

Roko MARKOVINA

The Building Technology by the Korčula Wooden Shipbuilding "School"

Review paper

Wooden ship (small and big size) construction can be realized by one of the following methods:

1. the touching planks method (Carvel-method)
2. the overlapping planks method (Clinker-method)
3. the diagonal planks method,
4. the unwrapping plane and "patching" method,
5. the lamina ("thin plate") building method, and
6. the combined (mixed) building method.

In this paper the classic touched panelling (Carvel) method, usually used in the Korčula wooden shipbuilding "School", is explained through ten building phases.

Keywords: Korčula, wooden boats, building, technology, methods

Korčulanska brodograđevna "škola" gradnje brodova u drvu

Pregledni rad

Drveni brodovi i brodice (barke) se grade primjenom jedne od sljedećih metoda gradnje:

1. Metoda dodirivanja platica oplata (Carvelov sustav gradnje),
2. Metoda preklapanja platica oplata (Clinkerov sustav gradnje),
3. Metoda dijagonalnog postavljanja platica oplata,
4. Metoda razmotljivih traka i umetaka („zakrpa“) vanjske oplata,
5. Metoda lamelirane gradnje i
6. Metoda kombinirane (mješovite) gradnje.

U radu je objašnjena klasična metoda dodirivanja platica oplata (Carvelov sustav gradnje) u 10 faza gradnje, najčešće korištena u korčulanskoj brodograđevnoj „školi“ gradnje brodova u drvu.

Cljučne riječi: Korčula, drvene brodice, gradnja, tehnologija, metode

Authors' Address (Adresa autora):

Faculty of Electrical Engineering,
Mechanical Engineering and Naval
Architecture - University of Split,
Croatia

E-mail: roko.markovina@fesb.hr

Received (Primljeno): 2010-01-04

Accepted (Prihvaćeno): 2010-02-25

Open for discussion (Otvoreno za raspravu): 2011-09-30

1 Introduction

It is not known when the shipbuilders of Korčula invented the original construction method named "mezzaluna – buška" (ship construction method without ship lines drawing), but a number of Korčula's shipbuilding families have distinguished themselves applying this method from the 15th century on, such as: *D'Angelis, Kapor, Bonguardo, Sessa, Depolo, Smrkinić, Dobrošić, Foretić, Vilović, Bernardi, Sambrailo, Trojanis, Geričić, Ivančević, Djurdjević, Gvozdenović, Paunović, Verzotti, Filippi, Fabris, Kondenar, Jeričević*. According to the recent archaeological data, it can be concluded that wooden shipbuilding on the Island of Korčula was born in the 8th-7th millennium B.C.

In the past twenty years that method has been used by some of the well-known Korčula's shipbuilders such as *Jakov Denoble, Todor (Danko) Tasovac, Vinko Vojvoda, Ivan Curać-Ćoro from Korčula, Marin Šale* from Žrnovska Banja and *Igor Čulić* from Lumbarda. They use this method to verify their preliminary ship design. However, there were a number of shipbuilders

who came to Korčula to learn the craft of shipbuilding and the "mezzaluna-buška" secret, and applied it in their trade upon returning home.

The basic principle in wooden shipbuilding was to ensure the strength of a ship construction while in service. For bigger wooden ships the longitudinal strength was very important, and for smaller ones the transversal strength. The wooden ships and boats were built by the transversal system of building, with frames tightly fixed on the keel, and the adequate interframe distance was:

- $l = 0.24$ m for the smaller boats ($L=5-6$ m), and
- $l = 0.34$ m for the bigger ships ($L= 17$ m).

The constructive elements that ensure the ship's longitudinal strength in the bottom part are as follows: keel, centre girder, down side-plating planks. The elements that ensure the ship's longitudinal strength on the deck side are the bulwark rail, upper side-plating plank and deck plating planks, and those ensuring the transversal strength are frames connected with deck beams and bottom floors by brackets.

2 The basic methods of wooden ship building

Wooden ships and boats can be constructed generally by using one of the following methods:

1. the touching planks method (Carvel-method)
2. the overlapping planks method (Clinker-method)
3. the diagonal planks method,
4. the unwrapping plane and "patching" method,
5. the lamina ("thin plate") building method, and
6. the combined (mixed) building method.

