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Goryeo Dynasty (918-1392), shipwrecks in Korea

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Abstract

To date, the history of Korean shipbuilding technology has not received much attention from international scholars despite the fact that a growing number of properly excavated and reported vessels are providing a rich source of information regarding historic Korean maritime culture. In this brief article, six Korean coastal vessels, Sibidongpado, Wando, Daebudo, Taean, Dalido, and Anjwa shipwrecks, all from the Goryeo Dynasty (918-1392) will be discussed with particular attention paid to hull structure. These archaeological discoveries represent ships from the golden age of Korean maritime history. The main focus is placed on describing the differences and similarities among these vessels. Evolutionary themes in Korean shipbuilding technology will also be illustrated. The basic features of historic Korean ships are the use of heavy timbers joined with wooden fasteners. These vessels were built without the use of iron nails and beams were placed in transverse direction to bolster hull strength. The gradual development and continuity of Korean shipbuilding tradition, as well as some peculiar construction features are illustrated.

要旨

韓国の造船技術の歴史は、沈没船の発掘や報告例から得られた豊富な資料が増えているにも関わらず、いまだに世界の研究者から正当な注目を受けていない 。本文は韓国高麗時代 (918-1392) の6隻の内航船（十二東波島船、莞島船、大阜島船、泰安船、達里島船、および安佐島船）それぞれの船体構造について特に詳しく解説してある。これらの考古学資料は、韓国海洋文化の黄金時代を築いた船であると考えられている。主な焦点はこれらの沈没船の基本構造と相違点や類似点などである。本論文を執筆するに至った主な目的は、韓国で発掘された沈没船をより多くの読者に紹介することであるが、韓国伝統船の発達過程もひとつのテーマである。朝鮮半島の伝統船舶技術の基本的構造は頑丈で大きな木材を使用し、それぞれの部材を木製の留め具で結合していることである。これらの船は鉄釘を使用せずに造られ、船体は横方向に配置された梁で強化されたつくりを持つ。これらの沈没船を研究・分析することによって、韓国高麗時代において基本的な伝統造船技術が時間を経て保持・継続されていると同時に、すこしずつ進化していく過程、そして、いくつか独特の技術も稀に見ることができる。

Introduction

This article provides an overview of excavated Korean vessels. A peninsula country like Korea would have a strong seafaring tradition with the potential of becoming a regional maritime power. However, it is often assumed that Korea did not possess a culture strongly oriented towards maritime enterprise. The lack of nautical development is often ascribed to the complex sea line of Korea, which is dotted with numerous small islands surrounded by mudflats, difficult currents, and one of the world's highest tides.[1] It is argued that because of these conditions, no great ships could be developed. The traditional ships were usually described as box-like and crude. Chinese envoys sent to the country in 1124 thought the Korean ships were crude, simple, and unworthy of mentioning in details.[2]

Due to this common notion, studies of Korean shipbuilding technology are often neglected. But these are the views of people who did not understand the ingenuity of local Korean watercraft, ships best suited for a peculiar and often hazardous marine environment. The maritime archaeology of Korea has seen a rapid development in recent years, as over a dozen shipwrecks have been identified, with some extensively analyzed and fully reported. Thanks to the work of Korean archaeologists, we know much about the ships from the Goryeo Dynasty (918–1392), considered to be the golden age of maritime Korea. The recent research provides new insights into the study of this important maritime culture; despite the detailed studies conducted by Korean researchers, the valuable information has not been widely circulated to a broader audience. This brief overview is intended to illustrate the potential of further research of Korean coastal ships from the Goryeo Dynasty.

This article describes the hull of the Korean coastal vessels from the Goryeo Dynasty based on archaeological evidence. The vessels discovered outside Korea, such as the *Penglai No.3* and *No.4 ships* believed to be Korean or Korean influenced vessels as well as ship timbers discovered at Takashima Underwater Site of Japan, are not discussed in this paper.[3] Particular attention is paid to the structure of the hull itself, but only limited references are made to its cargo and other artifacts from the shipwrecks. Iconographic and textual evidence regarding the Korean vessels are not discussed. The intention of this survey is to simply introduce the hull structures of the Goryeo vessels to a wider audience, and not to propose a new theory of shipbuilding technology. The vessels described here are only a small percentage of ships that sailed the Korean coast. The continuity of tradition, however, may be altered by a discovery of another vessel. Some of the vessels are undergoing the process of conservation

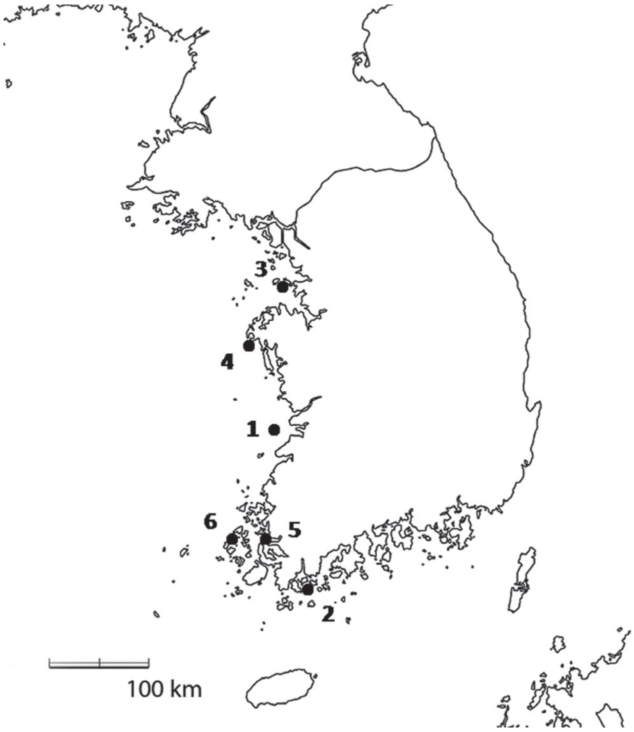

Figure 5.1 A map of Korea and location of excavated hulls. (Drawn by Randall Sasaki)

and only brief descriptions, drawings, and photographs are available for study. Nonetheless, it is not without merit to synthesize the archaeological evidence at hand to detect a possible pattern in the evolution of Korea's shipbuilding tradition. Only six vessels, Sibidongpado, Wando, Daebudo, Taean, Dalido, and Anjwa shipwrecks will be introduced by chronological order based on archaeological evidence (Figure 5.1 and Table 5.1). It should be noted that the date for both the Wando and Sibidongpado ships has been identified to the similar time period based on the ceramic analysis, and the exact chronological order is disputable. For this article, the Sibidongpado ship is placed earlier than the Wando ship. These vessels represent the local Korean watercraft from the Goryeo Dynasty. Despite the limited scope of this study, many readers will find new information on this often neglected topic. The hull characteristics of six vessels described below are followed by a brief discussion and summary. The reports of these vessels were obtained through the kindness of National Research Center for Maritime Cultural Heritage (National Maritime Museum of Korea at Mokpo). This project is part of the Toyota Foundation supported project Shipwreck ASIA; a field trip to Korea and some translations have been funded by the foundation. We would hope this small step in research would lead to a better understanding of the maritime tradition of Korea and that of the world, and instigate further investigation on this topic.

	Date (in Cent)	Bottom Structure	Survived Dimensions (m)	Estimated Length (m)	Estimated Beam (m)	Year Excavated
Sibidongpado	11–12	3 + 2L/Chine	7 x 1.8	14	5.5	2004
Wando	12	5 + 1L/Chine	6.5 x 1.65	9	3.5	1983–4
Daebudo	12–13	5	6.6 x 1.4	NA	NA	2003
Taean	12	NA	8.21 x 1.5	NA	NA	2007-on going
Dalido	13–14	3	10.5 x 2.72	12	3.6	1995
Anjwa	14	3	14.7 x 4.53	17	6.6	2005

Table 5.1a Basic Comparison of Six Hulls

	Central Bottom Plank Dimensions: W x Th (cm)	Average Bottom Plank Dimensions: W x Th (cm)	Average Side Plank Dimensions: W x Th (cm)
Sibidongpado	71 x 33	47 x 33	29 x 12.5
Wando	35 x 20	32 x 20	30–34 x 10–12
Daebudo	41 x 25	32 x 27	NA
Dalido	40–43 x 15–20	30–37 x 17–25	33–40 x 11–14
Anjwa	22–54 x 22–39	54–55 x 24–29	39–46 x 19–30

Table 5.1b Comparison of Plank Dimensions

Figure 5.2 A photo of a reconstructed traditional Korean vessel. (Photo taken by Randall Sasaki)

Archaeological Evidence

The traditional seagoing ships of the Goryeo Dynasty share common features that should be illustrated prior to describing each vessel. The most characteristic feature is the use of heavy timbers, both on bottom and side planks, to construct a hull. The bottom of the vessel is made flat, and the side planks are blocky in appearance, giving the distinguishing box-like shape of the Korean vessels (Figure 5.2).

