

# Bending of wooden planks in ancient shipbuilding

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## Introduction

The main structural material for shipbuilding in antiquity was wood, which was easy to work and available in most civilizations. When building a wooden ship, the shipwright had to bend the planks to fit the shape of the hull (Fig. 1). In order to reduce the bending effort, various methods were used to make the wood pliable: soaking in water, steaming (Fig. 2), heating in boiling water, heating with direct open fire, or a combination of these. The planks were clamped in place after fitting them into the hull.

## Research methods

In this study, bending experiments were conducted on seven groups of planks of the same timber species (*Pinus brutia*), including a control group, each group first being subjected to different treatment methods. The methods used were: soaking in fresh water, boiling in sea water, boiling in fresh water, direct open fire heating (Fig. 3), and combinations of these. The planks were then clamped into their new shape, some of the groups for three months in order to test the behavior under creep conditions.

The variables measured were: the degree of spring-back of the plank (after releasing from clamping and soaking in sea water), modulus of elasticity, fracture strength of the wood and the amount of bending causing fracture (Fig. 4).

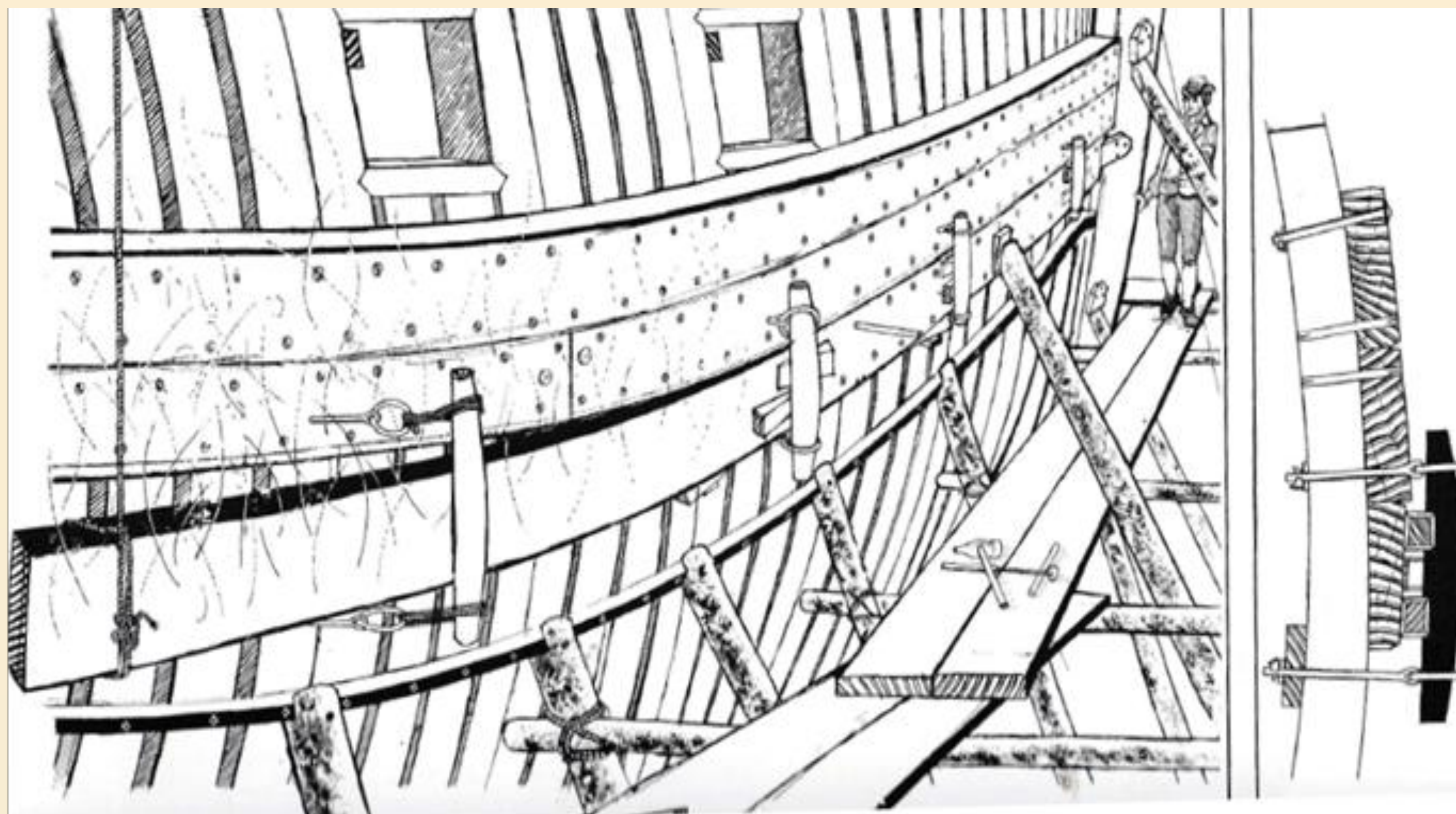


Fig 1: Steamed plank installed on an 18th century ship (Dodds and Moore, 1984: fig. 84).