2.1 The touching planks method (Carvel-method)

The method is based on the solid framework built along the ship's length. The outside shell plate planks are positioned and fixed on the framework in strict succession. The outside shell planks follow strictly the ship's frame (framework) lines and lean heavily against each other, and are caulked along the connection line with oakum hammered to achieve impermeability. This method requires a lot of preciseness and skilful carpentry, and is still in use in Korčula. (Figure 1)

2.2 The overlapping planks method (Clinker-method)

The method is based on overlapping previously prepared outer shell plate planks and their fastening onto the prepared framework, which creates one solid construction (Figure 2). The frames are thinner; the planks (10-15 mm thin) in the overlapping position are inclined. Tight connection between the two planks and the framework is realized by cuprum boat nails and impermeability is assured without any caulking. The ship has a fairly large resistance during navigation and better stability (the overlapping plates act like a small bilge keel).

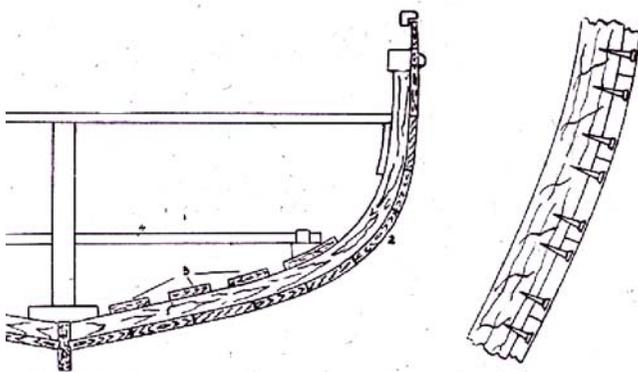


Figure 1 **The touching planks method (Carvel-method)**
Slika 1 **Metoda gradnje dodirivanjem platica oplate (Carvelov sustav gradnje)**

2.3 The diagonal planks method (diagonal building)

This method is based on positioning the multilevel outer shell plate planks, the cotton oiled-cloth being placed between them. The shell plate can be posed in:

- *two planks layer* ("double diagonal system") - outer planks are positioned at 45° angle to the aft perpendicular and inner planks are positioned horizontally (Figure 3 a) or at 45° angle to the perpendicular opposite to the outside planks (Figure 3 b), or

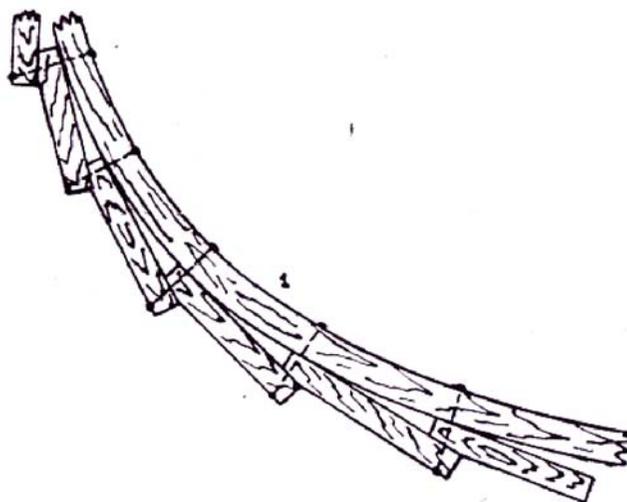


Figure 2 **The overlapping planks method (Clinker-method)**
Slika 2 **Metoda gradnje preklapanjem platica oplate (Clinkerov sustav gradnje)**

- *three planks layer* ("triple diagonal system") - outer planks are positioned horizontally, inner planks vertically and in the middle at 45° angle to the aft perpendicular (Figure 3c). The planks are fixed by copper wire or nails.