The hull derives most of its strength from these heavy timbers along with beams (가룡). The use of these beams is one of the most prominent characteristics of Korean vessels. The entire hull is built with strongly built timber and the use of curved timbers as frames did not develop in Korea. Bulkheads, a common feature of Chinese vessels, are not used on ships built in Korea. Another native feature is that Korean shipwrights did not utilize iron nails; traditional Korean vessels were flat

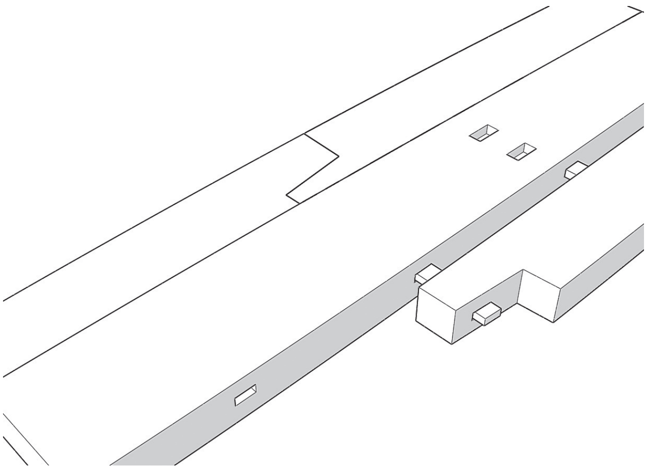

Figure 5.3 A simple model of bottom plank structure showing *jangsaks*. (Drawn by Randall Sasaki)

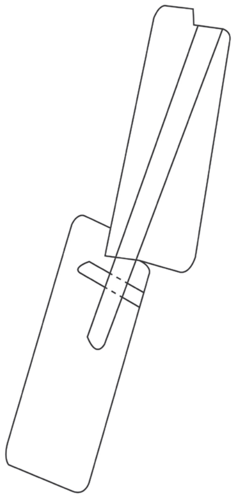

Figure 5.4 A simple drawing showing *pisak* and plank configurations. (Drawn by Randall Sasaki)

bottomed boats, consisting of three or five bottom planks, connected with *jangsaks* (장삭). A *jangsak* is a large and long tenon, fitted to the mortises cut through the width of the bottom planks. It not only joins the bottom planks together but serves also as an internal frame (Figure 5.3). Side planks of the Korean watercraft almost always have a rabbet cut at the upper outer edge where the next plank is placed above. The planks are joined with *pisaks* (피삭), a type of mortise and tenon joinery unique to Korean shipwrights. Usually, a mortise is cut through the width of a plank above and into the middle of the plank below. To hold two planks together, a *pisak* is secured with a peg placed only along the plank located directly below (Figure 5.4).

Another feature that all of these vessels share is the presence of two rectangular slots used to hold the heel of the mast located on a bottom plank. Bow and stern structures were found on several vessels, but more archaeological samples are required before making any conclusive statements regarding the structure at the extremities of the hull. However, it is known from the study of traditional boats and iconographies that the Korean vessel had both bow and stern transoms. The six vessels starting from the oldest are described below. In the description, overall information about the vessel is provided first, and the characteristics of the hull is described from the bottom timbers, side planks, beams, and other structures.

The Sibidongpado ship[4]

The Sibidongpado ship was excavated in 2004, and is believed to date back to the end of the 11th century to the early 12th century based on the style of celadon on board. The vessel was found near Gunsan city in Jeollabuk-do. Fourteen pieces of the hull, a stone anchor, more than 8,000 celadon wares, and a handful of personal and shipboard items were found. The presence of dunnage and packing materials gave archaeologists and historians a unique opportunity to study the seafaring practice of the time. The main structure of the hull consists of three bottom planks, joined with *jangsaks*, two L-shaped chine strakes on each side of the hull, and shell planking; the hull is kept in shape with several beams (Figure 5.5 and Figure 5.6). A possible bow section (bow transom-like structure) was found apart from the main hull section. Mast slots were discovered on the center bottom plank. Only three beams were found from the wreck, and one degraded hull plank. One interesting find is part of a windlass possibly for pulling the anchors. The surviving hull section measures approximately 7 m in length and 1.8 m in width. Korean researchers estimated the hull to be 14 m in length and 5.5 m in breath while the depth of the ship was about 2.5 m. It must be stressed that this is a rough estimate since only a small portion of the hull survived.

The bottom section of the hull consists of three strakes, and the total width is about 1.79 m. All three strakes are joined by *jangsaks*. The hull is curved upwards towards one end, considered to be the bow. The center strake consists of two planks, joined with a square tongue and groove joint (Figure 5.7). The total length of the central bottom strake is 6.86 m (2.20 m and 4.66 m) and the width and thickness appear to remain constant at 0.71–0.73 m and 0.33 m respectively. The cross-section is rectangular in shape, and both top (inside) and bottom (outside) surfaces are made flat. The port side bottom strake consists of two planks joined with a step joint. The total length of the strake is 7.07 m (4.89 m and 2.18 m). The

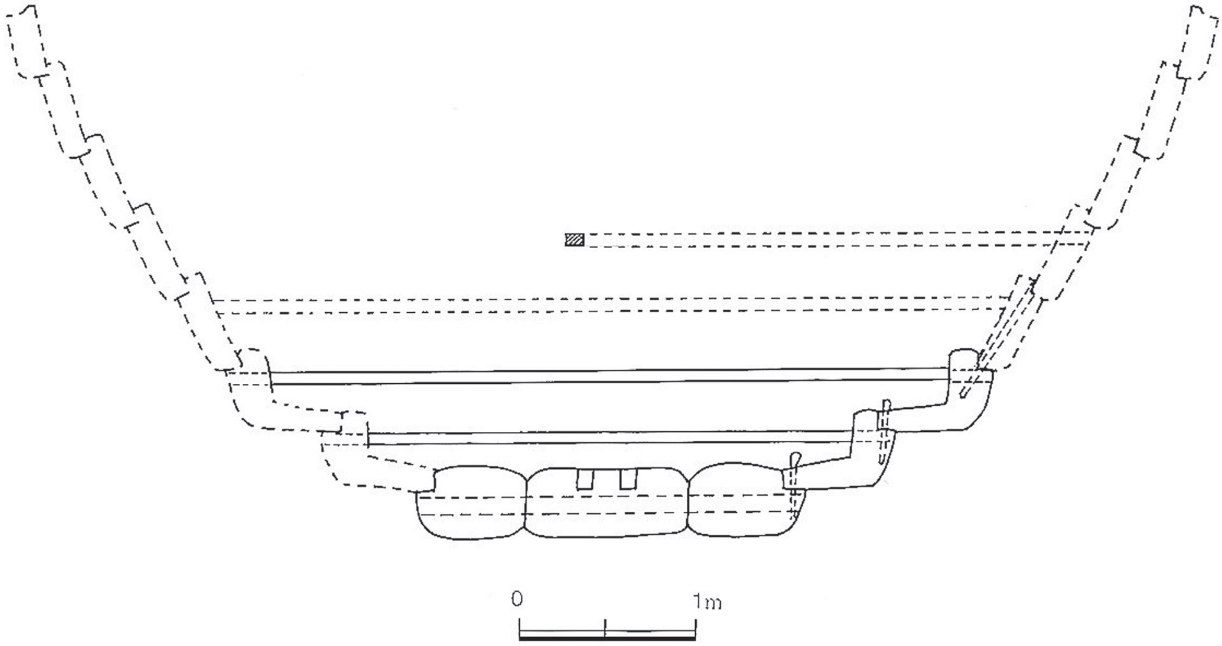

Figure 5.5 A possible reconstruction drawing of Sibidongpado ship. (Courtesy of the National Research Centre of Marine Cultural Heritage)

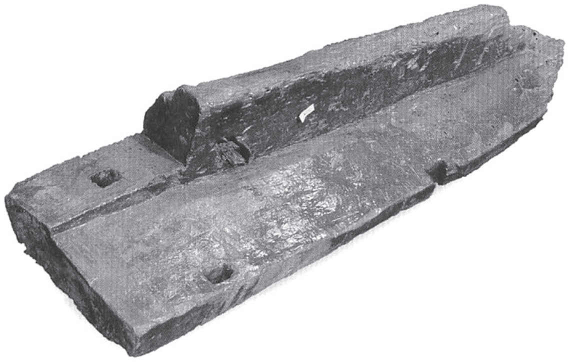

Figure 5.6 A photo of L-shaped chine strake. (Courtesy of the National Research Centre of Marine Cultural Heritage)

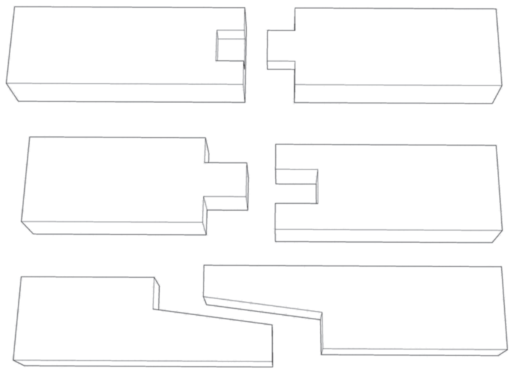

Figure 5.7 Example of some of the joinery found in Korean vessel. Top: complex tongue and groove joint, Middle: square tongue and groove joint, Bottom: step joint. (Drawn by Randall Sasaki)

width of the strake is about 0.47 m and the thickness is a constant 0.33 m, which is the same as the central plank as well as the starboard bottom strake. The starboard bottom strake also consists of two planks joined with a step joint positioned symmetrical to the portside joint; the step joints are located 1 m aft of the mast slots located most likely at the midship. The starboard strake is 6.16 m in length (4.88 m and 1.28 m). The maximum width is about 0.53 m and becomes narrower, about 0.43 m, towards the bow with a gentle curve. Both port and starboard strakes have a rectangular cross-section, but the bottom surfaces are made rounded, leaving the natural shape of the timber outside while upper (inner) surfaces are made flat. Rabbets are made at the outer upper edge of the strakes where L-shaped chine strakes are attached. A total of six *jangsaks* are used to connect all three bottom strakes together. Flat rectangular mortises of about 90 mm and 70 mm are cut out, and a *jangsak* is fitted into each mortise. These are set 1–1.1 m apart. One *jangsak* goes through the step joint position while no *jangsak* is placed at square tongue and groove joint on the center strake.

