CHAPTER IV

SHIPBUILDING IN GOA - 1510 - 1780

India afforded Portugal very commendable infrastructure for shipbuilding. The availability of wood and skilled manpower, the two main ingredients of shipbuilding were found in abundance in India. There were about 120 valuable varieties of timber in Malabar alone including the well-known Angeli-wood.\(^1\) With the Arab patronage, the shipbuilding yards thrived on the Malabar coast, Broach and Surat.\(^2\) There are many references to Indian rigging material i.e. cordage and cables, but they had to be stored in salt water to keep them strong.\(^3\)

When Albuquerque conquered Goa in 1510, he was astonished to find a number of ships, naval spares and artillery pieces of different calibre there. In a letter written to the Crown in 1510, he informed about the expertise and excellence of the Indian carpenters.\(^4\) The durability and the toughness of the Indian teak wood over European pine was well known to the authorities in Lisbon, although there was no unanimous opinion about the cost of it. A Royal order dated 1585 to Viceroy D. Duarte de Menezes and again in 1595, to the Viceroy, D. Mathias de Albuquerque emphasised the need of building ships in India.\(^5\) Galleons, Galiotias, Galleys etc. were built at the shipyards of Bassein, Cochin, Daman and Goa. It is proposed in this chapter to examine the various aspects of the Portuguese shipbuilding such as, the type of wood used, supply of timber and other material, selection
and cutting of timber, type of wood for different parts of the ship, system of joining the wood, causes for the decay of the wood, wood preservation techniques, and repairs at the dockyard etc.

Type Of Wood Used For Shipbuilding In India:

The Portuguese ships were built out of two types of wood. Firstly, the pine and the oak wood used in the Lisbon shipyards and secondly, the teak and other local variety that was available in India. The timbers used for shipbuilding had to be hard, dry and of a bitter and resinous sap. It had also to be soft. The hardness and sturdiness help to resist the fury of the seas and of the winds. If the timber is dry, it would not perish in the water. To avoid the ship-worm penetrating into it, the timber should have a bitter sap. It must be so soft that while giving a shape to the wood it should not develop cracks. The timber which the Portuguese used in India for shipbuilding was Teak, Zambo, Mango, Matti, etc.

a) Teak wood:

Teak wood was found mainly in India, Siam, Java and Phillipines. The wood was tough, durable, incorruptible and was used specially for pavements and costado. Its weight per cubic feet was 20 to 24 kgs. The ships built out of teakwood had certain advantages than that of the oak. Oak contains a powerful organic acid which corrodes iron and consume the very material which was supposed to keep the structure intact. The teak weighs
one-fourth less than oak. The ships built out of oak required repair or replacement every 12 years whereas the one made out of teak lasted more than 50 years. Another special feature of the teak wood is that it is hard and unalterable and does not contract when it is dried up. It does not attack iron and for this reason it was used in the planks of conves and decks.

a) Zambo-wood:
Zambo was found basically in the southern parts of India and Indo-China and also in Goa. The wood was moderate in weight, durable and susceptible to the variations of humidity. The height was normally between 30 to 40mts. The fibres of this wood were long and straight. This wood was used mainly because of its resistance capacity to white ants.

b) Mango Wood:
This wood was used mainly to build auxillary ships like Canoes, Pattmari etc.

c) Goting Wood:
Another type of wood that was used for building country-crafts was of Goting. This was found in Goa, Sri Lanka and even in Indo-China. The trunk of a tree had a large dimension of 35 m.

d) Matti:
Matti wood was used for putting up internal beams of minor proportions. The sap-wood was reddish-white and the heart wood dark brown. The pores were moderately sized and uniformly
distributed. Each pore was enclosed in an irregular shaped and elongated patch of soft tissue.\textsuperscript{12} Jackfruit and Champo were also used in the dockyard for raising supporting platforms for undertaking shipbuilding and repairs.\textsuperscript{13}

**Supply of Timber And Other Materials:**

The Portuguese got much supply of their wood and other material from Bassein, Kanara, Cochin, Cannanore and even from Maldives. Almost all the *Regimentos* given to the Captains of the Northern and Southern Fleet had instructions to give top priority for loading timber and other material for the shipyard. Under the various treaties signed by the Portuguese with the local rulers, the latter agreed to supply timber for Portuguese shipbuilding. In the treaty signed between the ruler of Amin Islands and the Portuguese, the former agreed to provide the latter all the necessary coconut fibre needed for shipbuilding.\textsuperscript{14}

