified in the decorative beam-head type, support type, and decorative layered type, respectively—likely due to the limited number of examples in these categories (Table 1).

3.2 ANALYSIS OF PROJECTING ENDS IN BEAMS WITHOUT PROJECTION IN THE BRACKET SYSTEM

The types of projecting ends found in beams without projection (chulmok) generally show similar patterns to those in bracket systems with projection, with the exception that extension types and layered types do not appear due to the absence of outer purlins.

The relative ease of decorative carving (chogak) across the types also reveals a distribution similar to that found in beams with projection. In this case as well, decorative elements carved into members of standard sectional width typically display decorative carving. However, among the 49 examples of the standard beam-head type, which are thicker than the standard width, only 19 cases (39%) exhibit decorative carving (Table 2).

Regarding the variety of decorative carving types, the bracket-head type and decorative beam-head type each show three distinct forms, followed by the standard beam-head type with two and the support type with one.

The fact that fewer decorative carving types appear in bracket systems without projection, compared to those with projection, can be attributed to two factors: the overall lower number of carving cases, and the higher proportion of thick standard beam-head types. In beams with projection, the standard beam-head type accounts for 52 out of 162 cases (32%), whereas in beams without projection, it accounts for 49 out of 75 cases (65%) (Table 1, 2).

On the other hand, the variety of carvings in the decorative beam-head type appears greater in beams without projection. This is likely due to the increased number of decorative types within this category. In fact, among the 162 examples of beams with projection, only 4 cases (2%) fall under the decorative beam-head type or decorative layered type, while in the 75 examples of beams without projection, 22 cases (29%) fall under the decorative beam-head type (Table 1, 2).

3.3 ANALYSIS BY TYPE OF PROJECTING ENDS IN TRANSVERSE BEAMS

The structural relationship between each type of projecting end of the transverse beam (chungnyang) and the supporting member that bears its vertical load is summarized in Table 7. In the no projecting end type, the transverse beam is completely inserted into a high column (goju), beam (ryangjae), or child post (dongjaju), with no part of the cross-section exposed externally. In the combined type, the transverse beam is tightly joined to a beam or child post, but the projecting end extends beyond the connection point and is fully exposed.

In the projecting end type and decorative projecting end type, the transverse beam rests on top of a beam. Its rear end is either partially embedded into the beam or simply placed on top without embedding, resulting in the cross-section being either partially or fully exposed. An exceptional case is found in the Main Hall of Baengnyeonsa Temple in Gangjin (1762), where the decorative type projecting end is completely inserted into a child post, and set apart from the beam.

Table 7

Structural Relationship Between Transverse Beam Projecting Ends and Supporting Members Bearing Their Load

Type	*Supporting Member*	*Connection Type*	*Cross-Section Exposure*
No projecting end type	High column, beam, child post	Full insertion	Not exposed
Combined type	Beam, child post	Full insertion	Fully exposed
Projecting end type	Beam, child post	Partial insertion	Partially or fully exposed
Decorative projecting end type	Beam, column-top bracket support, child post	Partial or full insertion	Partially or fully exposed

For the projecting end type and decorative projecting end type, the degree of connection between the rear end of the transverse beam and the supporting member (ryangjae or judu) can be categorized into three levels of exposure:

ʹaʹ: More than half interlocked, with less than half of the cross-section exposed

ʹbʹ: Less than half interlocked, with more than half of the cross-section exposed

ʹcʹ: No interlocking; the full cross-section is exposed

According to this classification, the results shown in Table 8 are as follows:

Among the 43 cases of the projecting end type, 9 (21%) fall under level ‘a’, 8 (19%) under level ‘b’, and 26 (60%) under level ‘c’.

Among the 22 cases of the decorative projecting end type, 1 (5%) is level ‘a’, 3 (14%) level ‘b’, and 18 (82%) level ‘c’.

These results suggest that the projecting end type tends to show a relatively higher level of structural connection with its load-bearing member and less cross-sectional exposure than the decorative projecting end type.

Table 8

Classification of Transverse Beam Projecting Ends by Structural Interlocking and Cross-Section Exposure				
Condition	***Category***	***Projecting End Type (43 cases)***	***Decorative Projecting End Type (22 cases)***	***Total***
Rear end of beam interlocked more than halfway	a	9	1	10
Rear end of beam interlocked less than halfway	b	8	3	11
No interlocking (fully exposed)	c	26	18	44

The degree of exposure of the transverse beam's projecting end is closely associated with the presence of decorative elements. The majority of examples fall under category c, where the cross-section is fully exposed, while a considerable number also belong to category b, where it is partially exposed.

