

# Holzlabor

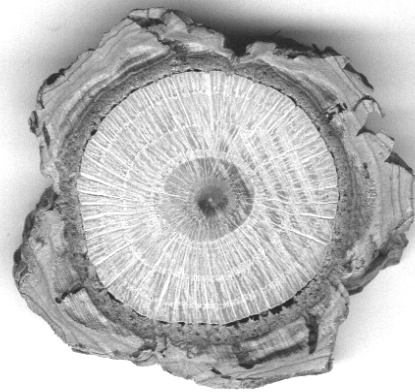
Beratung Gutachten Analysen  
Technologietransfer

Sachverständigenbüro  
Sanierungsempfehlungen ➔ Baubegleitung ➔ Qualitätskontrolle

Dr. André Peylo Blumenstr. 22 21481 Lauenburg

Ministério da Defesa Nacional  
Marinha  
Museu de Marinha  
Sr. Adriano Beça Gil  
Praça do Império

**P- 1400-206 Lisboa**  
**Portugal**



Öffentlich bestellter u. vereidigter  
Sachverständiger für Holzschutz  
von der IHK zu Lübeck

Blumenstr. 22  
**21481 Lauenburg**  
Tel. 04153/ 2282  
Fax 04153/58 22 26  
[www.holzlabor.com](http://www.holzlabor.com)

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## Research report Fregata D. Fernando II e Glória

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### Topic of the investigation

The frigate D. Fernando e Glória is laying as a authentional historical ship in the harbour of Lisboa. It is not equipped any more to serve as a vessel on the open sea.

Previous investigations reported on severe damages due to fungal decay.

The aim of this investigation was to re-examine the wooden structure and to develop a concept for the preservation of the frigate.

The investigation was done on June, 28. From 11:0 until 13:30. Investigated were the rooms on the bottom down to the bilge and the upper keel.

The investigation was practised by visual inspection of visible decay with the help of a carpenters hammer. Internal defects were searched by means of testing the drill resistance with a 3mm diameter drill of 40cm length.

An overview of the construction of the 54 m long frigate is given by pictures 1 and 2.

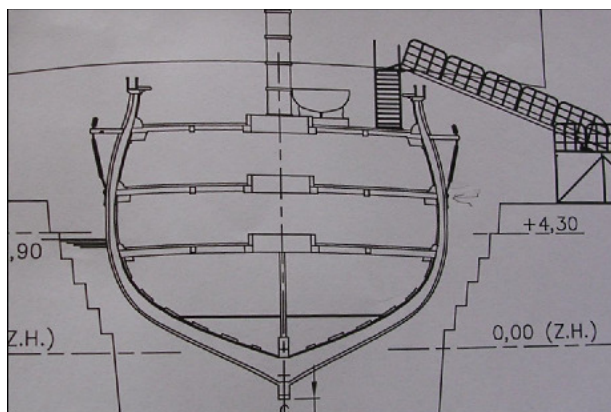
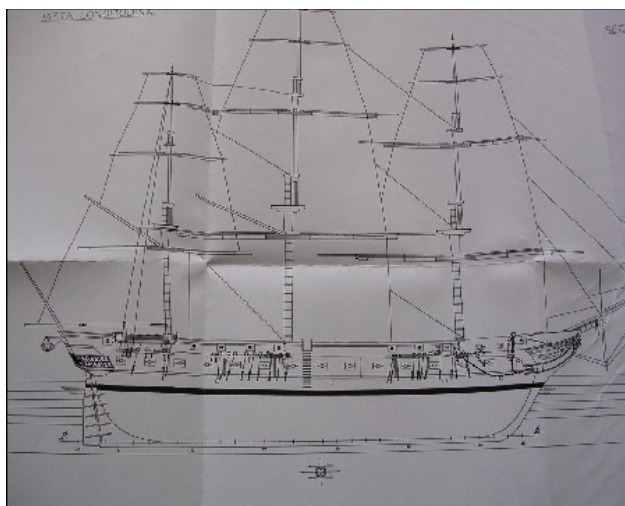


Fig. 1+2: with courtesy reproduction by Dr. Dos Santos

### Resumo

A Fragata D Frenando II e Gloria foi visitado no dia 28. de Junho 2004. As condições da madeira na região de sobra quilha a de „bilge“ foram inspeccionado relativo á aspecto visual e por meio de pancadas dum martel. A humedade da madeira foi medido directamente na superficie com mediador capacitivo e controllado depois nuns provas no laboratório . A resistência da madeira interior foi examinado mediante uma máquina de furtar.