The export or the sale of timber to any port was prohibited by the Portuguese. One of the conditions laid down in the Cartaz was that, the local merchants were not allowed to trade in teak wood and declared it as a Royal Item.\textsuperscript{15} This step was taken to ensure the easy availability of good quality timber. From Kanara, timber was brought for making masts and the yards.\textsuperscript{16} Nuno Vaz de Castelo Branco was asked to arrange teak wood in the north of Kanara, as the same was found to be highly durable and in conformity with the quality laid down in the shipbuilding rules.\textsuperscript{17} The supply of timber also came from Bassein. The Portuguese *fidalgos* who owned large forest areas around Bassein exported
timber to Goa. In 1683, the Feitor of Bassein purchased 100 corjas de patnigas of teak wood and sent the same to Goa in the ships of the Northern Fleet. Again in 1690, the Feitor of Bassein Rafhael Mendes bought 50 Corjas de patnigas of teakwood for the naval dockyard at Goa.

Supply was also obtained from the individuals who were involved in the timber trade with state permission. In 1712, an amount of 2,000 xerafins was given to the warehouse keeper of the fortress of Angediva who was felling the teak wood. The warehousekeeper was instructed that he should not spend any portion from the amount given for the purchase of timber without the orders of the Captain - General of the city of Goa. In order to facilitate shipbuilding in Goa advance timber acquisitions was made. In 1684, 1 Fragata and 6 Bracos sailed to Goa from Daman with wood measuring about 1000 covados. The authorities at the dockyard were ordered to measure and register the same in the Warehouse register. The Portuguese apart from acquiring timber from Cochin and Cannanore also acquired accessories like masts, yards, etc. for equipping Lisbon-bound ships. In 1641, some masts were acquired from Cochin to equipe a Galleon. An amount of 3,000 xerafins was given to the Captain to make the payment for the same. Teak wood and Zambo were also acquired from the forests of Goa. In 1717, the Commandar João Marinho de Mouro was asked to load all timber that was available at Canacona and to send the same to the dockyard. He was further instructed to make payments for the same at the prevailing rate. In 1683, the Feitor of Mangalore was
instructed to purchase coir from the Maldives for the stock of the Mangalore warehouse, which was later to be sent to Goa in the Nau Nossa Senhora dos Milagres. Coir was also obtained from Goa. In 1772, Pascoal de Braganza, Master Winder received 11 candis of fine coir from Bardez. In the same year, Antonio Baptista, Master of the Nau São Francisco Xavier, received from the Feitor of Goa thick coir of 7 arrobas for the service of the said Nau. There are references to the export of timber from Goa to other Portuguese colonies and even to Lisbon. In 1613 the King instructed the Viceroy of India and the Finance Comptroller to load the ships coming from India with timber for making various parts of the ship, such as calese, cabrestantes etc. Teak wood was also taken to Brazil for shipbuilding and for undertaking repairs. The supply of material was not always regular. This was mainly on an account of the lack of finance and other technical problems which the Portuguese Feitors faced at Kanara, Cochin and Bassein. In 1628, it was found that, the wooden planks and the poleam which were in the Northern Province did not reach Goa in time inspite of the consent of the Viceroy.

Selection And Cutting Of Timber:

The selection of timber was given top priority as the safety of the ship depended on it. As Anacarsi Selyta, Greek Sage described that, "It is a plank on it depends the safety of the seafarers as only two fingers of thickness lies between it and death". Only those tress whose wood posses certain distinct features and having all essential ingredients were used for
building different parts of the ship. If a tree is cut in transversal and perpendicular to the axis of the trunk 2 distinct zones or areas can be noticed (Fig. 13). The outer or external is called bark (casca) and the internal has been termed as lenho, both were made out of concentric layers but with different features.