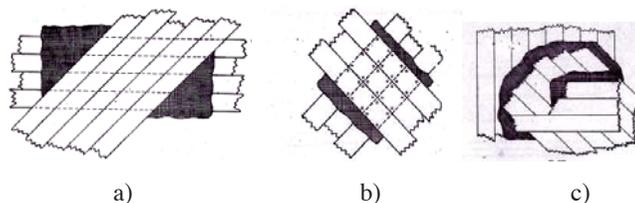


Figure 3 **The diagonal (double) planks method: a) outer planks are slanted and inner planks are horizontal; b) both side planks-outer/ inner slanting and c) diagonal (triple) planks method**

Slika 3 **Metoda gradnje dvostrukim dijagonalnim postavljanjem platica oplate: a) vanjske platice nakošene, unutarnje vodoravne; b) nakošene i vanjske i unutarnje platice; c) metoda trostrukim dijagonalnim postavljanjem platica**

These ships have greater elasticity, strength and impermeability, but also a greater mass, and their repairing is more difficult, construction is longer, the price higher, and for their building special knowledge, experience and high preciseness are needed.

2.4 The unwrapping plane and "patching" method

This method is used in the simple form building, usually in chine form, as a "do-it-yourself" activity, where no special shipbuilding knowledge and experience are needed (Figure 4). The building material is watertight wooden lamina available on the market. After the framework is finished, the outer shell plating is positioned onto the prepared lamina plate parts, and the plane unwraps over more than three frames. But the outer shell plating can also be placed by means of small "patches" by the touching method and they are fixed to the framework by high quality glues and screws. The boat construction is faster, with smaller boat mass

and not difficult for repairing, but the life of such boats is shorter than in the case of boats constructed by other methods (10-15 years) due to the weakening of connecting parts.

2.5 The lamina ("thin plate") building method

This method is a fairly new method made possible by the development of chemical industry and new technologies of joining by high-quality waterproof glues and by other water-proof materials. The frames and shell plating are made of lamina, the process of construction is faster and simpler, and material expenditure is smaller. The basic construction elements are made from a number of thin small parts glued together in order to obtain a desired form, (Figure 5 and Figure 6). The method is appropriate for "do-it-yourself" activities: the construction has a higher strength, elasticity, a high degree of material efficiency. Highly complex forms can be manufactured, but the disadvantage is that the method requires separate and clean working areas with appropriate temperature and humidity. The shell plating is performed by the touching planks method, or the unwrapping plane and "patch" method.

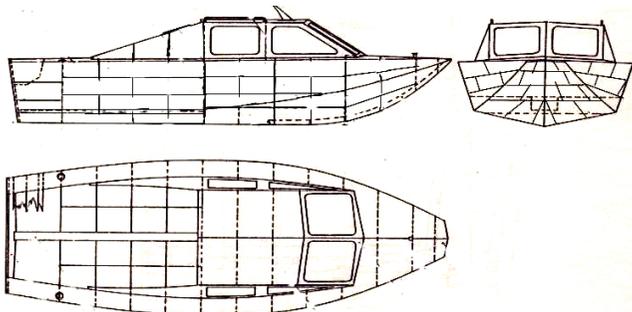


Figure 4 The unwrapping plane and "patching" method
Slika 4 Metoda gradnje s pomoću razmotljivih traka i umetaka ("zakrpa") vanjske oplate

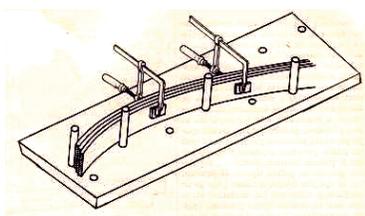
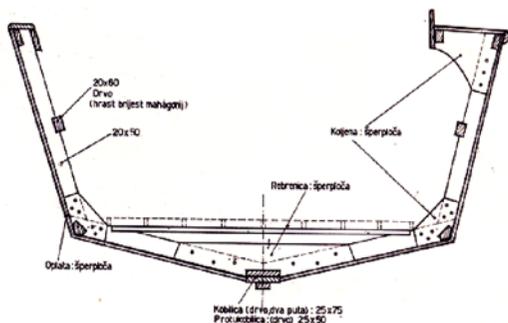


Figure 5 The lamina building technology
Slika 5 Tehnologija izrade laminata

Figure 6 The lamina building main frame section
Slika 6 Presjek glavnog rebra kod lamelirane gradnje



2.6 The combined (mixed) building method

The method is nowadays used especially in building bigger wooden ship with the chine form (Figure 7). The framework of underwater ship hull part (under the chine line) is built using the construction method with frames and longitudinals joined together (combined building), but in the construction over the chine line only frames are used (transversal building). Under the chine line, the shell plating is done by diagonal method, without curving planks at 45° angle to the fore peak, but over the chine line, the shell plating is posed horizontally by the touching planks method. The method is fast, ensures a good quality but the ships have a bigger mass.