One of the most important characteristics of the Sibidongpado ship is the use of double chine strakes. This vessel uses two overlapping L-shaped chine strakes for transition from the bottom strake to the side strake at the turn of the bilge. The bottom chine strake consists of two planks joined by an overlapping step joint. Looking at a cross-section, the plank is 0.50–0.58 m wide and approximately 0.30 m high. The shape is not uniform, but the flat area of the "L" is about 0.2–0.3 m, and the Long side of the "L" rises to about 0.2 m. The upper section of the outer edge has a rabbet where another L-shaped chine strake is connected. The upper chine strake did not survive well, but the size appears to be slightly larger than the one below, about 0.6 m in width and 0.45 m in height. *Pisaks* are used for connecting the bottom planks with the chine planks, and to the planks above as well. The sizes of the *pisak* vary according to the size of the plank, but they are usually between 280–400 mm in length, 60–80 mm in width, and 25–30 mm in thickness. A total of twelve *pisaks* were found. The *pisak* is secured with a wooden pin or a peg, only at the lower plank; this is the standard method of joining planks found in all of the traditional vessels discovered. The presence of pegs for the connection between the bottom planks and the first L-shaped chine planks is not mentioned in the available report. The location of these *pisaks* appears to be random, perhaps set 0.6–0.8 m apart. However, extra *pisaks* are used along the plank scarfs to secure the joints. A total of four *pisaks* are used to secure the overlapping step joint found on the lower chine strake.

Only one heavily degraded outer plank was found at the site. It is 1.38 m in length, 0.29 m in width, and 0.125 m in thickness. It has one *pisak* going through the width of the plank. The mortise for the *pisaks* located at the upper chine strake are set diagonally, compared to the *pisaks* that connect the bottom planks as well as the chine planks which are set vertical. Beams were used extensively on traditional Korean vessels, and three of them were found from the Sibidongpado shipwreck. Two of the beams were found at the lower chine strake with another found at the upper chine strake. It is not possible to reconstruct the layout of the beams due to the degraded nature of the find. The beams are about 85 mm by 70 mm, and were laid flat. However, it appears that less number of beams were used compared to the later vessels.

The mast slots appear to be a standard feature on all excavated Korean vessels, with slight variations in size and depth. The slots of the Sibidongpado ship are 90 mm wide, 285 mm long, and 90 mm deep. These slots are made on the surface of the center bottom plank. No feature or additional elements was found around the slots. Planks around the mast slots were slightly burnt, indicating that this area may have been used for cooking on board. Another important find from the Sibidongpado ship is the bow transom section, found 3 m away from the main hull. The remaining bow section consists of three planks placed vertically and it measures 1.65 m x 1.10 m, with a thickness of 0.11 m. Each plank is about 0.35–0.38 m in width. The bow becomes narrower towards the bottom of the hull, making a trapezoidal shape. A groove or notch is made in a step-like fashion where

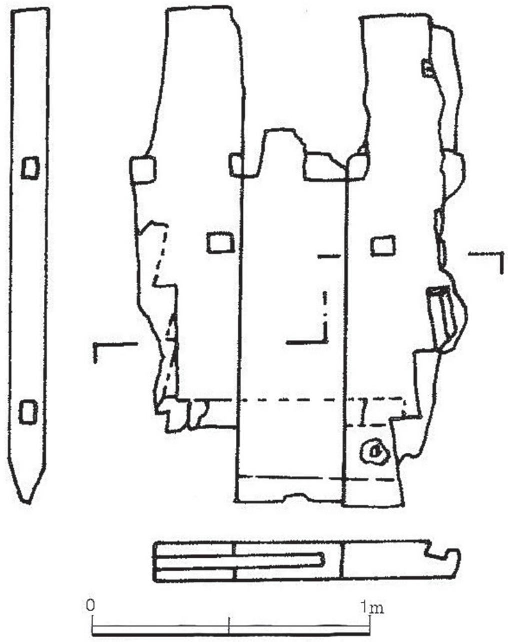

Figure 5.8 A drawing of the bow transom. (Courtesy of the National Research Centre of Marine Cultural Heritage)

the transom meets the planks. The hull planks are made to fit snuggly with the bow transom (Figure 5.8). Korean researchers have suggested that another layer of planks may have been placed over these transom timbers. The last feature of the Sibidongpado ship that must be mentioned is the presence of a windlass stand 1.97 m long, 0.195 m wide and 0.115 m thick. The hole at the top where the centerpiece of the windlass was fitted goes through this timber.

The Wando Ship[5]

The Wando ship was excavated in 1983–4, and it is the first local Korean vessel to be fully excavated underwater. Together with the Shinan ship excavation, this Wando ship's excavation is recognized as the beginning of underwater archaeology in Korea. Based on the cargo remains, the Wando ship dates to the late 11th century. The vessel was discovered in Wando-gun, Jeollabuk-do. Close to 30,000 artifacts, mainly of celadon porcelain, were uncovered from the site. It is one of the best preserved vessels discovered, providing a unique opportunity to compare the remains with traditional boats, and later, with other excavated vessels. The main structure of the hull consists of five flat bottom strakes, single line of L-shaped chine strake, and side strakes. As with other Korean boats, the transverse strength of the hull derives from several through beams. Planks are joined with *pisaks* as seen in the Sibidongpado ship. The mid-ship section of the hull is well preserved, but no bow or stern sections

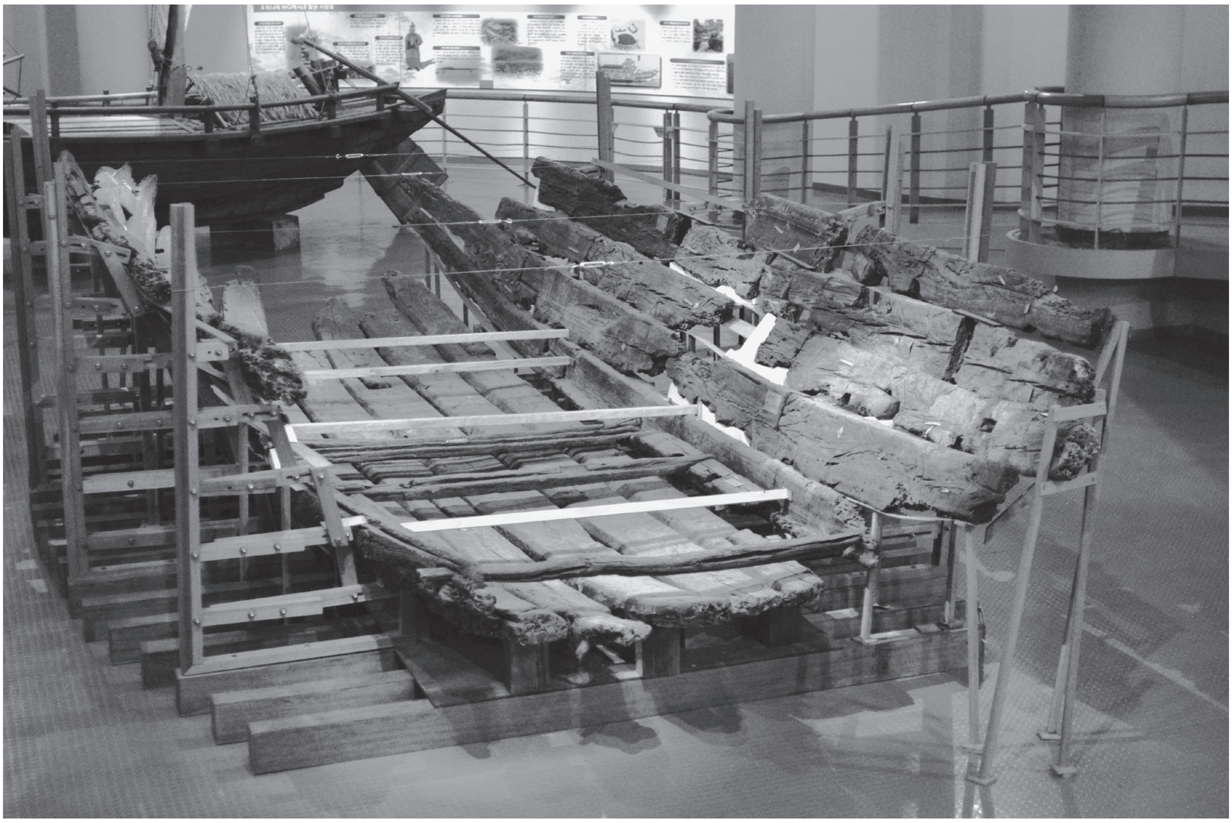
Figure 5.9 A photo of the Wando ship on display. (Photo taken by Randall Sasaki)

were discovered. Mast slots are located on the center bottom plank. Several wooden fragments of internal structures were found but the purposes are unknown. The survived hull section measures approximately 6.5 m in length and the bottom of the hull is 1.65 m in width. The Korean researchers estimate the hull to be 9 m in length and 3.5 m in breath while the depth of the ship as about 2.5 m (Figure 5.9).

The bottom section of the hull consists of five strakes, with each strake shaped close to square in cross-section. The positions of the scarfs are made symmetrical. The central strake consists of three planks, joined by square tongue and groove joints; the total length is 6.30 m (with the plank at the middle having a length of 3.93 m). The width is 0.35 m and the thickness is about 0.20 m; the strake becomes slightly narrower and flatter at both ends, where the hull has a gentle curve upwards, but the hull is damaged and lost. The central plank also hosts two rectangular mast slots near midship. The strakes next to the central bottom strake consist of two planks each joined with a step joint. The step joints are located towards the bow, between the midship and the square tongue and groove joint of the central plank, making the forward planks much shorter (forward planks are less than 2 m in length and the aft plank 3.5 m or longer). The step joint extends no longer than 0.5 m. The widths of the planks are 0.32 m and 0.2 m thick with slight variations. The two outer-most strakes consist of three planks joined by step joints. These step joints are located along the same line of the tongue and groove joints of the central plank. Thus the middle plank is nearly 4 m in length. The width of the strakes is 0.33 m and slightly tapers at both ends, giving the appearance of a curve towards the center of the boat. Planks are about 0.2 m in thickness. The rabbet for laying the L-shape chine-strake is made at the edge of the strake with a depth of 30 mm and a width of 60 mm. Some locations show the mortises used to fasten the L-shaped strake. All five strakes are joined by *jangsaks* piercing through the planks. An average dimension of a *jangsak* is 80 x 50 mm, laid flat. Additional wedges are inserted into mortises after *jangsaks* are fitted securely to fasten the planks in place. It appears the central three strakes might have served as a unit and the outer-most strakes were added later. A total of six *jangsaks* connect all three bottom strakes together. These *jangsaks* are not pegged and are set at the interval of 0.1–0.11 m apart from each other, avoiding the square tongue and groove joints and the mast slot; however one *jangsak* is pierced through the middle of the step joints of the two outer strakes. The outer-most strakes are joined to this central structure with *jangsaks*, but the mortises are chiseled only into the middle of the planks and do not reach the central strake. These *jangsaks* are pegged and placed in