When assessing the feasibility of decorative carving (chogak) by type of transverse beam projecting end—excluding the no projecting end type, which by definition cannot accommodate carving—the decorative projecting end type appears to be the most conducive to such treatment. This is because the decorative element in this type is structurally independent and typically consists of a detachable component affixed to the beam's end face, thereby minimizing construction complexity.

In the case of the combined type, although the projecting end fulfills a structural role—thus offering less freedom for decorative carving than the decorative projecting end type—a moderate level of feasibility is still observed. This is because the beam end often connects to a child post (dongjaju), functioning as a bracket arm (cheomcha) to support a middle purlin (jungdori), or is joined beneath a main crossbeam (daedeulbo) to form a standard-thickness base bracket wing (anchogong).

In contrast, the projecting end type typically has a cross-section thicker than standard and rests directly atop a beam (ryangjae), imposing greater structural constraints. As a result, it offers the least flexibility for carving. Indeed, while all recorded examples of the decorative and combined types feature decorative carving, only one case among the 43 examples of the projecting end type shows such treatment: the Daeungjeon Hall of Bulguksa Temple in Gyeongju (1765).

As for the types of decorative carving observed by type, the combined type exhibits the greatest variety, with three distinct styles identified: cloud-shaped (unhyeong), double-S curve (ssang-S-ja hyeong), and upturned tip form (gyoduhyeong). By comparison, both the projecting end type and decorative projecting end type exhibit only one style each.

In all 22 examples of the decorative projecting end type, dragon-head (yongduhyeong) carving is present. In the projecting end type, the sole carved example at Bulguksa Temple features an elephant-head motif on the front-right beam, a tiger-head motif on the front-left beam, and dragon-head carvings on both rear beams, consistent with the decorative projecting end type.

4 – ANALYSIS BY PERIOD AND BUILDING TYPE

4.1 PROJECTING ENDS IN BEAMS WITH PROJECTION IN THE BRACKET SYSTEM

This chapter examines patterns and notable characteristics of beam-end and transverse beam projecting ends (ppael-mok) in relation to historical period and building type, based on the typological analysis presented in earlier chapters.

When analyzing the projecting ends in bracket systems with projection (chulmok) by historical period, no strong linear trend is observed overall. However, one noticeable pattern is the sharp decline of the bracket-head type after the 17th century and the concurrent increase of the standard beam-head type from the 18th century onward (Figure 16).

This shift appears to reflect two opposing tendencies in late Joseon-era temple architecture: while the proportion of bracket-head types decreased, structurally minimized forms such as the extension type and layered type became more common, even as the structurally robust standard beam-head type also saw increased use. These parallel trends suggest a diversification of structural strategies rather than a singular evolution.

Additionally, the increased number of palace buildings constructed during the 19th and 20th centuries that adopted the standard beam-head type likely contributed to the rise in its overall frequency.

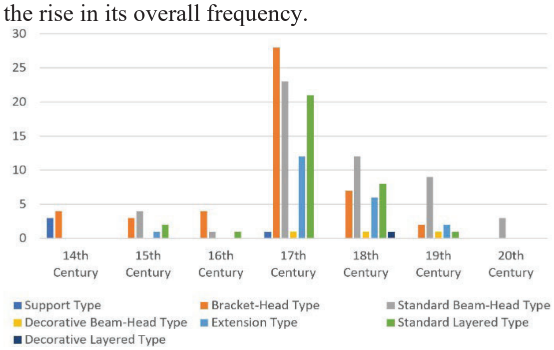

Figure 16. Types of Projecting Ends in Bracketed Beams with Projection by Period

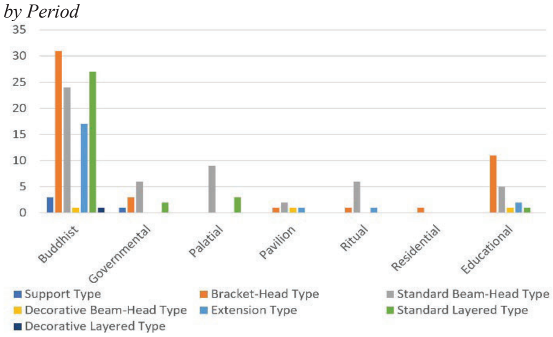

Figure 17. Types of Projecting Ends in Bracketed Beams with Projection by Building Type