Ao contrário de relatórios anteriores a situação actual foi concordado acceptável. A humedade de madeira e do ar era diminuido para um equilíbrio acceptável. Deterioração e fungos foram encontrado mas num quantidade e extenção que no média prazo não ameaça a estabilidade do barco situado nos cais de Lisboa.

Para preservar esta peça hisorica de alto valor no longo prazo um tratamento da superficie interior com um product á base de boro com alta penetração é recomendado.

### Summary

In contrast to previous reports informing of very bad situation the frigate D. Fernando II e Glória was actually found in satisfying conditions. Most of all the reported high humidity of wood and air as the reason for deterioration of the wooden structure where reduced to an acceptable equilibrium. Consequently, decay was found but in an extend that in short time is not able to threaten the stability and life of the frigate.

For a mean and long term preservation of the frigate the use of diffusible boron preservatives with high penetratability is recommended. All parts below the water line that will have moisture conditions sufficient for fungal growth should be surface treated with the boron product to provide a long term protection and thus preserve the special historical value of D. Fernando e Glória for the next decades.

## Results

### Bilge and lower deck



Fig. 3+4. Details of the construction of the hull: Rafters approx. 26\*26cm covered on both sides with planks of approx 8cm thickness. Distance of rafters approx. 40cm.

Throughout the whole ship the same situation was found (Fig. 3+4). Some decayed structural elements were detected (Fig. 5). The decay was mostly associated with parts of less durable pine wood where even the suspicion is probably that sapwood that has no natural durability was used. Wood of Pine, Oak (obviously Cork oak) and Teak were used. Taking into consideration the situation of the partly destroyed vessel before its reconstruction in 1992 (Fig. 6) this mixture and combination of species in the wooden structure is not surprising.

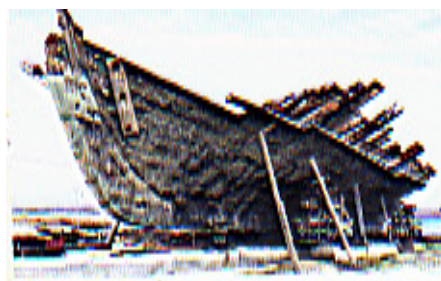


Fig 5 (left): Deteriorated rafter in the back

Fig. 6: (above) with courtesy taken from the on board distributed hand-out. Image before reconstruction

Moisture measurements (oven drying) were taken out on several specimens in the INETI laboratory. Sound wood showed a humidity of approx. 20-24%, but deteriorated wood raised up to approx. 80%. The air humidity was with 60-70% r.h. and a temperature of approx. 25°C (Fig. 7+8) well established and controlled by condensation air-dryers (Fig. 9)





Fig. 7: (left) Bow-room. Traces of floating water are visible but know the wood is at acceptable equilibrium moisture. Some deteriorated rafters are replaced by laminated and on site glued wood that is unfortunately of Spruce (*Picea ssp.*) with no natural durability (!).

Fig. 8, (right): Detail: Air humidity is controlled continuously.



Fig. 9: condensation air-dryer in the technical room in the middle of the vessel.



Fig. 10: Bilge below the technical room: Water is continuously standing at the keel which is normal for any vessel. No signs of decay were found.

The high natural durability of the original Teak wood can be demonstrated on the upper keel in the bilge (Fig. 10): No signs of decay are detectable although the wood is in continuous contact with water.

#### Upper decks

Decay was found on upper decks, too.

In the first deck above the bilge bow all surfaces are painted white. The lower deck area had been painted, too. Due to a previous recommendation to take the paint off, it had been sanded off.

The paint forms a thick coat on the surface preventing the evaporation of water penetrating the wood through natural cracks (Fig. 11). This effect can be studied on Fig 11: The crack on the surface resulting from a not, thus a natural structural defect, allowed water to penetrate in the wood. The paint prevented the evaporation resulting in decay around the not. Unclear is the source of the water. It must have been running down the planks after they were painted. It is the most probably explanation that this decay was initiated even at the shipyard at the reconstruction in 1992.