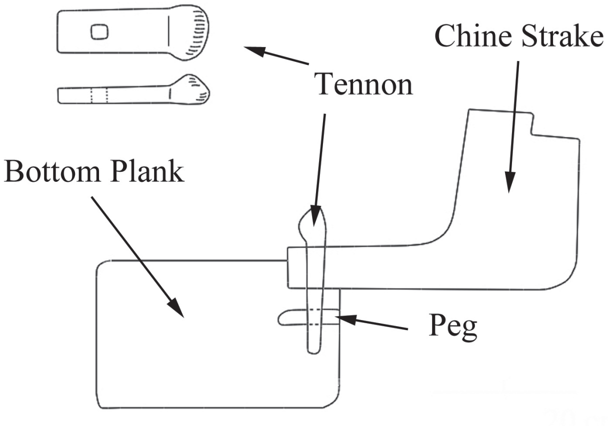

Figure 5.10 A drawing showing a joining configuration of bottom plank and the L-shaped chine strake. (Drawn by Randall Sasaki)

between the *jangsaks* of the central structure. It must be noted that *jangsaks* are placed in positions to go through all step joints.

The Wando ship uses L-shaped chine strakes for the transition between the bottom strakes and side strakes. The L-shaped chine strake consists of two planks joined by an overlapping step joint. This scarf is located parallel to a position slightly forward of the aft tongue and groove joint of the central bottom strake. Looking at cross-section at midship, the plank is 0.38 m wide and approximately 0.28 m high. The shape of the plank is archived by carving out the L-shape from a log and is not uniform. The strakes become narrower at both ends and curves upward and inward. The flat part of the "L" is about 0.2 m, and rises about 0.2 m, making the bottom section thin. The upper section of the outer edge has a rabbet where upper strake is joined. The bottom plank and the chine Strake are joined using *pisaks* placed at the flat section of the "L", making the upper third of the *pisaks* exposed inside the hull. The upper end of the *pisaks* are left unfinished, giving the appearance of a bulge that is left outside which locks the *pisaks* in place along with the square 20 x 20 mm peg, inserted at the bottom end and from the side of the bottom plank. The *pisaks* are about 180 mm in length and 60 x 20 mm in dimension. The *pisaks* are inserted approximately 0.90–1.1 m apart from each other (Figure 5.10).

Four starboard strakes and five portside strakes survived. Most of the planks are uniform in shape and size, approximately 0.3–0.34 m in width and 0.1–0.12 m in thickness. Some strakes, especially the lowest strakes, appear to become narrower towards the ends. Unfortunately, it is not possible to know if the Wando ship used a drop strake or stealer to adjust to the narrowing at prow, or how the bow and stern transoms were made. Although some parts of the strakes are damaged, it appears that all strakes consist of three planks with step joints, which the upper lips always project aft. The locations of the step joints are offset of each other in what appears to be an alternative pattern. The rabbet is cut along the outer upper edge of the plank to join another strake above. The rabbets are about 30–50 mm in width and 30 mm in depth. To secure the planks above and below, the Wando ship employs *pisaks*. The size of the *pisaks* varies according to the width of a plank, maximum of 450 mm in length, 80 mm in width, and 30 mm in thickness. As with the Sibidongpado ship, mortises are made completely through the width of the upper planks and stop at the middle of the lower planks where pegs are placed. No peg is inserted on an upper plank; however, small wedges are inserted to secure the movement of *pisaks*. The location of these *pisaks* appear to be random; however, a close examination reveals a certain pattern. The *pisaks* are placed forward and aft of the aforementioned set joints, as close as 0.2 m or about 0.5 m from the joint. Another *pisak* is inserted through each joint itself but not going through the plank above or below and is not pegged. These three *pisaks* fasten the scarf tightly together. Additional *pisaks* may be placed 0.6–0.8 m apart.

Several beams were utilized on the Wando Ship, but the details are not fully reported. The beams have a natural appearance around the center while both edges are shaped rectangular and are also made narrower to fit the square openings made into the planks. Several wooden pieces of what appears to be an internal structure of unknown function were also found. The mast slots are made on the central bottom plank as seen in all other excavated Korean vessels. The two rectangular holes are 50 mm wide, 160 mm long, and 50 mm deep. No feature or additional element was found around the slots. The wood species analysis revealed some hull components were made from species only grown in the southern half of Korea and all of the wood was available in Korea. This indicates that the Wando ship was made in southern Korea. Bottom planks are made of coniferous tree (*Torreya nucifera*) native to Japan and Cheju Island and the remaining bottom planks along with some hull planks are made of pine tree (*Pinus densiflora*). Some planks, beams, and pegs are of oak (*Quercus spp*). It is interesting to note that while *pisaks* are made of softwood (*Pinus densiflora*), *jangsaks* are made of hardwood (*Quercus acutissima*).

The Daebudo Ship[6]

The Daebudo ship was discovered in 2003 in a tidal flat near Ansan city of Gyeonggi-do. The excavation was conducted in 2006. Only a few porcelain shards and a small section of a hull, three bottom strakes and a garboard, were found. Based on the construction style and artifacts, the Daebudo ship is dated to the 12th century or possibly the early 13th century. The vessel originally had five bottom strakes and it appears that the L-shaped chine strake was not used. The transverse strength of the hull is achieved by the beams, as can be deduced from the mortise left on the garboard. The bottom planks are joined by *jangsaks* and the garboard to bottom planks by *pisaks*. The Daebudo ship is another example of the continuation of the traditional Korean vessels, and can be placed in between the Wando ship and the Dalido ship. The surviving hull section measures 6.62 m in length and 1.4 m in width. The estimate size of the hull has not been reported, as the hull components discovered were limited.

The central bottom strake and two strakes that are attached to one side, believed to be a starboard side, are all that is left of the Daebudo ship. The central bottom strake is badly damaged and only one plank survived. The plank curves upwards gently at both ends and becomes slightly narrower and thinner towards the end. The total length is 4.89 m, 0.41 m in width, and 0.25 m in thickness. Both the bottom and inner (top) surfaces are made flat; the planks are well made compared to the Sibidongpado ship. The first starboard side bottom strake consists of two planks joined with butt scarf. No additional joinery is made to secure this joint. The aft section is 1.43 m long, has a maximum width of 0.325 m, and a thickness of 0.27 m. The plank appears to be only slightly narrower at the end. The bottom surface is left rounded but the inner surface is made flat. The forward section is 4.4 m in length, 0.38 m in width, and 0.265 m in thickness. The cross section is a well fashioned rectangular shape compared the end piece just described above. The second strake, which is the outer-most bottom strake, also consists of two planks. These two planks are attached by a step joint. The outer edge has a rabbet cut with a width of 70–80 mm and a depth of 45 mm. The aft section is 2.46 m in length, 0.29 m in width, and 0.25 m in thickness. The cross-section is more rounded than square, but the inner surface is made flat. The longer front section is 4.54 m in length, 0.32 m in width, and 0.28 m in thickness. The cross-section also appears rounded compared to the shape of the first bottom strake. In general, all planks show changing cross-section shapes. The *jangsaks* are used for connecting the planks. The mortises are made through the width of the central plank and the first strake. The unpegged *jangsaks* of 120–130 mm in width and 60–70 mm in thickness are placed just forward and aft of the joint and additional *jangsaks* set approximately 1.10–1.50 m apart when there is no joint. It is assumed that three strakes, the surviving central strake and one next strake as well as one lost strake, consisted of the base. These three strakes are connected using *jangsaks* with no pegs as seen in the Sibidongpado and Wando ships. The outer-most bottom strake is connected using pegged *jangsaks*. The central bottom plank has mast slots, which measure 250 mm in length, 70 mm in width and depth.

The first side hull strake is badly damaged, but it appears that this is not an L-shaped chine strake found on earlier vessels. The total surviving length is 5.70 m, the width is approximately 0.33 m and the thickness is 0.15–0.22 m. The *pisaks* are used for connecting the bottom strake to the first strake, and are placed about 0.8 m apart. One important note to make regarding the Daebudo ship is that the pegs are placed from the side surface of the bottom planks, which is the same method employed on the Wando ship. Mortise for the beams are about 100 mm x 40 mm. All bottom and side planks are made of pine wood while *jangsaks* and *pisaks* are made of oak (*Quercus*).

The Taean Ship[7]

The recently discovered and excavated Taean Ship is one of the most unique traditional Korean vessels found. More than 20,000 celadon wares dated to the 12th century have been found, along with many shipboard items and wooden tags used for cargo registry. The Taean ship was discovered in Taean-gun, Chungcheongnam-do; excavation and research projects were directed by the National Research Institute of Maritime Cultural Heritage. The rough sea of Taean is one of the major waterways to reach the capital of the Goryeo Dynasty, Gaegyoeng. The 12th century is considered to be the height of maritime activity in Asia, when many foreign traders and government officials visited Korea. It should also be noted that the types of celadon discovered were the kinds deeply appreciated by the Song Dynasty envoy in 1124. Despite the fact that only four strakes were found, these discovered planks exhibit characteristics not known to other traditional Korean vessels. In addition, part of a windlass, possible anchor stones, and cables were found. A total of six planks were found, measuring 8.21 m in length and 1.5 m in width. The strakes have a gentle curve at both ends following the line of the hull. The size of the hull is uncertain, but it is estimated to be one of the largest Korean traditional vessels.

