Introducción a la Arquitectura Naval II

ABBAN

in the second

19000

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Part

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Floaters don't really need a shape





Boats do.







































This fundamental distinction (Fig. 2.1) has long been recognised for plank boats (Hasslöf, 1963; 1972: 27-72; Greenhill, 1976: 60-88), but it may also be recognised in boats built mainly of hide and of bark (McGrail, 1985). Most known examples of hide

the S. American pelota (Hornell, 1941b; 1946: 150-4) and certain N. American (Adney and Chapelle, 1964: 219-20) and Mongol (Sinor, 1961: 158) boats were built as a watertight shell of hide ('a leather bag') which was sometimes, but not always, reinforced by inserted framework. Bark boats conversely, have generally been built in the shell sequence (Hornell, 1946: 182-6; Greenhill, 1976: 124-8; Birdsell, 1977). but there is some evidence from Sweden, Siberia and British Columbia that boats were built there by sewing or lashing bark to a pre-erected frame (Brindley, 1919; Humbla and von Post, 1937; 11; Eskeröd 1956: 71; Hansen and Madsen, 1981: 4-5; On the other hand, the existence of shell-built

bundle boats (for example, of reed) seems unlikely, as an outer waterproofing layer has to be applied to the framework of bundles to turn this form of construction into a boat - and this is the skeleton

These two groups of boats, shell-built and skeleton-built, may each be subdivided according to the techniques the builder uses when converting his material into a boat. If we disregard modern boat-building materials such as metal, GRP, cement and the inflatables, the principal materials from which boats are and have been built are logs, reeds, hide, clay, tar and bone/antler. Three main techniques may be identified, which builders have used to convert

1. Reduction (or subtractive technique). The raw material is reduced in volume as in the hollowing of a log to make a logboat or in the fashioning of a log to make a keel.











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From the second half of the 14th century ships were built in Italy based on a small number of measurements:

- 1. length of keel and spring of stem and stern posts,
- 2. maximum beam (*larghezza in bocca*),
- 3. depth of hold (*puntale*),
- 4. width of the bottom measured between the bottom stringers (larghezza in fondo),
- 5. with of the master frame measured 3 feet above the bottom (trepie), and
- 6. width of the master frame measured 6 feet above the bottom (*seipie*).

(Andersen 1925; Bellabarba 1993, 1996; Bondioli pers. comm. 2008).









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Fig. 5. This plate from Vial du Clairbois' text shows two well worked out body plans of strikingly different types of ships. While the methods of developing these sectional shapes is dependent on geometric procedures, they are also subject to predetermation of stability and by hydrostatic analysis.







Definitions:

<u>Sewn</u> – continuous thread, holes pierced as one sews (skin craft).

<u>*Laced*</u> – continuous thread, pre-drilled holes; possible tightening/untightening (wooden craft).

<u>Lashed</u> – discontinuous thread.



Lashed, sewn and laced

Ships with sewn planks have been recorded from the late second millennium BC to recent time. To lace planks together seems to have been a solution found in many different places and spread through several regions, from Northern Europe to the Mediterranean, and on African and Asian coasts, rivers and lakes.





A number of ships have been found in the Mediterranean, dating to the Archaic Period, with some common characteristics: hull planking at least partially sewn, small keels, and frames with a round section with notches opened on the base to allow the passage of longitudinal caulking rolls pressed against the seams in the interior side.



Place Jules Verne 9



In the North of Europe sewn boats were still in use in the 1950s.



16th century drawing (Russia).



Lashed and sewn boat traditions are widely spread through the planet:

- Norway, Sweden, Denmark, Finland, Estonia, and the White Sea area of the former Soviet Union (Karelia and the Kola peninsula).
- Indian Ocean
- Adriatic Sea and Po Valley
- India
- Sri Lanka
- Southern Arabian Peninsula
- Persian Gulf
- Red Sea
- East Africa



Accounts of lashed boats are abundant in historic documents and ethnological studies:

Sometime in the 9th century BC, Homer refers in the *Iliad* that after nine years of siege in Troy the Greek fleet was in a very poor condition: the ship's strakes were rotten, and their lashes distended.