As regards the bark (casca) there were 2 portions internal and external. The internal portion, liber was composed of vertical fibres easily separable by marking. The layers were formed throughout the year as the tree matures. Between the external portion, epiderme and the liber there is a layer called subersoa which in certain trees acquires rapid growth. The line forming it also had two parts. One little adjacent to liber, generally dark in colour than that of the centre layer, which acquire toughness both, internally and externally as the time goes by. It was termed sapwood. The other was the heart (crene or corasao) which was dry, tough and compact. The central part of the tree trunk had a spongy substance called medulla which vanishes as the tree matures. The growth of a tree depended upon the circulation of sap which in turn depended upon the nutrition of the tree.

The prime season for the circulation of the sap was spring season. Every year it forms one new layer of line. The age of the tree can be determined on the basis of number of layers and in this manner the tree shown in (fig.14) was of 6 years. On each layer, every year a tissue is formed during the spring and autumn
fig. 13. Inner portion of the tree
Fig. 14. Inner portion showing 6 layers.
season. The growth of the tissue was not always identical in all the trees. In the case of the oak tree, the thickness of the layer during the spring season remains constant while it varies during the autumn and in the case of pine-tree it was contrary. The wood which was meant for naval construction had to fulfill the following conditions. Firstly, the wood should have precise homogeneity so that all its parts offer equal resistance. Secondly, the wood should be elastic, so that any excess load of cargo does not lead to any permanent deformation. Thirdly, the wood should be well dried so that it does not develop any crack after its use. Lastly, the wood should have straight fibres to provide resistance to pressure and to guarantee its durability.

Certain experts were of the opinion that, the trees should not be cut down either during the spring season or in the summer as the sap saturating from the vascular fibres of trunk leads to easy fermentation within the tree, and as a result the wood gets rotten. Others were of the opinion that, the felling of the trees should not be made during cold, winter or in autumn because the sap was solidified and as a result the wood becomes tough and susceptible of producing the cracks. The most appropriate time when the trees attains maturity and fit for felling is after they yield fruits i.e. gaining all their virtue and strength. The maturity of the tree depends upon the sun. The sun warms the tree in the beginning of spring and summer. When autumn arrives, the sun withdraw from the trees and with its absence they become cool. Thus autumn and winter season were considered suitable and appropriate for felling the trees.
The movement of the Moon also influence the trees. The increase and decrease in their humidity depended upon the light which they receive from the Moon. The experts recommended that, during December and January the waning of the Moon should be noted and the timber should be cut at that time. Timber for shipbuilding had to be cut at the waning of the Moon during the two months closer to the winter, one before its beginning and other after it.\(^{36}\)

As regards the method adopted for cutting the tree, a side of the tree was first identified and a rope was tied at the top of the tree and was taken the opposite side. Then a cut was put on that side with the axe, measuring approximately 2/3rd of its (tree) diameter. A profound stroke is given as it was required to bring down the tree. On some occasions such cut produce cracks and damage the wood and therefore the experts suggested the use of saw blade. The first cut was usually measured about 2/3rd of its (tree) diameter while the second was of 1/3rd just opposite and little above the first one.\(^{37}\)

**Types of Wood Used For Different Parts Of The Ship:**

A single tree could never posses all technical requirements of the shipbuilding and therefore a certain type of wood was used for specific portion of the ship. The sovaro or sobro wood was used specially for the liames because of its water resistance capacity. The sobro wood was substituted by 'azinho' which had the similar qualities.\(^{38}\) The resinous-pine was used for supporting interior of the hull while stone-pine was used for the
The masts of the caravela of small tonnage were made out of only 1 piece of *phino de flandres*. The yards were also made out of pine-wood. The size and the shape of the tree was given much importance as the same determines the fitness of the ship. In 1628 Master Manuel Gomes Galego declared that, the wood of *savaro* which they (contractors) fell was of insufficient size to make a tough ship boards and to join them with each other. It was on account of the non-availability of the wood of sufficient size the shipbuilders began to use raw wood and of insufficient dimensions which was one of the main reasons for the enormous loss of the ships. The standard timber requirements for one Nau of 17,5 r of keel (29,95cm) was 35 *chaos* of ribs, 70 *bracos*, 140 first riders and 145 second riders and more than 13 *enchimentos de proa* with 26 long sticks and 21 *enchimentos de popa* with 42 reversed. Each *chao de caverna* was required to be of a plank measuring about 8.10 m. of length by 0.50 m. and thickness of 0.30 m. Each *braco* and each rider required the planks of 2,00 m. of length by 0.50 m. width. Generally, there were two classes of wood. One meant for the hull and second meant for rigging. The wood meant for rigging (such of teak and oak) should have certain shape and dimensions as mentioned as below:—

a) **Paus Direitos**: Piece of wood with no curves AB in (Fig.15.)