The best way to illustrate the hull remains of the Taean ship is to describe characteristics of each strake beginning from the bottom, perhaps the garboard strake, and then observing the different joining methods employed between the strakes. The possible garboard strake consists of two planks joined by a step joint with a peg-less *pisak* going through the width. One end is broken and the other end has remains of a step joint where another plank had been added. The surviving planks are 4.555 m and 2.715 m in length. The cross section is thick and the exterior surface is made with a gentle roundness while the interior surface is made flat. The maximum width is 0.435 m and the minimum 0.35 m; the thickness ranges from 0.12–0.16 m. The strake appears to become narrower and thinner towards one end. In addition, the cross-section of the thinner and narrower edge appears to be fashioned straight for both the exterior and interior. In other words, the cross section changes from rectangular at the extremities to having a more rounded exterior surface near the midship. The second strake consists of one long plank of 8.21 m in length, 0.52 m in width, and 0.07 m in thickness. One edge is broken but the opposite edge shows the step joint configuration. The third strake also consists of one long plank, 8.17 m in length, 0.32–0.36 m in width, and 0.07 m in thickness. As with the second strake, one side is broken and the opposite end shows the step joint. Both strakes have a well-made straight rectangular shape at cross-section with no rounded surface. *Pisaks* are placed at the step joints, which do not go through the entire width of the plank. Two planks survived from the fourth strake, which is connected with a step joint. One end is broken and another end has a step joint. While the thicknesses of both planks are about 0.1 m, the width varies from 0.20–0.26 m. The planks are 4.28 m and 3.19 m in length. The cross-section shape of the strake is not a clean rectangular shape like the second and third strakes. The bottom surface is rounded and the upper surface is slanted down towards the outer surface. The step joint connecting the surviving planks are with *pisaks* going through the entire width and are pegged at the bottom.

Several methods of connection between the strakes can be found in the Taean ship. First, the connection between the first strake and the possible bottom plank uses traditional *pisaks* of 0.13 x 0.1 m in dimensions. The *pisaks* are placed forward and aft of the step joints, approximately 1.1–1.5 m apart from each *pisak*. This basic method is commonly found in most traditional Korean vessels. The connection between the possible garboard and the second strake uses a different method. A mortise is made near the edge of the upper plank, set diagonally to the plank at the bottom, going through the interior surface of the lower plank. Smaller 40 x 20 mm *pisaks* are placed and the pegs (20 x 10 mm) are placed from the upper-edge of the bottom plank to secure the *pisak*. The *pisaks* are set about every 0.45 m. The rabbet is cut on the upper surface of the outer edge of the lower plank. The connection between the second and third strakes use an identical technique just mentioned; however

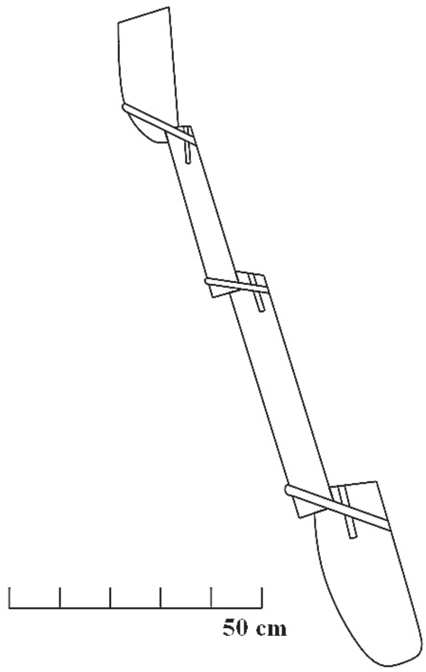

Figure 5.11 A cross-section diagram of the Taean ship's plank arrangement. (Reproduced by Randall Sasaki from Munhwajaechung Guklip Haeyang Munhwajae Yeonguso 2009)

the *pisaks* are slightly smaller. The third and fourth strakes were connected much the same way, using diagonally set *pisaks*. However, the rabbet is made on the inner edge of the upper strake (fourth strake), and the lower plank (third strake) has no rabbet making this third plank the only plank from a Korean vessel with no rabbet cut. The last connection, which can be found on the upper surface of the fourth strake, exhibits two joining methods. The diagonal *pisaks* are used much the same way as the connection between the third and fourth planks, but with wider interval. Another method, which is the traditional long *pisaks* placed vertically from the strake above, is also used. The intervals of the *pisaks* are set at 1.1–1.5 m. Such a complex hull construction method described here has not been seen on other excavated vessels (Figure 5.11).

The Taean ship utilizes beams for transverse strength of the hull. While no beams remain, their distribution pattern can infer from the holes that were made in the planks. The beams are placed in a row, with approximately 1.5 m intervals. Not all planks have a beam placed in a row. It appears as though beams were not placed where *pisaks* are located. The rectangular openings on the second strake are smaller, 100 x 80 mm as compared to other strakes, which have openings the size of 120–130 x 100 mm. There are two types of beams, Type A (가룡) and Type B (멍에형가룡). Type A is a typical through beam where an opening, or a mortise, is made at the center of a plank going through the thickness. Type B may be called a hooked beam where a cut is made at the upper edge of the plank and the beam is rested on top of the plank. Type A beams are found on the second and third strakes, while the hooked Type B beams are found on the first and fourth strakes.

The artifacts discovered on board the Taean ship provides new information regarding trade, and seafaring life and practice. Some planks show evidence of a charred surface on one side, which may be purposely made to prevent attack by marine organisms. A total of five timbers of what appears to be components of windlasses were found. These timbers are heavily damaged and distorted. The length of the most complete component is 0.69 m long and 0.06 m in width. The end of the shaft is made smaller to fit a mortise. Two stone anchors or anchor stocks were also discovered. A stone is roughly of rectangular shape with dimensions of 1.23 x 0.49 x 0.23 m. It weighs 115 kg. A small notch is made on a side surface where it is suggested that a rope had been lashed to hold a wooden anchor component. The second stone is made into a thin rectangular shape. It is 70.5 kg in weight, and the size is 0.9 x 0.34 x 0.14 m. The result of the species identification of the timbers conducted showed that all planks are made of pine, and *pisaks* made of either oak (*Quercus*) or a kind of Walnut tree (*Platycarya*) native to the region.

The Dalido Ship[8]

The Dalido ship, found in a tidal flat located near Mokpo-city in Jeollanam-do, was excavated in 1995 and the vessel is believed to date to the 13th or14th centuries based on the carbon 14 dating of the hull timbers. No cargo was discovered from the site, making the precise dating of the hull somewhat uncertain. The main structure of the hull consists of three bottom planks joined directly with the hull planking. The hull is kept in shape with several beams and planks joined with large mortises and tenons. The three bottom planks are nearly complete, and up to the fourth strakes were found. The aft section of the hull survived well compared to the forward section. A part of the stern transom boards was discovered while almost none of the port side planks forward of the midship survived. Several beams were also found revealing the precise pattern of the beam placement. The survived hull section measures approximately 10.5 m in length and 2.72 m in width. The Korean researchers estimate the hull to have been 12 m in length and 3.6 m in breath, while the depth of the ship to have been about 1.6 m. The Dalido ship appears to be a relatively narrow vessel with a sharp turn of the bilge.

The bottom section of the hull consists of three strakes, and the total width is slightly over 1 m. The center bottom strake consists of two planks, joined by a complex square tongue and groove joint. The upper and lower surfaces are made into a different step, creating an appearance of a step joint when viewed from the side. The upper protrusion, or a tongue of the step, is faced towards the stern. The forward plank is 3.43 m in length, 0.43 m in width, and 0.15 m in thickness. The longer plank, which has the mast slots, is 6.03 m in length, 0.4 m in width, and 0.2 m in thickness. The cross-section of the plank is rectangular. The strake rises at both ends. The strakes next to the central bottom strake consist of three planks each joined with a complex butt joint. It appears as a straight butt joint from the top surface while appearing to be a step joint when viewed from the side. Two of the bottom strakes are made in symmetry and the forward planks are approximately 2.22 m, middle planks are 5.17 m on both sides, and the aft planks are about 2.13 m. The width of each plank at the midship is 0.37 m, but it becomes narrower (0.30–0.33 m) towards the ends. Both of the strakes are 0.25 m in thickness at the midship, and they become thinner towards both ends to 0.17 m. It is important to note that the planks at the midship are made uniform and flat; only the shorter planks at both ends are made narrower, thinner, and curving upwards (approximately 15 degrees at bow and 9 degrees at stern). It must also be noted that the center bottom strake is thinner than the outer-strakes, which may seem contrary to the Western shipbuilding tradition. The rabbets to place the garboards are cut, and several mortises and pegs used to connect the garboard can be seen. All three strakes are joined by *jangsaks* pierced through the planks. A typical *jangsak* of the Dalido ship is about 120 x 40 mm, the length varies according to the width of the planks they join. A total of twelve *jangsak* mortises can be observed and these are placed slightly aft and forward of the strake joints, but are not put through the joint. At the middle of the hull, *jangsaks* are placed about 1–1.10 m apart.