Both Varro (1st century BC) and Pliny the Elder (1st century AD) seem to have understood what Homer meant.

There is archaeological evidence suggesting that Greek ship's strakes were laced (Pabuç Burnu).

For historic references see Pomey...



Boats being sewn in the inner Finnish area, from a woodcut in Olaus Magnus (1539, 1555).





Basic principles:

- 1. Hull planks laced;
- 2. Shear stresses absorbed by dowels;
- 3. Caulking secured by lacing over the seems;
- 4. Frames lashed.



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<u>Basic principles</u>:1. Triangular holes;2. Caulking holes with conic pegs.



Saami tradition (lashed).



<u>Basic Stresses</u>: General: Torque; Sagging; Hogging.

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Local: Tensile stress; Compressive stress; Shear stress.





Tensile stress





Compressive stress





Shear stress:

Longitudinal; Transversal.









Fig. 7 Reconstruction of boat 1, North Ferriby.







Reconstruction of boat 1, North Ferriby.





Reconstruction of boat 1, North Ferriby.



Basil Greenhill's three examples:

- Laced plank boats from the Bronze Age (Ferriby);
- Laced logboats (Bay of Bengal);
- Laced plank boats of the Saamish (Lapland).



1. Laced plank boats from the Bronze Age (Ferriby);

Remains of three boats;

Dating to about 1300 BC;

Flat bottomed (3 strakes) w/ 2 side strakes;

Ends closed with transoms

The most complete thought to have been 15.35 m long;



Reconstruction of boat 1, North Ferriby.



2. Laced logboats (Bay of Bengal);

Still in use in the 1950s; Round bottomed (logboat base) w/ 1 or 2 side strakes; Ends closed with transoms or stem and sternposts; The largest around 11 m long w/ 2 m beam.





2. Laced logboats (Bay of Bengal);











3. Laced plank boats of the Saamish (Lapland).

Earliest is Hjörtspring (4th c. BC); Still in use in the 1950s; Keel and posts; light ribs; V-bottomed with Hard chine; The largest around 8 m long. sewing material roots of some trees, like spruce or pine




3. Laced plank boats of the Saamish (Lapland). Spr

Spruce roots.





3. Laced plank boats of the Saamish (Lapland).





3. Laced plank boats of the Saamish (Lapland).





Mortise and tenon construction

Laced ships are mentioned and have been found around the Mediterranean in the archaic period: Egyptians, Etruscans and Greeks laced the planks of their vessels together.





Romans, however, used a different technique to join the planks of their ships.





They called it "Phoenician joints".





This type of joinery has been found in the Middle East, on a table dating to around 1700 BC.



Figure 10.28. Wood table constructed with pegged mortise-and-tenon joinery found in Tomb H at Jericho (Middle Bronze IIB): (A) top; (B) underside; (C) elevation of end; (D) section; (E) reconstruction of underside (from Kenyon 1960: 462 fig. 198; courtesy British School of Archaeology, Jerusalem)





Figure 10.29. Detail of pegged mortise-and-tenon joints connecting frame to table (from Ricketts 1960: 530 fig. 229: 1; courtesy British School of Archaeology, Jerusalem)



And has been consistently used in the Mediterranean throughout the Roman period, from the 4th century BC to the 7th century AD.



Caligula's barges.



It consists of a labor-intensive, extremely sturdy and versatile method to edge-join the ship's hull planks with pegged tenons inserted in mortises opened on plank's edges..





The earliest archaeological example dates to the 14th century BC. A small portion of the hull of a merchant ship fount at Uluburun, Turkey, showed that the garboards were connected to the keel and second strake planks with mortise and tenon joints.



Uluburun hull remains c. 1300 BC



Uluburun:

Tenons = $30 \times 6 \text{ cm}$;

Cape Gelidonya

Tenons = $24 \times 5 \text{ cm}$.







FIG. 3-29. Typical method of staggering mortise-and-tenon joints.



FIG. 3-30. (a) Attitudes of mortise-and-tenon joints in scarf seams where the left plank was installed after the right plank; (b) attitudes of joints in scarfs where both planks were preassembled before installation in the hull.

Average tenons in Roman ships: 4.3 x 0.6 x 15 cm // 12.5 cm.