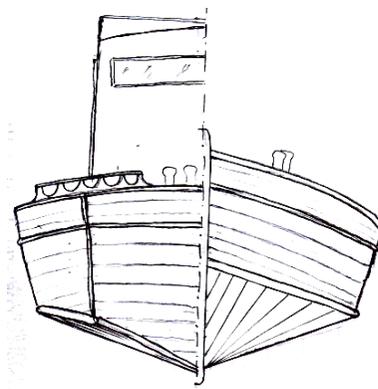


Figure 7 The combined (mixed) building method
Slika 7 Metoda kombinirane (mješovite) gradnje

3 The Korčula standard boats building technology

In Korčula's shipbuilding, over the centuries, the touching planks method has been used with previously prepared and curved shell plating planks to obtain the ideal form resembling very much the framework form. This method is very demanding and more complex than all other methods, it requires a good knowledge of shipbuilding and experience, but boats/ships built by this method have the longest life. The wooden material has to be located in the natural environment, sampled and prepared in the right size, which requires a good practical experience. That building technology is usually performed in the 10 phases described below.

3.1 The first erection phase

The building berth is equipped with all the necessary tools and materials. The basic girder for the framework construction is positioned on solid supports on which the boat will stand upright all the time during construction until it is launched.



I PHASE: Basic -solid support, keel stem and stern post positioning



Figure 8 The first construction phase
Slika 8 Prva faza gradnje

The boat construction starts by keel fitting, and at its ends the stern frame and stem post are also fitted (Figure 8). After that, the "mezzaluna-buška" is designed (the construction method without ship line design), by means of which the fore and aft boat form is defined, and the bottom and the side inclination.

3.2 The second erection phase

The fixed keel is divided in an adequate number of interframe spaces, depending on the boat's size, on which the frames will be positioned. First, the "two main frames" (fore and aft) in the middle of boats are fitted (Figure 10), composed of three or five parts, depending on the boats main characteristics (Figure 9). On the bottom floors, small square (2x2 cm) openings ("scallops") are carved for water drainage.

3.3 The third erection phase

The frame fitting continues on the fore and aft parts of the boat (from the middle to the ends). The deck line and bulwark rail line are marked on the frames, as well as the position of the first outer shell plate plank (named "centa").

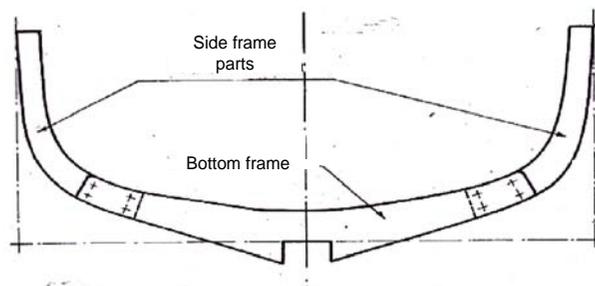
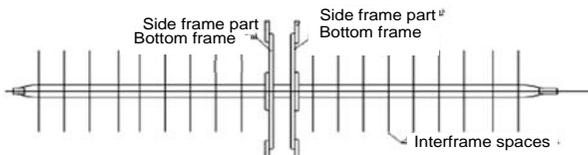
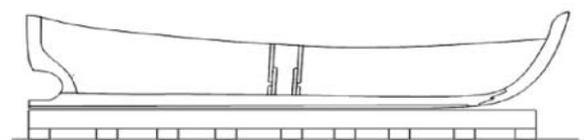


Figure 9 The main frame shape
Slika 9 Oblik glavnog rebra

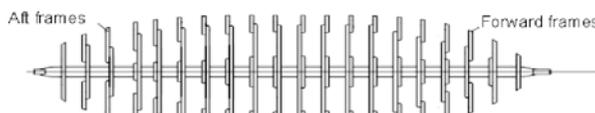
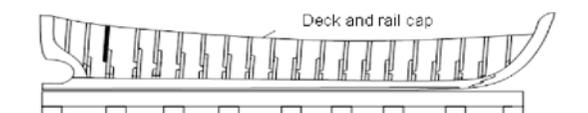
The frames are cut in accordance with the deck and bulwark rail line and they are fixed, on the inside and the outside, by wooden laths. In the middle, usually there are 8-12 frames named middle-frames, and at the top of fore and aft parts the frames are made from one V-shaped piece (Figure 11).