b) **Paus de Volta**: Should have one regular and continued curve equal to 1/50 m. of its total length, like the piece C in fig.15.
c) **The Curvas**: Called improperly because they are the pieces in angle with two straight logs, one forming the trunk and another forming the branch of the tree as seen in D, fig. 15.

d) **Piques**: These were very much used for the balisas de proa and for stern. The stone-pipe provides the best piques (Fig. 16). The dimensions of the paus were classified by its thickness. The straight and the turned ones were divided in five groups. The first two of lower classes were termed as liames pequenos with the maximum thickness of three inches and the second was termed as liames grandes with the maximum thickness of six inches. The thickness of the paus of the third group was eight inches, while that of the second category the maximum thickness was of ten inches. The maximum thickness of the first category was twelve inches.

**System Of joining The Wood:**

To ensure proper jioning, special cuts were put to connect the wood pieces. The samblagenes had to be as simple as possible so as to reduce the cost. The joining invariability could not be matched since its toughness was destroyed, not only by the contraction of wood, but also on account of different forces of pressure affecting the skeleton of the ship. This invariability is obtained by means of bolts and nails which were always put where the pieces were to be joined. When two pieces were crossing, it was sufficient to fix one piece crossing another, placing certain number of bolts on the points of intersection. But in most cases it increases the resistance of joining by
putting one entalhe on each piece as seen in (Fig.17). In case the end point of one piece meets another rectangular point, the samblagen was to be made as shown in (Fig.17) which is said mecha and respiga, consolidated by means of one bolt. 44

The cavity put on piece A is mecha or mortagem and on the part of the piece B which enters in this cavity is called the respiga. The two pieces which forms the escarva are fitted on the bizel as shown in (Fig.18) The length of escarva AB was between four to six times the height H of viga and the thickness B of the end point was in general equal to one-third of the same height. It could also give the form as shown in (Fig.19). The connection or joint was made by means of three or four bolts depending upon the dimensions of the escarva and sometimes even using two nails on each end. The escarva is described as escarva lisa or lavada whose make was simple and of great resistance. (Fig.20) shows the escarva de dentes which was used during the early days of naval construction. The number of dentes was variable. But the use of this type of escarva was given up since its efficacy was guaranteed only by the accurate cutting of the connecting piece. The shipbuilders adopted another method of joining known as escarva de cunha, which consisted of putting a cunha at two places. 45 (Fig.21)

Nails and bolts were used to connect the planks and wood pieces. The bolts used to connect the joints must have the top embuttered in the wood. The escarva having the length of 2.50m would have 4 bolts, being the last one placed at a distance of
Fig. 19.

Fig. 20.
0.25m. from the end point of the joint. The nails were made of iron, copper and even of wood. In cold water the wooden nails were used but their use in the warm waters of the Indian Ocean was not suggested by the naval experts for two reasons. Firstly, due to heat the wooden nails breed worms which completely destroy timber and secondly, the insertion of wooden nails was not feasible on account of the size of India-ships and the thickness of the planks.

Sometimes, a chemical content called tanino found in the wood attacks the iron nails slowly if the wood was well dried, but if the wood has humidity the corrosion is rapid and the wood decays. The head or the top of the nail was put, in the wood at the profoundity of one - inch and the upper portion of it, i.e. from the head of the nail till the surface of a plank was covered by one wooden plug called rolha.

Many times in certain parts of the ship bolts of square section were used. But the disadvantage of this was that, it was difficult to fix the square shaped bolt in the round drilled whole. This was one of the causes for the deterioration of wood at the time of building the ships.