FIG. 3-31. Cross section of the Kyrenia ship's hull at amidships.













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Épave de la Bourse de Marseille (c. 200 BC)



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Construction techniques

Madrague de Giens (75-60 BC)

Include Steff Stop Reconstruction Laboratory ShipLAB





The oceangoing ships of the Iberian Peninsula seem to be Mediterranean ships with North Atlantic reinforcements.









Lapstrake Construction

One of the types of boatbuilding that developed from extended dugout construction was lapstrake building.







One of the earliest examples of an assembled boat built with overlapping planks is the 4th century BCE Hjörtspring Boat, which has two lapstrake planks laced per side.



Discovered in Denmark 1921

- Deposited after 350-300 BC (an offering): war vessel?
- 13 x 2.1 m (16 w/ bow and stern projections)
- Paddled

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- 10 paddlers on each side
- Bottom plank
- Bent hazel branches for frames
- 2 strakes on each side
- Sheer strake includes the caprail
- Stanchions and crossbeams









Fig 3. In Viking and Medieval Scandinavian ships the overlapping planks are normally held together by clench-nalls with a round head outside, a round shaft and a rectangular rove on the inside of the planking. The seam is made watertight by placing "luting", a loose string of wool, in a groove before inserting the nails.



Fig 4. In Medieval West Slavic ships the overlapping planks are normally held together by "treenails", small wooden pegs with a conic head on the outside and a wedge on the inside of the planking. The seam is made watertight by placing moss or a mixture of wool and moss as luting in a groove before inserting the treenails.

Definitions

<u>Clinker-built</u>: shipbuilding method in which the strakes overlap and are fastened together with rivets or clenched nails bent over metal washers called roves (Viking ships).

<u>Lapstrake</u>: shipbuilding method in which the strakes overlap and are fastened together with clenched or double-clenched nails (Cogs).

Land: the surface of the plank overlapped by the plank above it.



Some scholars, like Basil Greenhill, suggested that the use of cleft planking – widespread in the North of Europe – made lapstrake building almost a natural solution because untrimmed cleft planks are triangular in section.







There is a consistent evolution in this shipbuilding tradition, shown in a number of shipwrecks, all rowed (there is scarce evidence for the use of sails in northern Europe before the 8th century):

Hjörtspring (4th century BC)

Bjorke boat (c. AD 100)

Nydam oak boat (c. AD 320)

Gredstedbro boat (AD 650-650)

Sutton Hoo ship (AD 600-625)

Kvalsund (c. AD 700)

Graveney boat (c. AD 900)

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The boats of Nydam, Gredstedbro, and Sutton Hoo may represent variations of the boatbuilding traditions of the peoples who invaded Britain from North Germany and Denmark from AD 400 to AD 600.





Discovered in Denmark 1863;

• Built AD 310-320;

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- Deposited after 350 AD (an offering): war vessel;
- 30 x 3 x 1.3 (deep) m;
- Not sailed: there was no mast step;
- 15 rowers on each side;
- Keel strake tapering at ends, where it meets the posts;
- 11 strakes, all 1 solid plank of oak;
- Sheer strake includes the caprail;
- Frames lashed, resting on cleats;
- Quarter rudder not fixed to the hull, small tiller stanchions and crossbeams.

Nydam Oak Boat

007 NYDAM





Sutton Hoo

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- Discovered in England 1939;
- Deposited around AD 650 (a burial);
- 27 x 4.5 x 1.5 (deep) m;
- Had a keel plank not sailed no maststep;
- 20 rowers on each side;
- Keel plank riveted to the posts;
- 9 strakes of oak;
- Frames treenailed to the planks, resting on cleats;
- Caprail independent from upper strake;
- Quarter rudder not fixed to the hull, small tiller.





Both the Kvalsund and Bårset boats have remains of lashing and lacing:

The Kvalsund boats (18 m and 9.56 m) have the frames lashed to the lower strakes' cleats (to the upper strakes with treenails and iron spikes); [c. AD 700]



The Bårset boat has the upper strake laced to the strake below. [c. AD 825]





The Kvalsund boats (18 m and 9.56 m long) have the frames lashed to the lower strakes' cleats (to the upper strakes with treenails and iron spikes):





Kvalsund II

- Discovered in Norway;
- Deposited around AD 700 (an offering);
- 18.3 x 3 m;
- Had a deep keel could have been sailed: there was no maststep;
- 10 rowers on each side;
- T-shaped keel;
- 8 strakes of oak;
- Sheer strake includes the caprail;
- Bite (cross-beams);
- Quarter rudder not fixed to the hull, small tiller.