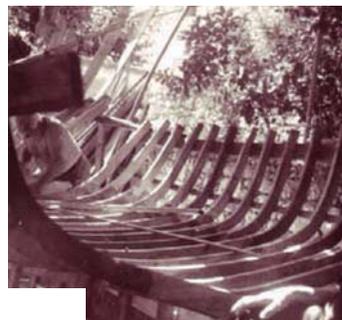
II PHASE: Interframe space and two main frames determining

Figure 10 The second construction phase
Slika 10 Druga faza gradnje

Figure 11 The third construction phase
Slika 11 Treća faza gradnje



III PHASE: Forward and aft bottom and side frames positioning



IV PHASE: Lattice screen bordering and inside stinger positioning

3.4 The fourth erection phase

When the fixed boat's framework is correctly positioned, i.e. all the constructive elements are in the real position, the first inner side stringers are fixed. When all the elements are fully finished, they are protected by a layer of base paint coating (Figure 12). After all the frames have been fixed correctly, the boat's framework is immediately bordered by a lattice screen.

3.5 The fifth erection phase

After checking and possibly correcting the boat's vertical position and after the boat's framework has been fixed, the side plating starts by positioning the first under deck side plate plank. The side plating starts from the middle of the boat to the ends, and continues, with the second, third and maximally fourth layer of shell plate planks level from the deck to the bottom (Figure 13).

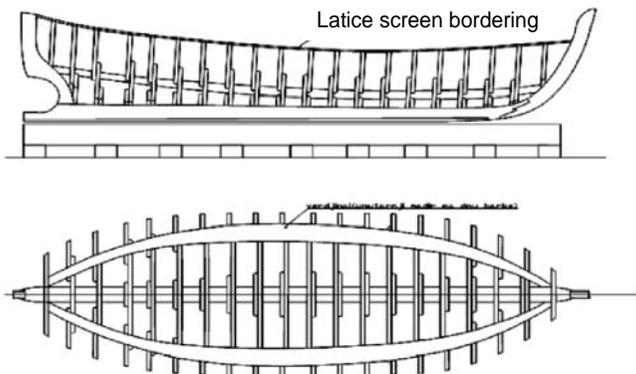
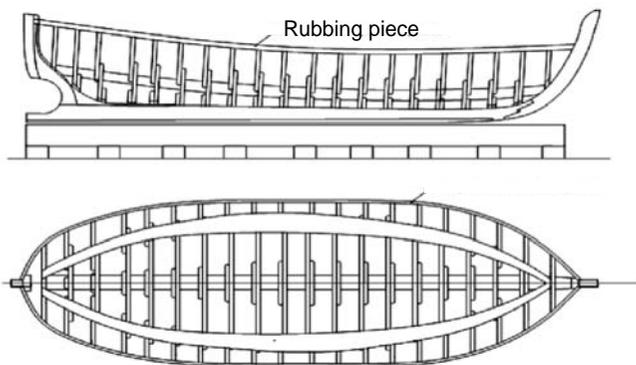


Figure 12 **The fourth construction phase**
Slika 12 **Četvrta faza gradnje**



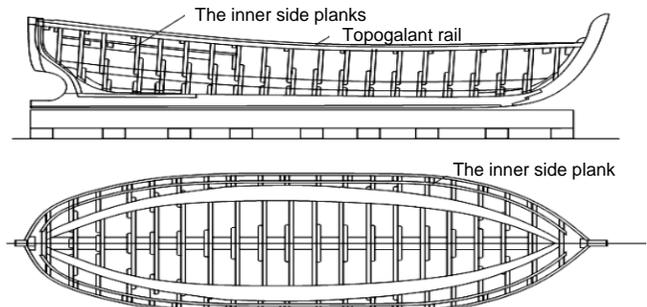
V PHASE: The under deck side plate planks positioning