Cavilhas Frapadas : Was another type of nail which was used for shipbuilding. But the experts declared that the wood was more prone to develop cracks while inserting this bolt on account of its sharp edge. (Fig.22)
fig. 22: Cavilha Farfadets
The Portuguese naval architects unanimously supported the use of iron nails in place of copper and wood for India ship.\textsuperscript{49}

\textbf{Causes For The Decay Of The Wood And Preservation Techniques :}

The trees such as teak, pine, oak etc. were affected by various kinds of diseases which generally led detrioration of the decay of wood. Some of the most common diseases which affected the trees were as under :-

\begin{enumerate}
\item \textbf{Caria} : It is a local disease which led to the rottening of the tree. The tree develops cracks on its trunk which facilitates the infiltration of water through them specially at the junction point of the branches.
\item \textbf{Pe de Gallinha or Crows Foot} : It is another type of disease which affects the wood. The main indication of this was that a crack starts developing from the crene and then moves towards the periphery of the tree. When there is a violacious or dark powder, it was a sign of severe decay of the wood. Sometimes the cracks were caused due to the action of winds or intense heat. But this does not always affects the wood, as the wood contains a preserving substance.
\item \textbf{No's} : It is a kind of disease which develops from the improper cutting of the branches. This results in reducing the resistance of wood and making it difficult to work with it.
\end{enumerate}
d) **Madeira Picada**: The wood was affected due to the action of the larvae which were affecting the tree from the bark and making cavities in all directions which totally ruins the tree.

e) The white ant is another insect which destroys the heaps of wood stored at the dockyard. The attack of white ants to wood could go unnoticed as it does not affect the external surface.

f) **Taredo**: It was a mollusic disease which could increase to one meter. This insect penetrates into the wood by small orifice which was made externally and extraordinarily increasing the same in the direction of the fibres. This larva was usually found in the clean water but not beyond the depth of 3 m. The growth of this larva was more rapid in the warm water than in cold water.

g) The **lymexylon** was a very small larva that penetrates into the wood before the trees is cut, but it develops only when the wood was kept in a heap.

h) The **rosca** or Carancho was a parasite insect which basically destroyed the wood.

Wood Preservation Techniques:

Once the wood is cut and felled it should not be used
immediately for shipbuilding as it would wrap, shrink and crack. To avoid this the wood should be kept either in the field or in the yard or in the salt water according to the nature. Before the wood is used, its bark was to be removed because besides, providing protection from the larva, which affects the tissue of plants, its contact with the sambago and the variations of heat and humidity could lead to the decay of the same. The presence of sap in the wood facilitates the decay of the same. Another method that was followed was to desiccate the intrinsic humidity. This involves the cutting of the tree till the middle of its heart and keeping it erect, so that all its superfluous humidity is removed through that and the tree was brought down when it ceases to drip humidity. The branches were to be cut while it is kept erect and the bark should be removed, so that the tree does not get nourishment neither from the bark nor from the roots. The sap in the wood could be dissolved rapidly in the sweet water, but it leads sometimes to the weakening of the wood. The use of salt water although suggested, could also have an adverse effect on the wood as it was affected by taredo. In view of these reasons, the following measures were recommended:

i) Depositing the wood at the mouth of the river at such a point, that it would get the mixture of sweet and salt water thereby preventing the growth of taredo.

ii) Burying the wood in the sand. This process was used to conserve wood which was kept in the dockyard.
iii) The wood had to be preserved in the water because long exposition to air results in the loss of resin and reduces the resistance capacity. After the immersion, the wood had to be exposed for a sufficient time to moderate and regular ventilation.

iv) The wood which was stored in the warehouse should have proper and unaffected floor which would not lead to the decay of the wood. The warehouses with low roofing should have convenient openings in the form of chimneys on the roof. To have a tough and dry wood at least 3 years were required for resinous wood and 4 years for the oak. 53

Repairs at the Goa dockyard:

There is no specific reference for any first Portuguese ship built or repaired at the Goa dockyard. Albuquerque may have repaired his ships at Goa before departing for Malacca. In 1512, ships of 800 tons were built at the Goa dockyard. 54 The dimensions of the parts of the ship, tonnage, etc. were discussed and elaborated by a Technical Board known as Junta de Fabricas de Rebeira de Lisoa, formed in 1623. 55 All master builders, who were appointed by the authorities at Lisbon had to be acquainted with all naval construction rules and regulations formed or laid down by the Technical Board at Lisbon. The Revenue Council was the main body approving the construction and repair of the ships with the help of the dockyard officials and making payments for the same. Based on the guidelines of the Technical Board, the Revenue Council laid down the measurements of the ship which were
to be built on contract basis by the captain of the fortresses.