Decay at the windows of the rear part have the same reason: Uptake of water but no or only slow drying due to coatings in combination with less durable wood species or parts of wood (Fig. 12).



Fig 11: Decay in the painted planks



Fig. 12: the highly structured rear part gives many water traps.

## Conclusions

Decay is a natural process in wood when it becomes wet. Wet means humidities above 20-25% (weight water/weight dry wood). Several brown-rot and white-rot fungi were found so that it can be concluded that not a special fungus infected the wood but that the humidity conditions were suitable for decay.

The use of air-dryers and the sanding of the paint coat reduced the humidity surprisingly fast to an acceptable extend. Consequently, the situation became less dangerous.

Decayed parts are still humid giving conditions for the fungi to survive and to infect the still sound structures.

To prevent decay durable species, most of all teak or other coloured tropical hardwoods were used as was done when the vessel was first build in 1843. Any chemical treatment can not be as efficient as a durable wood. Unfortunately during reconstruction and even with recent repair non durable softwoods were used. This parts have to be protected chemically. The amount and the individual positions of this non-durable parts are not known. Consequently, a treatment of the whole area in contact with water, that is the part below the water line has to be treated.

It was discussed, if the daily cleaning of the deck with water could be a reason for decay. In principle it could. But by wetting the deck surface the planks will swell. This normally results in closing all small cracks etc. that could water let run down into the construction. Consequently, normally water should not enter into the inner parts of the vessel. When the investigation was done, the deck was cleaned. No traces of water were seen to enter below the upper deck. May be in former times some shots ore other openings were not closed allowing water to enter. As a conclusion the cleaning of the deck seams not to be a main reason for increasing the humidity of the wood.

Some decay on wooden structures exposed to the weather have to be considered normal. Thus, a constant control and maintenance is essential for a wooden vessel.

## Recommendations

① Continuous control of the humidity of the air. If necessary ventilation.

② Removal of all paint coatings in the lower part that could be wetted by the water from the river penetrating through the hull. It is recommended to keep free an area aprox. 1/2m above the outside copper plates. (compare yellow lines drawing p.7).

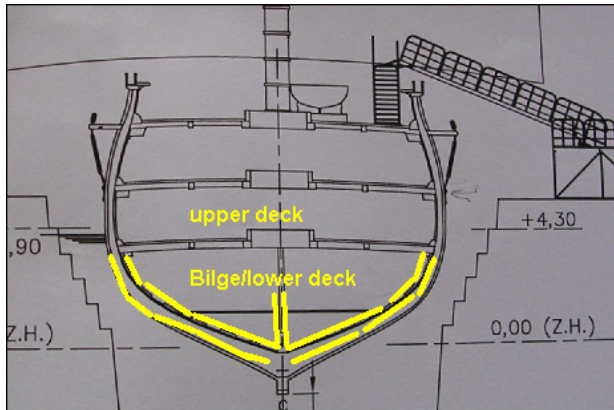
③ An additional chemical treatment will be recommended. This aims at to points: Giving durability to non durable parts which are distributed throughout the whole vessel without knowing where and how many there are. Second: Combating or stopping the fungi in the deteriorated parts which are also somewhere camouflaged in the vessel. Thus, it is easier to treat all surfaces.

The treatment should be done by a active substance that shows high diffusibility in moist wood - that is the general advantage of Boron preservatives - but is also able to penetrate dry wood and to penetrate between the joints and contacting surfaces. To reach the inner surfaces of the hull construction between the rafters, a liquid product should be sprayed.



Taking into consideration the health aspects for the crew and the visitors, again boron preservatives are first choice.

Due to the penetrating capacity in dry wood BORACOL 20 is recommended. This boron preservative is based on glycol and not on water giving the penetration. Due to the penetration the surfaces will remain mainly clean after treatment if the recommended amount of 300ml/m<sup>2</sup> is not exceeded. The treatment should be repeated after 5-10 years.



With a length of 54m and a width of 8,5m a hull surface of approx. 12m is estimated. The hull has 3 surfaces thus a surface of approx. 2000m<sup>2</sup> is calculated. With 300ml/m<sup>2</sup> a total consumption of approx. 700l is calculated.

In case of any comments or questions do not hesitate to contact us.

With best regards

Dr. André Peylo