The Bårset boat (c. AD 825) has the upper strake laced to the strake below.





The Bårset boat has the upper strake laced to the strake below.







Vikings

From the 8th to the 11th century:

<u>Norwegians</u> went West, to the West of the UK, Iceland and Labrador;

<u>Swedish</u> went East, to the Caspian Sea and the Black Sea;

<u>Danes</u> went West, to Normandy, eastern UK, and the Mediterranean Sea.



"Uh-uh-uh-uh-uh. ... Question. Can anyone here tell me what Hanson there is doing wrong with his elbows?"


Common elements in Viking ship construction:

- Clinker-built hull;
- a rugged but shallow keel;
- Side-mounted rudder at the rear;
- high stems and sterns;
- only one mast;
- rectangular sail with a crossbeam at the top;
- open boats without cabins;
- the boats could be driven by oars in addition to the sail, or by oars only;
- the hulls were slightly flexible, and sleek and fast in the water.

From: http://home.online.no/~joeolavl/viking/



Viking ships

Ole Crumlin-Pedersen introduced the concept of <u>fingerprints</u> in the study of Scandinavian (or Viking) shipbuilding, and came up with a number of traits that are common to this particular culture and lack, for instance, in the shipbuilding methods of the neighboring region of the eastern Baltic shores:

- 1. Wood from split logs worked only with axes;
- 2. Iron nails with round shafts clenched over square iron roves;

3. Caulking ("luting") with tarred wool placed in a narrow groove in the overlap area (on the outer plank), before the riveting is done.



Flexibility is the price shipwrights pay for lightness. Flexible hulls are undesirable because they:

a) Deform when beached or portaged;

b) Ware faster;

c) Caulking falls off;

d) Are fragile;

e) Are slower on the sea because they seat on the waves.



"Everyone can just put down their loot and plunder, and Sven here—yes, old Sven, who was in charge of reading the tide chart—has something to say to us all."



Scandinavian ships required special, odd-shaped timbers for the frames, and large high-quality logs that could be split for planks.





As forests became depleted due to population growth, from the early 11th century onwards, Scandinavian ships changed in the way they were conceived and built and were replaced by another type of vessel – the cog – probably developed in eastern Jutland around this time, which required a lot less high-quality timber to build.





More than 50 Viking ships have been found and studied, and this constitutes a good sample for the beginning of an in-depth study of this type of craft and its evolution, in relation with the socio-economic, demographic, and cultural aspects of the region and period in which they were built.





Öseberg Discovered in Norway 1904; Built in AD 800; Buried around AD 840 (a burial); 21.4 x 5.1 x 1.4 (deep) m; Had a keel deep and a maststep; Sits low in the water and must have been sailed only in calm waters;

15 rowers on each side;

12 strakes of oak: 9 forming the lower hull, 1 meginhufr (L-shaped), 2 upper strakes that do not touch the posts;

Oarports on the sheer strake;

No caprail;

Frames lashed to the planks, resting on cleats;

Stanchions and bite w/ knee connecting to the upper strakes.





Gokstad

Discovered in Norway 1880;

Built around 850 AD;

Buried around 905/6 AD (a burial);

23 x 5.2 x 1.85 m;

- Had a keel deep and a maststep;
- 16 rowers on each side;

16 strakes of oak: 9 forming the lower hull, 1 meginhufr

(rectangular), 6 upper strakes;

Oarports on the third strake from above;

Caprail nailed to sheer strake;

Frames lashed to the planks, resting on cleats; Stanchions and bite w/ knee connecting to the upper strakes.





Graveney

Discovered in 1970 in Kent, England.

Built in c. 895 AD.

Abandoned around 950 AD.

13.60m long, 4m wide and 1m high (6-7 tons)

Possibly had a mast step, but it's low freeboard would not allow this ship to

sail on high seas.