Figure 13 **The fifth construction phase**
Slika 13 **Peta faza gradnje**

3.6 The sixth erection phase

The boat's framework plating continues by putting up side planks from the keel to the middle of the boat side plating, level by level. The side planks on the construction waterline position are thicker by about 2.5% for smaller ($L = 5\text{m}$) and by 3.5 % for bigger ($L = 17\text{m}$) boats. On the bottom, one hole on the central

plank is bored and closed from the inside by one wooden stopper. The inner side reinforcements are fixed by two levels of under deck inner side planks (Figure 14), where the inner second level plank is designed as a support for the boat's middle bench, as well as the aft bench. In some types of wooden fishing boats (*Leut, Trajta*) in that phase the deck bridge is fixed onto the fore part to facilitate the embarking and disembarking of fishermen on the rocky seaside (Figure 16).



VI PHASE: The garboard - strakes and inner side planks positioning



Figure 14 **The sixth construction phase**
Slika 14 **Šesta faza gradnje**

The side corridor covers the frames' ends and connects the outer plating planks with two levels of inner side plating and is used as a communication "road" from the fore to the aft part of the boat. Its form depends on the boat's form. If a sailing boat is constructed, the mast is fixed at the 1/3 fore part of the boat length ($L/3$), and instead of the transverse deck girder, the solid transverse girder is posed, with an equal opening at the centreline to fix the mast, and on the keel the "mast heel" is fixed at the bottom.

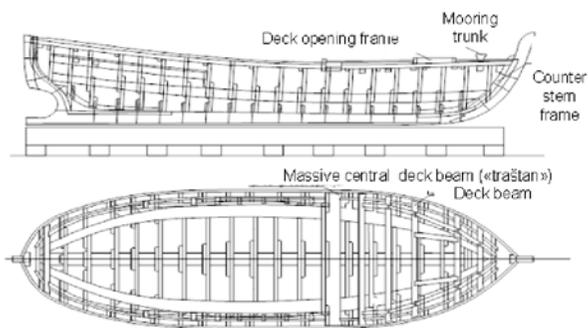
3.7 The seventh erection phase

The boat's framework plating from the deck side starts with building a short deck (at the stem or stern part of boat, or, in several fishing boats, on both sides) depending on the boat's type, and it usually amounts to 1/3 of the boat's length. The deck construction starts by positioning a massive central deck transverse, in connection with adequate frames by a solid connection knee, and continues by positioning and fixing other deck beams with corresponding boat's frames. The final horizontal connecting element, which fixes the boat's sides at the stem and stern part, is constructed, and the deck is finished by putting up the central longitudinal deck planks in the middle of the deck, and the other

deck's planks on the left and right sides. Finally, corridor planks, named peripherals are fixed on both sides, and the deck side of the boat is finished (Figure 15).

3.8 The eighth erection phase

When the deck openings have been finished, the deck openings covers will be posed onto them, the boat inside work has started. At the fore part the horizontal stiffener knee will be fixed, designed to assure a strong connection of the right and the left side. The same construction parts are designed for the aft part of the boat, and even two horizontal stiffener knees are designed for the transom stern, one for each side of the transom end. In bigger boats, sometimes, the counter-keel is fixed on the keel, the counter-stern frame is fixed at the stem and sternpost, and the base of the main engine is positioned on adequate floors (Figure 17).



VII PHASE: The deck beams, inner stern frame and deck opening positioning

Figure 15 The seventh constructing phase
Slika 15 Sedma faza gradnje

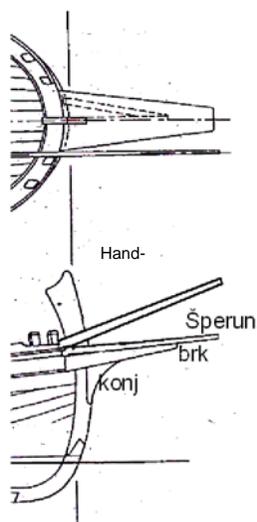


Figure 16 Deck bridge and hand-help girder
Slika 16 Pramčani palubni mostić ("šperun") i pomoćni rukohvat ("baštun")