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According to the analysis by building type, a clear distinction was found between Buddhist and non-Buddhist architecture (including government, palace, pavilion, ritual, residential, and educational buildings).
The support type, in which the projecting end of the beam is exposed externally and plays a significant structural role, accounted for 48 out of 58 non-Buddhist buildings (83%). More specifically, it appeared in 10 out of 12 government buildings (83%), 9 out of 12 palaces (75%), 4 out of 5 pavilions (80%), 6 out of 8 ritual buildings (75%), 1 out of 1 residential building (100%), and 17 out of 20 educational buildings (85%), indicating a high proportion across all non-Buddhist types. In contrast, only 59 out of 104 Buddhist buildings (57%) fell under this category, showing a relatively lower proportion.
In particular, the standard beam-head type, which emphasizes structural function while minimizing decorative expression, was found in 28 out of 58 non-Buddhist buildings (48%). This includes 6 government buildings (50%), 9 palaces (75%), 2 pavilions (40%), 6 ritual buildings (75%), and 5 educational buildings (25%). Excluding the single residential building, this suggests that structurally oriented types were widely favored in non-Buddhist architecture.
By contrast, in Buddhist architecture, only 24 out of 104 buildings (23%) were of the standard beam-head type, ranking third after the bracket-head type (31 buildings, 30%) and the decorative layered type (27 buildings, 26%).
Differences between Buddhist and non-Buddhist buildings were also evident in the type of bracket system used. Among the 20 non-Buddhist buildings employing the multiple complex bracket style (dapo), the standard beam-head type appeared in 16 cases (80%), followed by the standard layered type in 3 cases (15%) and the extension type in 1 case (5%). In contrast, among 85 Buddhist buildings of the same bracket style, the standard layered type appeared most frequently (27 cases, 31.8%), followed by the standard beam-head type (21 cases, about 25%) and the bracket-head type (18 cases, about 21%).
This suggests that, even within the same multiple complex bracket style, non-Buddhist buildings tend to favor structurally emphasized types like the standard beam-head type, while Buddhist buildings more often employ types with a stronger decorative function such as the standard layered type.
A similar trend can be seen in buildings with the projected bracket wing style (chulmok-ikgong). Among 28 non-Buddhist examples, the bracket-head type was most common (12 cases, about 43%), followed by the standard beam-head type (9 cases, about 32%) and the extension type (3 cases, about 11%). In contrast, among the 9 Buddhist buildings, 7 cases (about 78%) were bracket-head types and 2 cases (about 22%) were standard beam-head types.
While the small number of Buddhist examples limits generalization, it is noteworthy that both types of architecture show a high proportion of projection-supporting types (bracket-head and standard beam-head types).

4.2 BEAM-END PROJECTIONS IN BRACKET SYSTEMS WITHOUT PROJECTION

Although no clear chronological trend was observed among the cases of bracket systems without projection, it is notable that the decorative type began to appear from the 17th century onward not only in beam-end projections of bracket systems with and without projection, but also in transverse beam-end projections, which will be discussed later (Figures 16, 18, 20). This suggests the following: first, from around the 17th century, a stronger emphasis on decorative elements emerged in architecture; second, there was a shift in traditional timber-frame construction, where structural and decorative elements had previously been integrated, toward a separation of their respective functions; and third, a growing prioritization of construction efficiency over formal or sculptural refinement began to take shape.

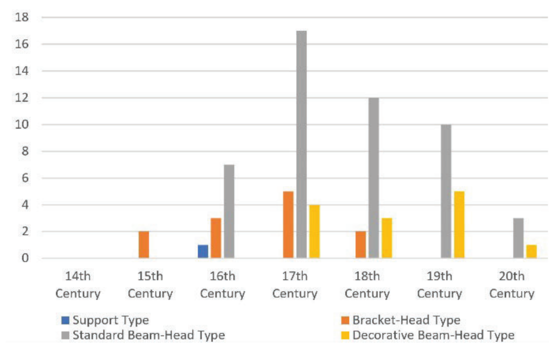

Figure 18. Types of Beam-End Projections in Bracket Systems without Projection by Period