The Dalido ship does not utilize the L-shaped chine strake for the transition between the bottom strakes and side strakes. The garboard strakes are the thickest of all planks, but only slightly so (0.14 m compared to 0.11 m). The width varies depending on the position within the hull; in general, strakes become narrower towards the ends. At midship, the garboard is 0.33 m, the second strake is 0.38 m, the third strake is 0.28 m, and fourth strake is 0.4 m. No plank is longer than 4 m in length, and it appears that each strake uses three planks connected with step joints seen in other excavated vessels. The locations of the step joints are offset by each other in what appears to be an alternative pattern, made nearly symmetrical on port

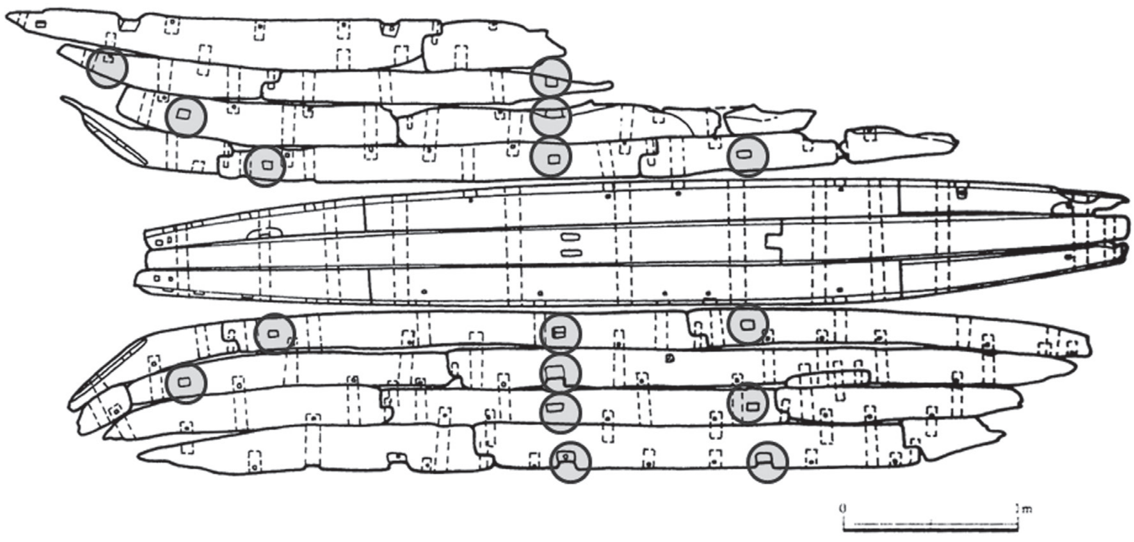

Figure 5.12 A flat view of the Dalido ship showing beam stations. (Reproduced by Randall Sasaki from Guklip Heyang Yumul Joensi Gwan 1999)

and starboard sides. Rabbets are cut at the outer edge of the upper surface to the depth of 30 mm and 30–50 mm in width. No modification is made for the lower surface of the plank, except for the garboard. The garboard strakes appear to be made slightly flat at the lower surface, giving irregular cross-section shape. The Dalido ship uses *pisaks* to secure the planks above and below, including the garboard and the bottom plank connection. For the bottom planks, the pegs are placed from the upper surface to secure the *pisaks*, fitted to the mortises made through the width of garboard strakes. This is different from the Wando or Daebudo ships where pegs were placed from the side. The sizes of the *pisaks* varied according to the size of the plank, 550-600 mm in length, with the average of 100 mm in width and 50 mm in thickness. As with the Wando ship, mortises are made completely through the thickness of an upper plank and stop at the middle of a lower plank where pegs, roughly 20 x 20 mm are placed. The *pisaks* are placed as close as 0.20 m forward and aft of the aforementioned step joints. Another *pisak* is inserted through the joint itself, but does not go through the plank above or below and is not pegged. Additional *pisaks* may be placed along the longer planks. The connecting method used between the third and fourth strakes is unique. Along with the regular *pisaks* that go through the entire length of the plank straight, another type of *pisaks* is placed from the middle of the upper plank and set diagonally. Pegs are placed from the side of the bottom plank.

Only six beams were found from the Dalido vessel, but archaeologists had the chance to study the placement pattern because of the mortises found on the planks. It is assumed that there were four rows of beams but the row closest to the bow cannot be detected. Two sets of beams are set straight in transverse direction while the set of beams closest to the stern is set at an angle parallel to the rise of the bottom plank, or the angle of the stern transom. Two basic types of beams are used on the Dalido vessels, Type A beams and Type B beams, discussed above with the Taean ship. However, the Dalido ship provides more information regarding the use of beams because some of the beams survived. Mortises of the Type A beams are 70–90 mm x 150–210 mm in dimensions, and located at the middle of planks to create through beams. The beams on these mortises naturally appear with rounded cross-sections, with edges shaped to fit the rectangular mortise made. These beams are used on the garboard and the third strakes. The Type B beams are "hooked" on the planks and the beams are made flat and rectangular in cross-section, which is about 0.14–0.17 m x 0.15–0.21 m. The notches for the Type B beam are found on the second and third strakes. A beam at the stern located on the second strake has two stanchions attached. These stanchions are fitted into the mortises cut in both the bottom planks (left and right) and the beam (Figure 5.12).

Thanks to the discovery of four degraded transom boards from the Dalido ship, the stern structure of traditional Korean vessels became clear. The width of the boards ranges from 95 to 200 mm, but all are 50 mm in thickness. Protrusions are cut out at both edges of the boards. There are also diagonal grooves or slots cut near the outer edge of the inner plank surface at the stern. The transom boards are fitted into these slots. However, these boards are only loosely fitted and there is no apparent waterproofing mechanism in place, suggesting an additional transom structure was built extending over the stern; however,

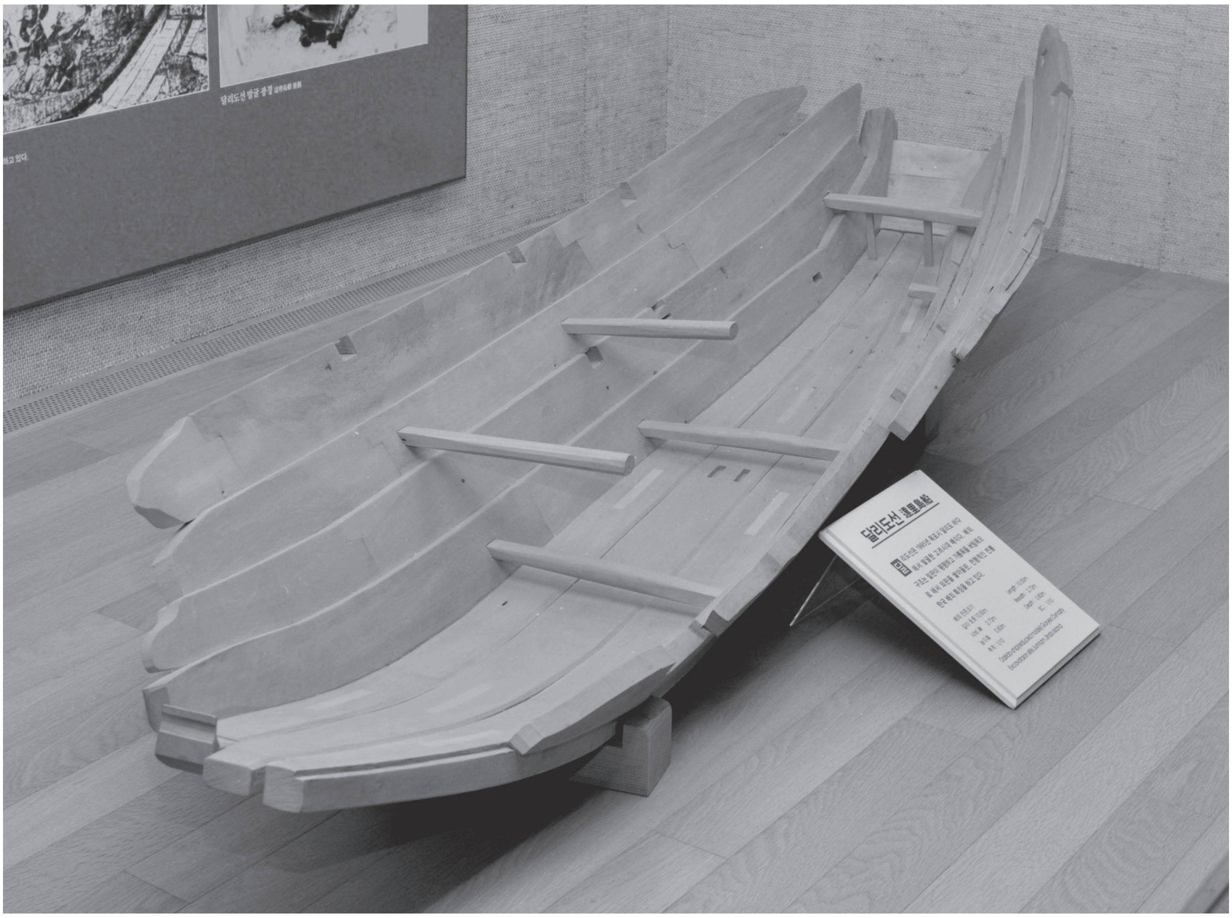

Figure 5.13 A small model of Dalido ship on display showing beams and stern board. (Photo taken by Randall Sasaki)

no remains were found. The two rectangular slots for the mast were also found on the Dalido ship. A row of beams located just aft of the mast slots most likely played an important role in supporting the mast. In fact, one of the beams had additional pieces of timber attached (Figure 5.13). Unfortunately, at this point, the exact way in which this structure functioned is not known, but it was likely a tabernacle that held the mast in place. The last feature of the Dalido ship to be mentioned is a possible repaired section of hull planking. The second plank of the starboard second strake has a small piece of timber added. Four *pisaks* are set through this small timber, and no pegs are used. The species identification of the hull revealed that side planks as well as bottom planks are made of pine (*Pinus densiflora*) while beams are made of oak (*Quercus acutissima*).

The Anjwa Ship[9]

The Anjwa ship was discovered in a mud-flat by a local resident in Shinan-gun, Jeollanam-do and excavated in 2005 by the National Maritime Museum. Based on a few cargo remains, and Carbon 14 dating of the hull itself, the Anjwa ship is dated to the late 14th century. The artifacts discovered, including a whetstone, an anchor stone, basket, and firewood, all revealed the life on-board these traditional vessels at the time. The Anjwa ship may be the latest Goryro period vessels showing a well developed tradition with various features in details. The hull consists of three bottom planks and the garboard is directly attached to the bottom planks. The cross-section of the hull shows a flat bottom with a gentle wineglass-like turn of the bilge not seen in previous Korean vessels (Figure 5.14). Beams were used to hold the hull in shape and the Anjwa ship exhibits a complex use of beams to support the hull. As with other Korean vessels, planks are joined by *jangsaks*. The entire three bottom planks, seven starboard planks, port garboard, stern transom board, and beams were found. The remains of the hull measures 14.7 m in length and 4.53 m in width. The estimated length of the ship is 17 m, width is 6.6 m, and depth is 2.3 m. Much of the hull has survived, but the short report published by the National Maritime Museum is not sufficient to fully understand this archaeological treasure. Detailed analysis and reconstruction are expected once the conservation process is complete.