In 1655, the Revenue Council laid down that the keel of a ship was to be 6 **covados** and would have **boca** of $7\frac{1}{2}$ covados while the depth would be $1/2$ of the **boca**. The thickness of the bottom planks was laid down as $2\frac{1}{2}$ **angullas** while the planks of the keel upto the **ponta de caverna** and from there to **apostura** the thickness was to be of $2$ **angullas**.\(^{56}\) Among the most celebrated ships built at the Goa dockyard was a Carrack **Cinco Chagas** built in 1559-60 under the personnel supervision of the Viceroy D. Constantinio de Braganza. Another Galleon **Bom Jesus** was built whose keel was laid in 1630 at Goa.\(^{57}\) In 1650, a Galleon **Madre Deus** along with Nau São Francisco was built in Goa.\(^{58}\) To meet the Dutch challenge, the Portuguese built a Galeota in 1655 at Vengurla for its quick deployment.\(^{59}\)

In 1613, the authorities finding many handicaps to shipbuilding at Cochin and in the North decided to build ships in Goa on contract basis. A contract was signed with one, Bostião Fernandes and a sum was allotted to him from the amount of **Cabedal**.\(^{60}\) In 1616, two Navios and two Sanguicies were built and equipped with all necessary accessories and fulfilling other technical requirements as laid down by the Revenue Council.\(^{61}\) In 1618, the Viceroy D. Francisco approved the building of two Naus and the shipyard Master was asked to prepare a detailed report of expenditure of the same.\(^{62}\) A new yard near the wharf of St. Catherine, next to the Galley's yard, was established by the Viceroy Conde de Linhares, where he laid down the keel of two
powerful Galleons. The old yard became unserviceable on account of the flooding of the sea water. This was the only yard where the construction of the carracks could be undertaken. In 1654, the Master of the dockyard, Francisco Carneiro built the keel of a ship measuring 66 covados with the bocca of 18 covados. The depth was 9 covados with the stem height of 18 covados. The thickness of the keel was given as 12 angulos with the breadth of 14 angulos.

Ships built at Goa shipyard were sent to all Portuguese naval establishments in the East. In 1703, the lanchas of the fortress of Mocambique were ordered to be repaired at Goa. The order further stated that, if the Lanchas were found irreparable, the Feitor had to make arrangements for building new ones, capable of rendering good and effective service. In 1747, Marques de Castello Novo ordered to build one Palla and two Pataxos each with twenty-four artillery pieces. The ships were anchored at some distance form the main dockyard and were taken to the yard only at the time of undertaking the repair. In 1652, the Galleon São Jacinto which was at Panelim was ordered to be repaired immediately before the outset of winter. The said Galleon was to be taken from the São Pedro, Ribandar to the dockyard. Expert opinion was sought to bring the Galleons from the bar to the Panelim dockyard. In 1644, two Galleons namely Santa Milagrina and Santa Margarida which sailed from Lisbon were ordered to be repaired immediately. The Revenue Council sought the opinion of the officials of the dockyard and the pilots of the bar whether it would be safe for the Galleons to pass through the shore of
Panelim during the full moon night. The experts suggested that, the said Galleons should be brought before 16th of that month from the bar to Panelim. Repairs of the ship were undertaken only after ascertaining the exact nature of the damage. In 1680, the Fragata Nossa Senhora de Conceição was declared unfit and beyond any repair. The same Fragata was repaired in 1672. The keel was found totally decayed and it was so weak that, it was difficult to make safe entry and departure from the bar. The authorities suggested that the mast and other wood be used for some other work. Periodical inspection of the ships were carried out by the officials of the dockyard. In 1737, the Clerk of the Treasurer and the Feitor inspected the Nau Nossa Senhora da Aparecida along with the dockyard officials to ascertain the condition of the same. In 1740, the same officials examined the Nau Nossa Senhora de Nazareth and found that the stern of the ship was in bad shape. In 1690, all the Fragatas, Galiotas and Navios of Goa and Diu were ordered to repaired. These vessels were meant to guard the coast. Old and irrepairable ships were disposed off in public auction. This was done inorder to get rid of the old and unfit vessels, thereby reducing the anchoring pressure at the dockyard and also to obtain some revenue for the State Treasury. In 1632, the Finance Comptroller Lourenco Melo de Sa was ordered the dispose of old Navios and Sanguices. In 1690, three Galeotias of one mast, two Navios of the fleet, one Bicha and two Barquinhas which were in the dockyard and not serviceable were ordered to be sold out in public auction. The Finance Comptroller was directed to make the valuation of the ships with the help of
the dockyard officials. No auction could be held without the presence of the Feitor of the city.