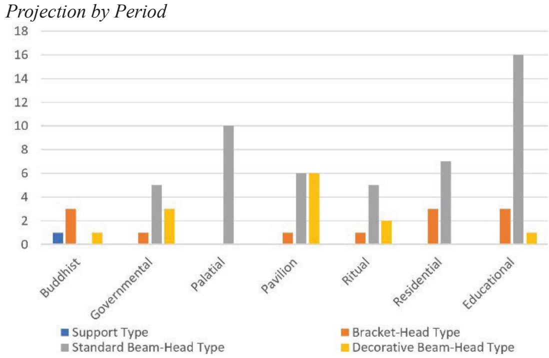

Figure 19. Types of Beam-End Projections in Bracket Systems without Projection by Building Type

In the analysis by building type, although the number of Buddhist buildings is limited to five out of the total 75 cases—making absolute comparison difficult—a noteworthy trend emerges. In Buddhist architecture, there were no examples of the standard beam-head type, whereas in the remaining 70 non-Buddhist buildings, 49 examples (70%) fell into this category, making it the most prevalent type. Further analysis by architectural category—government, palace, pavilion, ritual, residential, and educational—also shows that the standard beam-head type is dominant across all non-Buddhist types (Figure 19).

This suggests that even in bracket systems without projection, non-Buddhist architecture tends to emphasize structural aspects, while Buddhist architecture places greater importance on decorative expression. Notably, in palace architecture, all 10 analyzed buildings adopted the standard beam-head type, consistent with the trend observed in bracket systems with projection, where 9 out of 12 palace buildings also used this type. This indicates that in palace architecture, the structural function of the beam-end projection was the primary consideration, and ornamental design was added only after structural requirements were satisfied.

Meanwhile, all 75 examples analyzed fall under the bracket wing style (ikgong) without projection, which may have influenced the overall results to some extent. However, the preference for specific beam-end types is likely attributable not only to differences in bracket system formats but also to broader cultural distinctions between Buddhist and non-Buddhist architectural traditions.

4.3 PROJECTING ENDS OF TRANSVERSE BEAMS

Although the analysis of projecting ends of transverse beams revealed no distinct chronological trends, clear differences were observed between Buddhist and non-Buddhist architecture. In non-Buddhist architecture, the proportion of the no projecting end type was generally higher across most building types, except for residential buildings (Figure 21). Additionally, in the standard projecting end type and decorative projecting end type found in non-Buddhist architecture, the transverse beam's end showed a greater degree of overlap with the supporting beam (ryangjae) compared to those in Buddhist architecture (Figure 22).

In contrast, Buddhist architecture showed a relatively high proportion of the standard and decorative projecting end types, but the projecting ends tended to be more visibly exposed overall.

Specifically, the no projecting end type was found in 40 out of 71 non-Buddhist examples (56%), while it appeared in only 16 out of 55 Buddhist examples (29%). This type was particularly prevalent in palace and governmental buildings, which tended to retain front columns and directly connect the transverse beams to them. In contrast, Buddhist architecture often omitted front columns to preserve the space in front of the Buddha image for worship, resulting in a structural condition where the rear end of the transverse beam rests on a beam (ryangjae). Consequently, this led to a higher frequency of standard and decorative projecting end types in Buddist examples.

An examination of the structural engagement between standard projecting ends and the beams (ryangjae) or bracket supports (judu) reveals the distribution shown in Table 22.

Among the 20 examples from Buddhist architecture, 16 cases (80%) fall under category 'c', where the end is minimally engaged and the cross-section is fully exposed. Categories 'b' and 'a' each account for 2 cases (10%).

In contrast, among the 23 examples from non-Buddhist architecture, 10 cases (45%) fall under 'c', 6 (26%) under 'b', and 7 (30%) under 'a', indicating that non-Buddhist architecture exhibits a greater tendency to reinforce structural interlocking between the transverse beam ends and the receiving members. In these cases, deeper grooves were often cut into the projecting end or the receiving beam to ensure a more secure joint, whereas in Buddhist architecture, the end section of the transverse beam was more frequently exposed.

In the case of decorative projecting ends, Buddhist architecture accounts for 17 of the 22 total examples (77%), and among these, 15 cases (88%) are classified under category 'c'. This suggests that while in non-Buddhist buildings the ends of transverse beams more commonly served a structural role, in Buddhist architecture they often functioned both as structural and decorative elements. In particular, the cross-sections of the projecting ends were more prominently exposed and intricately carved, emphasizing their ornamental character.