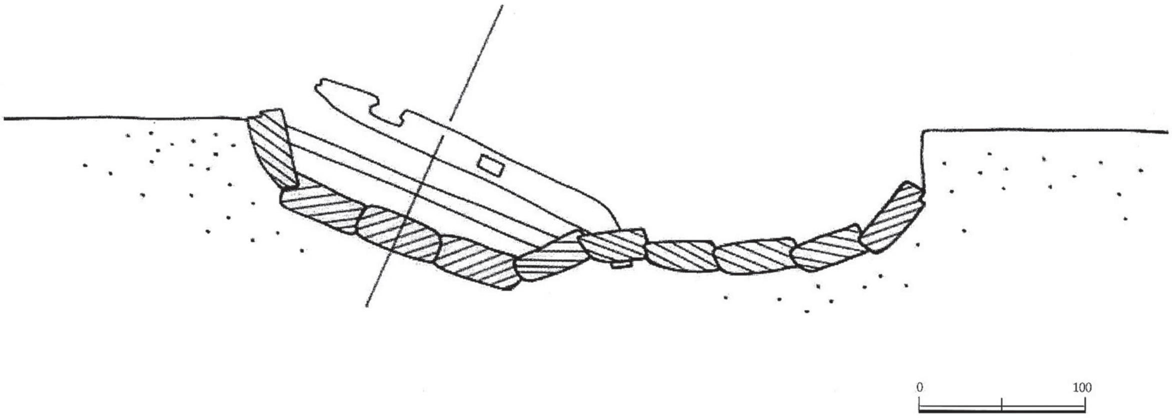

Figure 5.14 A cross-section of Anjwado ship as it lay at the site. (Courtesy of the National Research Centre of Marine Cultural Heritage)

The total length of the three bottom strakes structure is 13.33 m, and its width at the broadest point is 1.55 m. At the bow, the width becomes 0.89 m, and at stern 0.91 m. All three bottom strakes have two planks each. The forward middle plank is 3.76 m in length with changing thickness and width; the bow is made narrower and thinner. It is 0.22 m wide and 0.22 m thick at the bow, but it becomes as large as 0.54 m in width and 0.39 m in thickness. The forward section has a rounded bottom surface while the plank becomes a well shaped rectangular in cross-section towards aft. The aft middle plank is 9.88 m long, the maximum thickness is 0.24 m, and the maximum width is 0.54 m. The cross-section shape remains almost the same throughout the length of the plank, except near the stern. The width and thickness decreases, but not as dramatically as the forward middle plank. A complex tongue and groove joint, similar to the joint found on the Dalido ship, joins the two planks. Both the starboard and port bottom planks are made almost identical, so only the description of one side is provided here. The forward plank is about 4.60 m in length, 0.54 m in width, and 0.24–0.29 m in thickness. The plank becomes narrower towards the bow and the cross-section becomes more rounded. The aft plank is 9 m in length, 0.55 m wide, and 0.25 m in thickness. It becomes slightly narrower towards the stern. The forward and aft planks are joined by a complex butt joint, similar to the Dalido ship. The rabbet is cut at the outer edges, approximately 90 mm wide and 30 mm deep where the first side strake is laid. The connection between the three bottom strakes employs *jangsaks* much the same way as other excavated vessels. These *jangsaks* are placed forward and aft of the bottom plank scarfs and additional *jangsaks* placed roughly 0.9–1.1 m apart. The size of a *jangsak* is 0.13–0.20 x 0.04–0.07 m. The mortises of the central strake are made to fit the *jangsaks* almost exactly. However, the mortises of the starboard and port bottom planks are made slightly larger where additional wedges are placed to hold the *jangsaks* firmly in place. A total of fourteen *jangsaks* are used to connect the bottom planks. Both the bow and stern are raised steeply, but the curve of the stern is gentle. Grooves are cut at both ends, suggesting that stern as well as bow transom planks were inserted. A bulge is present beyond these groves, which appears to be extended out from the transoms. The bottom planks of the bow section are shaped carefully and are difficult to illustrate without more detailed information (Figure 5.15). The transom and other structures related to the hull's extremities will be discussed in detail below. The connection between the first side plank, or a garboard, and the bottom planks are achieved by using several *pisaks* placed through the garboard and into the bottom plank and pegged placed from the top surface of the bottom planks. The intervals of the mortises are 0.3–1 m, depending on the location of the plank scarfs.

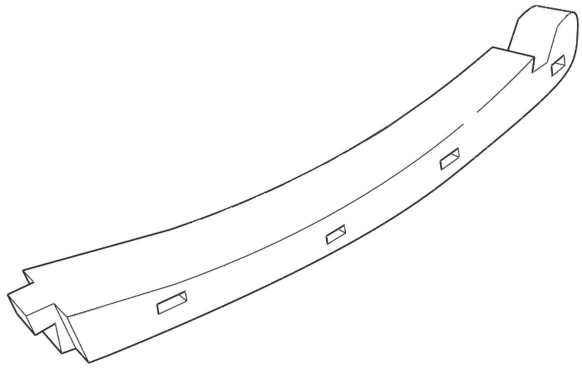

Figure 5.15 A 3D model of the Anjwa ship's central bottom plank near the bow. (Drawn by Randall Sasaki)

The Anjwa ship was listed to the starboard side when it was discovered, and thus only the garboard and small section of the second strakes of the port side survived, while much of the starboard strakes, up to the seventh strakes, survived. Each strake usually has three or four planks connected with a step joint. These scarfs are spaced across the hull so that no joints are overlapping in close proximity to avoid making a weak point; all scarfs are aligned with the upper projection towards the bow. Usually, a *pisak* is placed through these scarfs. The garboard of the Anjwa ship is unique among the Korean vessels. The plank closest to the bow is 3.22 m in length and has a width of 0.39 m. The cross-section of the plank becomes an upside down triangle, creating a broad platform facing upward. This structure is most likely made to hold the windlass that operated anchors and perhaps to support the bow as well. A mortise was cut into this surface in the dimension of 230 x 70 mm. The thickness of the plank ranges between 0.19–0.3 m, and the planks become narrower but thicker towards the bow. The rabbet is cut on the upper edge of the outer surface, 90 mm wide and 40 mm deep. *Pisaks* are used to connect the planks. The next two planks are over 4 m in length, 0.45–0.46 m wide, and 0.19 m in thickness. These two planks display standard plank features, including rabbets as well as *pisaks* placed 0.6–1.6 m apart and extra *pisaks* placed close to the scarfs. The sizes of the *pisaks* average 110 mm in width and 40 mm in thickness; however, it exhibits a variety of shapes depending on the angles of the joining plank. The plank at the stern must be described in detail. It is 2.32 m in length and 0.16 m in thickness. The plank appears "bulky" and becomes wider (0.45–0.57 m) and projects upward towards the stern. No rabbet is cut into the last quarter of the length. A diagonal groove is cut into the side of the inner hull surface where the stern transom board is fitted in. A *pisak* is placed through this groove to fix the transom board. The second strakes and above show little deviation from the standard plank joining methodology found on other excavated vessels. All planks are over 2 m to sometimes over 5 m in length. The planks at the stern are usually the shortest, often 2 m or less, except for the second strake, which is over 3 m in length. The thickness varies from strake to strake and plank to plank, but usually within 0.15–0.2 m. It appears that the planks are thickest at the bow and become thin towards the stern, while maintaining thickness along midship. The width also decreases towards the stern. For instance, the second strake is 0.5 m wide at the bow, about 0.4 m across the middle of the hull, and becomes 0.38 m at the stern. The planks at the bow appear "twisted" to accommodate the change in direction of the strake to fit the blunt but wider hull shape at the bow. On the other hand, the planks at the stern show a gentle curve inwards. The stern is narrower and has a gentle curve upward as well. The planks near the bow appear to have been burnt, and it is suggested that the planks were burnt to twist and fit the curve of the hull.

The transverse strength of the Anjwa ship, as seen in all Korean traditional vessels, derives from the beams. It appears that five rows of beams are placed in the hull. There are three mortises on the garboard, two on the second strake, three on the third strake, only one on the fourth strake, two on the fifth strake, three on the sixth strake, and one (or perhaps more) on the seventh strake. The beams were divided into two types, Type A and Type B as seen in the Dalido Ship. The smaller Type A beams (approximately 100–120 mm x 40–70 mm) are put through the planks, while the larger Type B beams (300 x 300 mm or larger) are "hooked" on the notch cut at the upper edge of the planks. Type B beams were only found on the second, sixth, and seventh strakes. The largest beam of the hull is placed just aft of the mast slots. This beam is 2.6 m in transverse length, about 300 mm in width, and has the maximum thickness of 340 mm. The bottom is made flat while the upper surface are made with a gentle bow, narrowing towards the both ends to become 300 x 300 mm square to fit the notch made at the top of the second strake. A possible mast support structure was attached to the beam, but the exact detail is not known.

The Anjwa ship provides an excellent opportunity for archaeologists to examine the bow and stern of the ship. One stern board was found attached to the stern. This board has a trapezoidal shape with the wider side at the top, and is 0.75 m across, 0.39 m in width, and 0.07 m in thickness. The transverse edges are made thin to fit the groove cut into the garboard. An additional two *pisaks* are placed from the garboard; the *pisaks* go through the garboard to the external surface where two pegs are place to lock the *pisaks* and the garboard in place. The transom is tilted 120 degrees. The V-shape groove is cut at the bottom planks that do not seem to have a strong connection. No bow transom board was found attached to the hull; however, possible bow transom boards were discovered 30 m away from the main wreck site. Three planks were found connected during the initial survey, but only two planks were found during the main excavation. The maximum length is 1.3 m, width 0.35 m, and the thickness 0.185 m. The planks are joined using *pisaks*. The boards are thick and appear strongly built compared to the stern transom. At the bow, the bottom planks have a groove of 0.1 m in depth and 0.15 m in width where the bow and transom board are fitted. The bottom strakes extend out with a bulb where additional support for the bow transom may have been constructed. The transom is tilted 110 degree, which is a steep angle compared to that of the stern transom.