3.9 The ninth erection phase

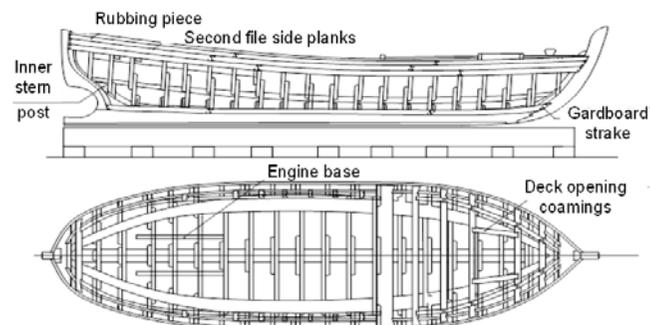
In this phase the final refinements and outfitting start. The rounded margin plank (2x2 cm) is posed on both sides along the boat, 10 – 12 cm under the deck and corridor line, in order

to protect the side plate planks from direct collisions with other boats, but also for aesthetic reasons. On the deck, the opening covers are posed and fixed, as well as at the fore and aft boat's parts, the deck lashing parts, and wooden bulges for positioning and fixing the rope of oars (straps), which may be shorter and longer (Figure 18). In fishing boats, the two transverse flat girders, on the aft part are provided on both sides, for longer oars, and their ends hang over the boat side plating for about 80 cm, with appropriate niches for oars, at the edges, to enable easier rowing and manoeuvring during fishing.

In smaller boats the wooden side bilge keel is fixed, as well as the hand-help girder ("baštun") with the deck bridge ("šperun"), (Figure 16), in bigger boats, which is designed for easier embarking-disembarking on the rocky seaside. On the stern post the rudder metal reinforcements are fixed, as well as the metal reinforcement at the stem, for night fishing gas lamp.

3.10 The tenth erection phase

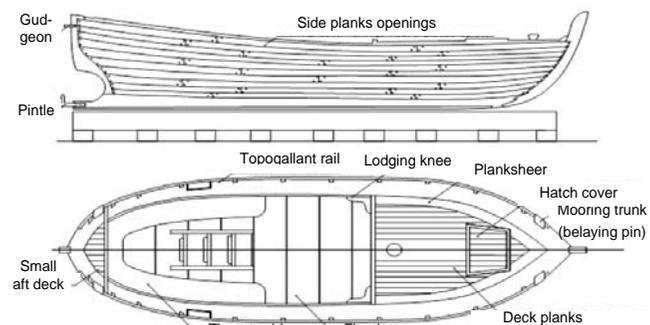
When the boat hull is structurally finished and completely closed on both sides and the deck, the cleaning and finishing works can start, such as preparing touching sides of side planks for caulking, i.e. filling openings between side shell planks using special tools with hemp immersed in liquid tar (Figure 19). The force and speed of caulking are determined by experience of shipbuilders and their skillfulness, but it must always be uniform. Larger openings require more hemp, and smaller openings less.



VIII PHASE: Inside works starting

Figure 17 The eighth construction phase
Slika 17 Osma faza gradnja

Figure 18 The ninth construction phase
Slika 18 Deveta faza gradnje



IX PHASE: Outside works finishing (deck planks, knees, mooring trunks etc.)

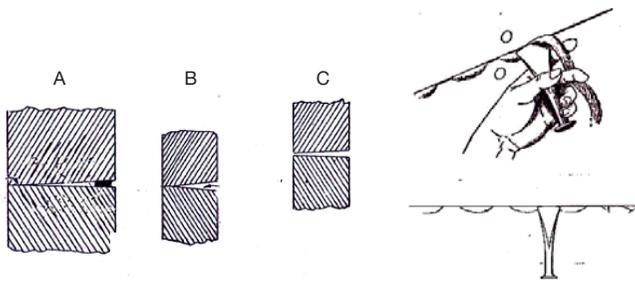


Figure 19 **Caulking of boat side shell plating (A- correct joining; B and C incorrect joining)**

Slika 19 **Šuperavanje platice bočne oplata (A – ispravno, B i C – neispravno šuperavanje)**

The touching parts of planks and the holes of nails or screws on the side plating planks are covered by putty or by wooden corks, and all the outside of the boat (side shell plating and deck) is fine treated by a rasp and abrasive paper. When the boat is completely cleaned, the final painting can be applied in 3 layers:

- 1st layer of basic boat paint is applied on the inside and on the outside of the whole boat,
- 2nd layer of coating is applied on the inside and on the outside to the draught line (constructive waterline)
- 3rd layer of antifouling boat paint is applied only on the outside, below the draught line (constructive waterline).