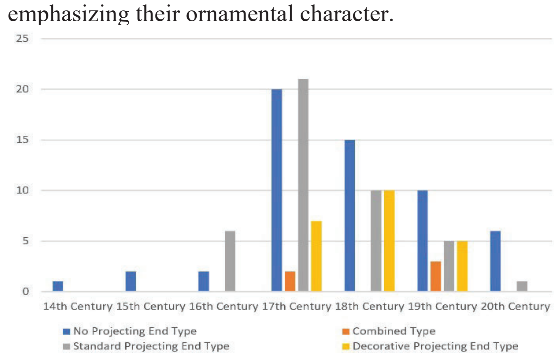

Figure 20. Types of Projecting Ends of Transverse Beams by Period

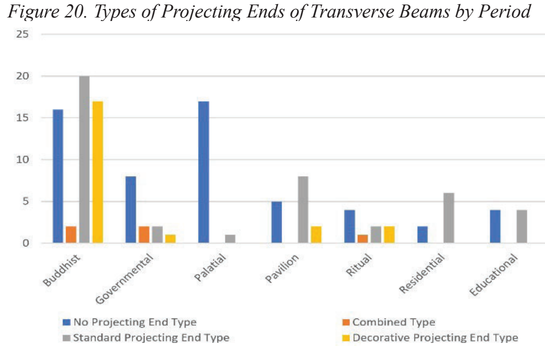

Figure 21. Types of Projecting Ends of Transverse Beams by Building Type

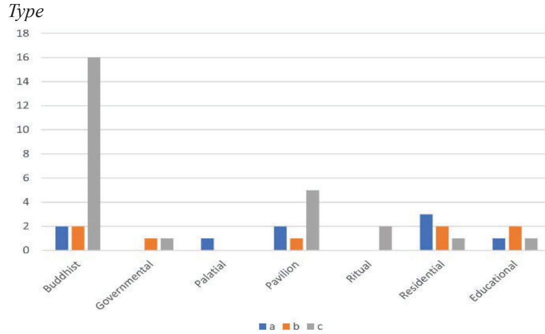

Figure 22. Structural Engagement with Beams (or Column-Top Brackets) and Cross-Sectional Exposure by Building Type in Projecting End Types (Table 8)

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5 – ANALYSIS BY PERIOD AND BUILDING TYPE

This study aimed to systematically classify the projecting ends (ppalmok) found in beams and transverse beams—two principal horizontal structural members in Korean traditional wooden architecture—and to analyze the interaction between structure and ornamentation. Through this, the study examined the overlapping and divergent structural and aesthetic functions embodied in ppalmok.

In beam-end projections, seven types were identified in bracket systems with projection, and four types in systems without projection. These showed clear differences in both structural contribution and the ease of executing decorative carving (chogak). Structurally, types that support the outer purlin—such as the standard beam-head type and bracket-head type—played the most critical roles. Ornamentally, types with non-structural decorative components or with members of standard sectional width were most suitable for chogak carving.

Transverse beam-end projections were also classified into four types based on the presence of projection, degree of structural integration with other members, and the presence of decorative elements. A significant correlation was found between the exposure level of the beam-end cross-section and its ornamentation, with the decorative type exhibiting the greatest freedom for ornamental expression.

The chronological analysis revealed no dramatic shifts in the overall distribution of types, but decorative types began to emerge prominently around the 17th century, suggesting a clear move toward the separation of structural and decorative functions. This shift reflects a growing emphasis on ornamentation in architectural composition and a concurrent prioritization of construction efficiency.

In terms of building type, a clear distinction was observed between Buddhist and non-Buddhist architecture. In non-Buddhist buildings, structural integrity was emphasized, with the standard beam-head type and no projecting end type being predominant. Transverse beams in these structures also tended to be more structurally embedded, with less visible cross-section exposure. In contrast, Buddhist architecture showed a consistent tendency toward lower levels of structural interlocking and a greater emphasis on visual ornamentation across both beam and transverse beam projections. These differences stem not merely from variations in bracket styles or member forms, but from fundamentally different architectural purposes and spatial design principles that inform their respective aesthetic attitudes.

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