Flat keel

8 strakes

10 heavy frames

Replica: Ottor (half size)





Cargo ship (possibly a *knarr*); Discovered in Denmark 1962; Dating: c. 1030; Place of building: Western Norway; Sunk around 1070/90 AD (for defensive purposes); Preserved: approx. 60%; Possibly a *knorr* (sailing cargo vessel); Material: pine, oak and linden ; Flat bottom amidships; Length: 16.0 m; Breadth: 4.8 m; Draught: unladen 0.6 m, laden 1.3 m;





Displacement: max. 36 t (incl. 24 t cargo); Cargo capacity: 20-24 t; No. of oars: 2-4 (4 oar ports on each side); Crew: 6-8 men; Sail area: approx. 90 m²; Average speed: approx. 5 knots; Top speed: approx. 13 knots.





Skuldelev 2/4

Warship (possibly a *drakkar*); Discovered in Denmark 1962; Built around 1042 AD in Dublin, Ireland; Sunk around 1100/1140 AD (for defensive purposes); Preserved: approx. 25%; Material: oak; Length: approx. 30 m; Breadth: 3.8 m; Draught: 0.9 m; 36 to 38 rowers on each side (70 cm for each); Deep keel (hogging and sagging); Wide frames; Long maststep, almost a keelson; Shelf clamp linking posts, beams, knees and side frames.





Skuldelev 2/4

Displacement: approx. 25 t (fully equipped); No. of oars: 60; Crew: 70-80 men; Sail area: approx. 120 m²; Average speed: approx. 6 knots; Top speed: 15-20 knots.







Small cargo ship; Discovered in Denmark 1962; Dating: c. 1040; Place of building: Denmark; Sunk around 1070/90 AD (for defensive purposes); Preserved: approx. 75%; Was a sailed cargo vessel; Material: oak; Length: 14 m; Breadth: 3.3 m; Draught: 0.9 m; 5 oar ports at the bow and 2 at the stern; Bow and stern decked; Lightly framed.





Displacement: 9.6 t (incl. 4.6 t cargo) Cargo capacity: 4.6 t No. of oars: 5 oar ports Crew: 5-6 men Sail area: approx. 45 m² Average speed: approx. 4 knots Top speed: approx. 8.5 knots

Replica: *Roar Ege*







Warship;

Discovered in Denmark 1962; Dating: ca 1030; Place of building: Denmark; Sunk around 1070/90 AD (for defensive purposes); Preserved: approx. 50%; Material: oak, pine, ash and alder; Length: 17.3 m; Breadth: 2.5 m; Draught: 0.5 m; Very lightly built; 12 rowers on each side; Mast step over three frames; Upper strake of ash with oar ports.





Displacement: 6 t (fully equipped) No. of oars: 26 Crew: approx. 30 men Sail area: approx. 45 m² Average speed: approx. 6 knots Top speed: approx. 15 knots

Replica: *Helge Ask*





Probably a fishing vessel; Discovered in Denmark 1962; Dating: ca 1030; Place of building: Western Norway; Sunk around 1100/1140 AD (for defensive purposes); Preserved: approx. 70%; Wide beams; Material: pine, birch and oak;

Length: 11.2 m; Breadth: 2.5 m; Draught: 0.6 m.





Displacement: 4.7 t; No. of oars: 14; Crew: 12-14 men; Sail area: approx. 27 m²; Average speed: approx. 5 knots; Top speed: approx. 10 knots.







By 1400 it seems that most typologies sailing in the Baltic and North Atlantic worlds belonged to two shipbuilding families: shell-based lapstrakes (hulks?), and bottom-based cogs.





Two-masted ships are mentioned in the North of Europe for the first time in 1410 (England).

Early in the 15th century (England), first mention in England and designated karaque (an Arab word).

It seems that the larger two-masted *cocche* were called carracks in the north, after 1410.





England. Battle between carracks. Warwick Roll, c. 1485.

England. Four-masted ship, Warwick Roll, c. 1485.



All these two, three, and four-masted ships seem to have been lapstrake built .





1400s – Northern Europe

Archaeological record: the Newport Ship, 1469.







Questions?