The possible stem of the rudder was discovered from the shipwreck site. It is 6.55 m, and the cross-section has a changing oval shape of roughly 0.2 x 0.32 m. Two openings are present where the tiller was inserted. In addition, four mortises were found where blades were attached. A paddle blade or a possible yuloh blade was also excavated. It is 0.67 m long and 0.13 m wide. The blade is thickest at the center (40 mm) and becomes thinner (10 mm) on both sides. Several stone blocks, or possibly tiles or bricks, of various sizes and shapes were collected. These bricks were used as a cooking stove in the ship's galley. These are important artifacts for studying life on board the ship at the time. The mast slots, the standard feature of traditional vessels, can be found on the Anjwa ship as well. The slots are made on the raised surface, which is a new feature that has not been found on other excavated ships from the period. One important technological development seen on the Anjwa ship is the use of a caulking compound, a form of lime paste used between the planks as adhesive as well as for waterproofing the hull. Another significant discovery of the Anjwa ship is that markings with ink are used for building the Anjwa ship. The location of *jangsaks* is marked by ink, indicating that a preconceived plan of the vessel existed, which may have delineated the construction pattern and placement of the hull elements.

Discussion/Comparison

The Goryeo Dynasty vessels represented in this article share similar characteristics and exhibit continuity in tradition. Although some changes can be seen, the Sibidongpado boat already shows developed features as a Korean traditional vessel, which continues to the Anjwa ship and later traditional ships. There are "things that did not change" in Korean ships, which may be called a core structural concept of Korean traditional vessels. Changes, however, occurred and were prominent the disappearance of the L-shaped Chine strakes. Corresponding to this change, the cross-section of a hull began to change from the box-like hull to a vessel with a grace curvature. Strategic use of the beams and stronger hull components can also be seen. One important vessel that must be noted is the Taean ship. This ship appears to be made of a slightly modified traditional form than the rest of the vessel. In this conclusion, some characteristics shared by all vessels are discussed, as are some general developmental trends over-time, and the importance of the Taean ship.

All traditional Korean ships, perhaps except for the Taean Ship, relied on heavy plank structures for primary hull strength. These almost rectangular bottom and side planks connected using only wooden joineries created a strong hull, albeit heavy and clumsy appearance. This hull did not require much internal structures for strength because the hull itself provided rigidity. The joinery method of these ships did not change over time. The three bottom strakes consisted the base of the vessel. Even with vessels having five bottom planks, such as the Wando and Daebudo ships, the central three bottom planks acted as the foundation on which other planks were added. All traditional Korean vessels discovered so far have three bottom planks joined using "un-pegged" *jangsaks* that went through all three planks. The bottom planks that were added to the central three planks used "pegged" *jangsaks*, which may be considered almost as *pisaks*.

In a sense, the outer most bottom planks were a part of the L-shaped chine that became flat to increase the cargo capacity at the bottom. The *jangsaks* are almost always placed 0.9–1.1 m apart except when joineries were found on the adjoining central three planks, and joinery (or scarf) bolstered by placing *jangsaks* forward and aft. This bottom structure acted as the fundamental concept in the traditional Korean ships. Another unchanged feature is the side plank building method. *Pisaks* were the main technology used for joining strakes. *Pisaks* acted as an internal framing in some cases, and were made of hardwood, which expanded when wet and secured the joinery. The diagonally placed *pisaks* may be considered a slight variation in applying this method. The spacing appears to be random, but *pisaks* are placed around the scarfs. Often an un-pegged short *pisak* was placed inside the scarf, and served as reinforcement for the joinery. The use of beams is another unchanging characteristic of the traditional Korean ships. However, what may have been a simple bolstering timber quickly developed into an elaborate system of making the hull strong. Perhaps, we can also add the presence of mast slots as an omnipresent characteristic of the traditional Korean ships.

Despite the fundamental concepts of shipbuilding technology remaining unchanged, there were many changes that took place as well. Scholars have attributed the use of L-shaped chine strakes seen in Japanese and Korean vessels as the vestigial structure that developed from a log-boat tradition. It is usually assumed that the vessel developed from a dugout boat, either by adding extra strakes to increase freeboard or adding extra bottom strakes to increase the cargo capacity. The Sibidongpado ship seems to occupy a unique place in the development of ships for it may be the only example of a hull using two, or doubled, L-shaped chine strakes. With such a small section of the hull surviving, it is difficult to make a conjecture as to why two L-shaped chine strakes had to be used. The unfashionable and somewhat crudely made bottom strakes may suggest a recent development from the log-boat tradition, or perhaps it developed from a raft. The question, however, cannot be answered using currently available evidence.

The Wando ship had five bottom strakes and the two of the outer bottom strakes were attached to the central three bottom strakes using *jangsaks* with pegs. The Daebudo ship also exhibits characteristics of a possible box-like shaped vessel, but without the use of the L-shaped chine strake. It is reasonable to assume that the later vessels did not employ the L-shaped chine, but further discoveries may invalidate this statement. The loss of hard chine may have allowed the Korean shipwright to create a shape of the hull more freely. The box-like hull is indeed efficient for carrying cargo, but with the sacrifice of efficient hydrodynamic qualities. The Dalido and Anjwa ships show an almost wineglass shaped turn of the bilge; such a shape usually represents a compromise between the cargo space and the hydrodynamic properties. Combined with the rudder that can be lowered or raised, the sailing quality of such vessels in various sea conditions may have been superb compared to other vessels of the world with similar hull shape at the time.

The graceful curvature of the hull gave rise to a need to make the ship stronger by adding beams. Perhaps, it may have been the other way around; the discovery of efficient or strategic use of the beams may have opened the way for the Korean shipwright to create vessels with graceful lines. The first example of the strategic use of beams — the use of different types of beams as well as the pattern — can be first seen on the Dalido ship. The Wando ship does not seem to have had such a pattern. However, because of the lack of substantial hull remains from the earlier period, it is problematic to propose the exact pattern of evolution with confidence. The general trends toward the increase reliance on internal structure in bolstering the hull can be seen when comparing the Wando ship and the Anjwa ship. The earlier box-like vessels probably did not require much internal structure considering that the bulk of the hull itself provided the hull strength. The shapes of the planks were also adjusted as seen in the garboard of the Anjwa ship, which exhibited various cross-section shapes. The size and shapes of the *pisaks* also appear to vary on later vessels. The earlier, perhaps a simple, brick-like vessel did not require much variation in the shape of the planks and *pisaks*. With the specific shape of the plank and *pisaks*, the shipwrights who built these vessels had to determine which part fitted where and the sizes of mortises. Thus, with the Anjwa ship, we see evidence of marking using ink. The graceful curvature of the hull, however, did not only require internal bracing by beams, but also improvements in holding the seams together. The Anjwa ship is the first example of having caulking material. The changing hull design led to the decrease in holding strength of the seams, and *pisaks* were not enough to hold the seams tight.

The discovery of the Taean ship came as a surprise. This vessel may be the largest vessel discovered, but has possibly the thinnest planks among the traditional Korean vessels. The use of *pisaks* is different than other ships as well. The cargo appears to be of high quality and it may have been a royal carrier or belonged to a noticeably wealthy merchant, set apart from a local cargo carrier such as the merchants who were on board the Wando ship. The difference in hull structure suggests that there might have been different types of vessels built for different purposes. It can also be inferred that there were different shipbuilding traditions. If this was the case, however, it is difficult to explain why archaeologists were unable to find a vessel similar to the Taean ship until now. In addition, the nature of the cargo, which we have not discussed in detail in this paper, was different than other excavated vessels. If we assume that the Taean ship was specifically made for carrying highly valuable cargo, perhaps for overseas transportation, it explains well why no similar vessel was found before. Perhaps, such a vessel needed speed and manoeuvrability more than the cargo space. There are many arguments and counter arguments to be made, but not enough hull remains were found to support or disprove any of the theories that might be proposed. Further surveys may prove the existence of many types of vessels that the Koreans once had. Nonetheless, the Taean ship proved a colourful variety in the traditional Korean ships.

Conclusion

The purpose of this paper is to illustrate the characteristics of the traditional Korean ocean-going vessels based on archaeological evidence. The Goryeo Dynasty was the golden age in Korean maritime history and was an important period in development of Korean vessels. The vessels archaeologists have discovered so far date from the 11th to 14th centuries. Beginning with the Sibidongpado ship, the Wando ship, the Daebudo ship, the Dalido ship, the Taean ship, and the Anjwa ship have all been excavated and reported. This report provides detailed illustrations of hull structures of these local vessels discovered within Korea. Thus readers who wish to study Korean vessels excavated elsewhere should refer to other sources. It is unfortunate that these vessels are not well known outside Korea. It is my hope to engage scholars in the study of East Asian vessels. The detailed descriptions provided in this report may not be relevant to scholars at this point, but it may be used as a "starting point" in learning about these Asian watercrafts. Those who are interested in Korean vessels should refer to the original publications for further studies.[10] We have only illustrated the hull details and structures, and kept the description of other artifacts, such as cargo and personal items, minimal. As this is a preliminary report of the excavated vessels, interpretation of evidence is kept at minimum. Nonetheless, these vessels provide insights into rich and well-developed shipbuilding tradition of Korea. The bottom three planks acted as the fundamental basis for each vessel, and all planks were joined using wooden joineries. The box-like ship with chine strakes gradually changed to a graceful vessel with hydro-dynamic form. The changes led to the development of well-planned beam supporting hull with purposefully made planks. The Taean ship is a unique discovery, which sheds a new light onto possibly more diverse Korean shipbuilding tradition. The research on this subject is only emerging and further discovery will provide a chance for further analyses and new interpretations of the finds described herein.

Notes

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