Shipbuilding or repair was carried out under the supervision of the people appointed by the King or the Viceroy. In 1640 two Jesuits Priests, Andre Ferreira and Gaspar de Valle were authorised to supervise the building of 2 Galleons. All the materials that were received and utilized for the work had to be recorded in the official register. In 1652, the Revenue Council decided to appoint a person of high integrity to oversee the building of Galleons at the dockyard. The person appointed was entrusted with the task of supervising the use of timber, nails, planks etc. meant for the Galleon. The person appointed to monitor the work, had to report irregularities, if any to the authorities. Damage to the hull of the ship was caused on account of the use of immatured wood, improper loading, the use of wooden nails and the attacks by the tropical water insects. The damage caused to the bottom of the ships by boring worms was heavy. In Surate, such was the situation that it could make the wooden hulls and the rudders unseaworthy within three or four months. In 1636, Princess Margarida, on behalf of Felipe V. wrote to the Viceroy of Goa to take adequate measures to protect the ships from the ravages of insects.

The ships before leaving the shores of Goa to Lisbon had to be cleaned underneath for greater durability of the hull. The Portuguese Captains felt that, one of the primary reasons for the damage by ship worms was the failure of the dockyard officials to
clean the bottom properly.\textsuperscript{79} The use of wooden nails also facilitated the worm attacks. Due to heat, the wooden nails caused breeding of worms. These worms enter into the plank at the back (under) the ship and through them they go on making holes all along till they reach the most interior portion of the wood.\textsuperscript{80} The best remedy was to clean the bottom of the ship. Almeida ordered that India ships should be unloaded, cleaned and repaired before taking a new cargo.\textsuperscript{81}

Careening Of The Ships:

Careening was probably an ancient technique that originated and used in the tideless Mediterranean and spread rapidly when ships became too large to readily haul them at ashore.\textsuperscript{82} The use of careening in Portugal was at least a century old: There were three fundamental requirements of careening. (i) It required that wherever practicable the ship should be lightened (ii) It demanded a control over the movements of ballast or of an equivalent weight within the ship. (iii) It required an ideally sheltered water.\textsuperscript{83} Under the system of careening the ship left a float, but put on her beam ends by shifting her ballast and hauling her down with rackle rigged to her masts even to the extent that the part of the keel was exposed. All the difficulties of keeping large rounded hulls upright ashore were avoided but enormous stress was put of poorly fastened ship.\textsuperscript{84}

Caulking System:

Another measure that was used for checking the underneath damage was the caulking system. Caulking is a technique of making
joints tight or leak proof by forcing oakum between the parts that were not tightly fitted. Caulking was therefore a second step in the European shipbuilding after the planks were joined together by any method of carpentry. At Goa dockyard, caulking check was carried out by the Master Caulker in the presence of the Chief-Master. Sometimes, the material used for caulking was of a very poor quality and as a result, many a times the caulking had to be removed. Early in the 16th century, the Portuguese adopted a technique of protecting the hull by applying additional strake layers, both above and below the waterline, a technique which they had borrowed from the Chinese junks. Almost all the ships were provided with a pitch stove etc. for undertaking caulking work whenever desired to do so. The authorities at Goa were directed to carry out proper check of all the vital components of the ship particularly of the pitch used in caulking operation at the time of issuing technical fitness certificate for undertaking a voyage to Lisbon. However, there was no separate area in the dockyard marked for undertaking any caulking or careening operations of the ship.