(In the past, as there was no boat paint available on the market, boats used to be painted with liquid black tar in order to save wooden material from wormholes.)

The deck planks are covered with a coat of colourless paint, but the first side shell plank is painted in a colour different from the boat colour, for aesthetic reasons, as well as the draught line (a thin area between the parts immersed in water and parts above the sea, (named *bagnasciuga*), i.e. the line of constructive waterline, Figure 20 and Figure 21.

For the boat powered by a main engine fixed inside, the one-foil rudder is provided at the stern with a square opening on the top, for positioning the rudder tiller. The rudder tiller is specially constructed in accordance with the boat's size, rudder dimensions, forces and moment of the boat rotating, the size of the owner's palm etc. The end of the rudder tiller is specially designed and formed, depending on the owner's palm size.

Figure 20 **The tenth construction phase (completing, polishing, cleaning and painting)**

Slika 20 **Deseta faza gradnje (dovršavanje, poliranje, čišćenje, bojenje)**

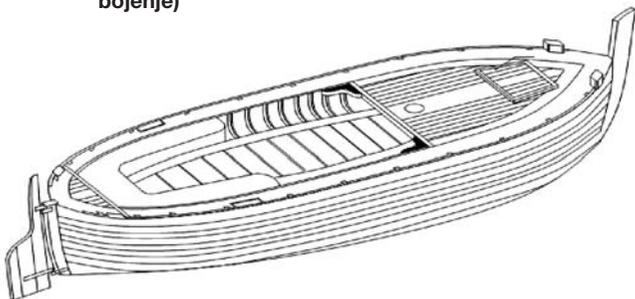


Figure 21 **The final look of the designed Korčula fishing boat**
Slika 21 **Konačan izgled završene korčulanske ribarske brodice**

The rubbing strips (Figure 22) are prepared and fixed in their place on the boat (fore, side and aft). They used to be made from rolled up ropes, or from the whole or a part of a car tire, but today they are made from strong plastic material in different shapes, sizes and form, with compressed air inside. The rubbing strips serve for saving the fore, side and aft of the boat from damage caused by impact with other boats, or to soften the blows at a rocky seaside.



Figure 22 **Rubbing strips: rolled up ropes, automobile tire and strong plastic material**

Slika 22 **Bokoštitnice ("pajeti"): od zamotanog konopa, automobilske gume i materijala od jake plastike**

Before launching, the size of adequate "main anchor" is provided for each boat (calculated empirically), depending on the boat mass and the most frequent sea state in the area where the boat usually sails, along with an adequate length of rope, which depends on the maximum sea depth, and a small "spare anchor", which will always be in the boat, for short voyages. A minimum anchor rope length is 15-30 m, for smaller boats but for bigger boats it is from 30 to 100 m.

Figure 23 **The old fishing boat ("trajta") in Lumbarda (Korčula) in use today**

Slika 23 **Stara ribarska brodica ("trajta") u Lumbardi (Korčula) i danas u korištenju**



The flooring made of quality wood is provided, by which all the bottom space, above floors, is covered. The bail with a handle (volume 1-1.5 lit.) is carved from a very thick piece of wood for bailing out sea water from the boat's bottom. When the boat is finished, the launching ceremony follows and the boat is named and launched gliding down the slide bearing (building berth) or it is lifted and lowered in the sea by a boat crane or an automobile crane.

These are general principles of boat construction in Korčula performed in 10 phases.

4 Conclusion

From all the six known and presented wooden ship building methods, the Korčula's shipbuilders over the centuries have been using the touching planks method (later known as Carvel method). In the course of time, relying on their experience they have modified it a little and divided in ten phases in order to produce the long life boats of excellent form and quality that are still in use today, Figure 23.

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