The Economics of Shipbuilding:

Since the days of the early Portuguese discoveries, shipbuilding was directly financed by the State. Sancho Afonso III gave his estate to the shipbuilder João de Miona. King Fernando initiated series of measures to boost shipbuilding by offering timber from the state forests at concessional rates, allowed duty free import of raw material etc. After 1498, the
Portuguese King embarked upon the policy of sending annual fleets to India. The State now began to award contracts of shipbuilding to the Captains of the fortresses. The objective of this policy was to raise the required number of ships promptly for undertaking naval expeditions. In 1530, Governor Nuno da Cunha declared that, any person who built a ship of any type would be given a Captain's salary and receive artillery to arm the vessel. In 1636, Princess Margarida ordered the Viceroy to build oarships and also a high-sea vessel. This contract was given to Rui Dias de Cunha, Captain of Bassein. In 1663, Joao de Faria built 13 ships on contract signed with the Revenue Board.

Purchase advances were made to the contractors by the state only under exceptional circumstances. In 1631, the Revenue Board provided capital to the contractors to buy wood, iron nails etc. for the dockyard. The funds were allotted from the Cabedal for undertaking the ship repairs. The King ordered the Viceroy to formulate rules for setting aside a certain portion of amount from the Cabedal every year for meeting the cost of shipbuilding and repair. The difference that occurs in the amount on account of the diversion of finance had to be adjusted from other sources of revenue. The authorities suggested the use of 1/8th of the amount from the cabedal for buying sails, teak wood, iron, nails, etc. In 1655, the Revenue Council ordered to purchase timber from Cochin. An amount of 9,000 reis from the cabedal was sanctioned. The timber was to be sent to Goa in the Galeota captained by Manuel Coutinho. Revenue obtained out of tobacco duties was used for carrying out artillery production in the
dockyard. In 1636, during the reign of Conde de Linhares, revenue collected in the form of tobacco duties in Bardez and Salcete was allotted to the Goa dockyard to expedite artillery production for ships.97

The rate of the timber was fixed only after ascertaining the quality of the same by the officials of the dockyard. One plank of teakwood of standard size, costed around 9 'xeralfins' in 1620.98 In 1640, the cost of a teak wood plank measuring 13 inches, the rate was 2 tangas 18 reis per covado, while the planks of Zambo measuring 17 inches of height and 3½ of the thickness the rate was 2 tangas 25 reis per covado.99 In 1668, the repair cost of the Nau Nossa Senhora de Oliveira was put to 12,522 cruzados, including the cost of timber and labour.100 In 1775, the Revenue Council approved the cost of lead which was 200 cruzados for 40 quintals, while that of the pitch was 70 cruzados for 70 quintals.101 In 1655, the Revenue Council approved the purchase of timber which consisted of the following :-

Thirty planks of costado of 3 angulos, the cost was 3600 xeralfins, while the cost of the 7 planks of teakwood was 560.102 The cost of 1 Nau of Carreira da India with all accessories was about 29,534 cruzados.103 The officials of the dockyard at Goa demanded 30,000 to 40,000 cruzados to start a work.104 The repair cost of the Nau Nossa Senhora de Neves undertaken at the Goa dockyard in 1710 was around 13,550 xeralfins.105 Timber meant for the dockyard was exempted from the custom duties and registered in the separate book.
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32. Ibid., p.5.

33. Ibid., p.2.
34. Ibid., p.4.

35. Ibid., p.5.


39. Ibid., p.164.

40. Ibid., p.29.

41. Ibid., p.32.

42. Ibid., pp.289-290.


44. Sambalgen: a technical term given for a half cut, put on the piece of wood or plank to make a joint.


46. Ibid., p.19.


49. Ibid., p.21.

50. Ibid., p.5.

51. Ibid., p.6.
52. Ibid., p.7.

53. Barata, Op. Cit., p.7. For longevity of wood coconut oil was applied to the planks and the heat was given to the same, Oral information obtained from the country craft builders from Betim, during the field trip on 24-8-93.


56. ACF, HAG, Mss.no. 1168, f1.174v.


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67. ACF, HAG, Mss.no. 1166, fl. 55.

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The cost of the timber was 5,550 xerafins.
7 Candis of Iron ........ 5,600 xerafins.
2 Iron anchors .......... 400 xerafins.
2 Amarra de Lenho ...... 2,000 xerafins.