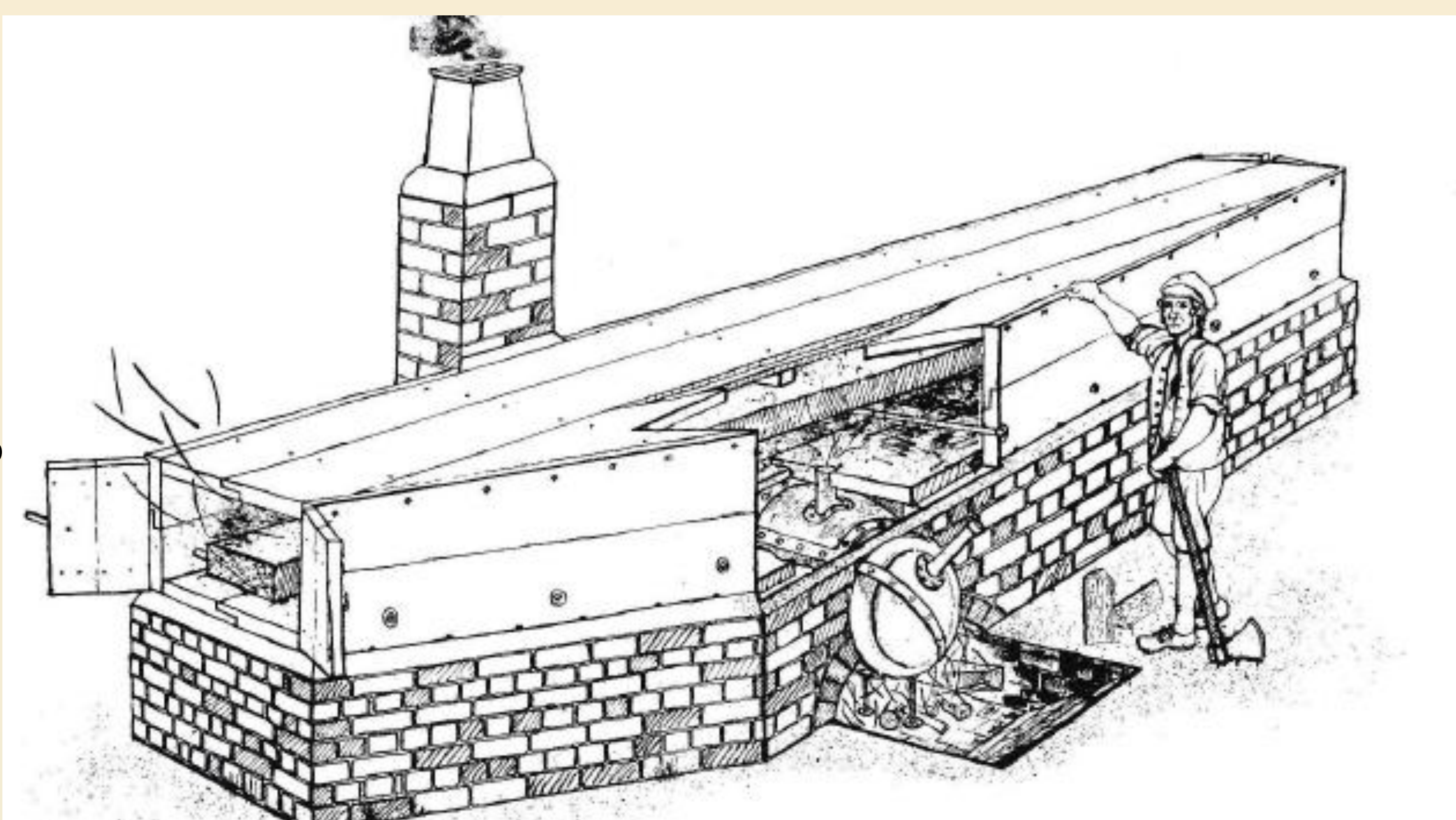


Fig. 2: 18th century steam box used for treating planks (Dodds and Moore, 1984: fig. 83)

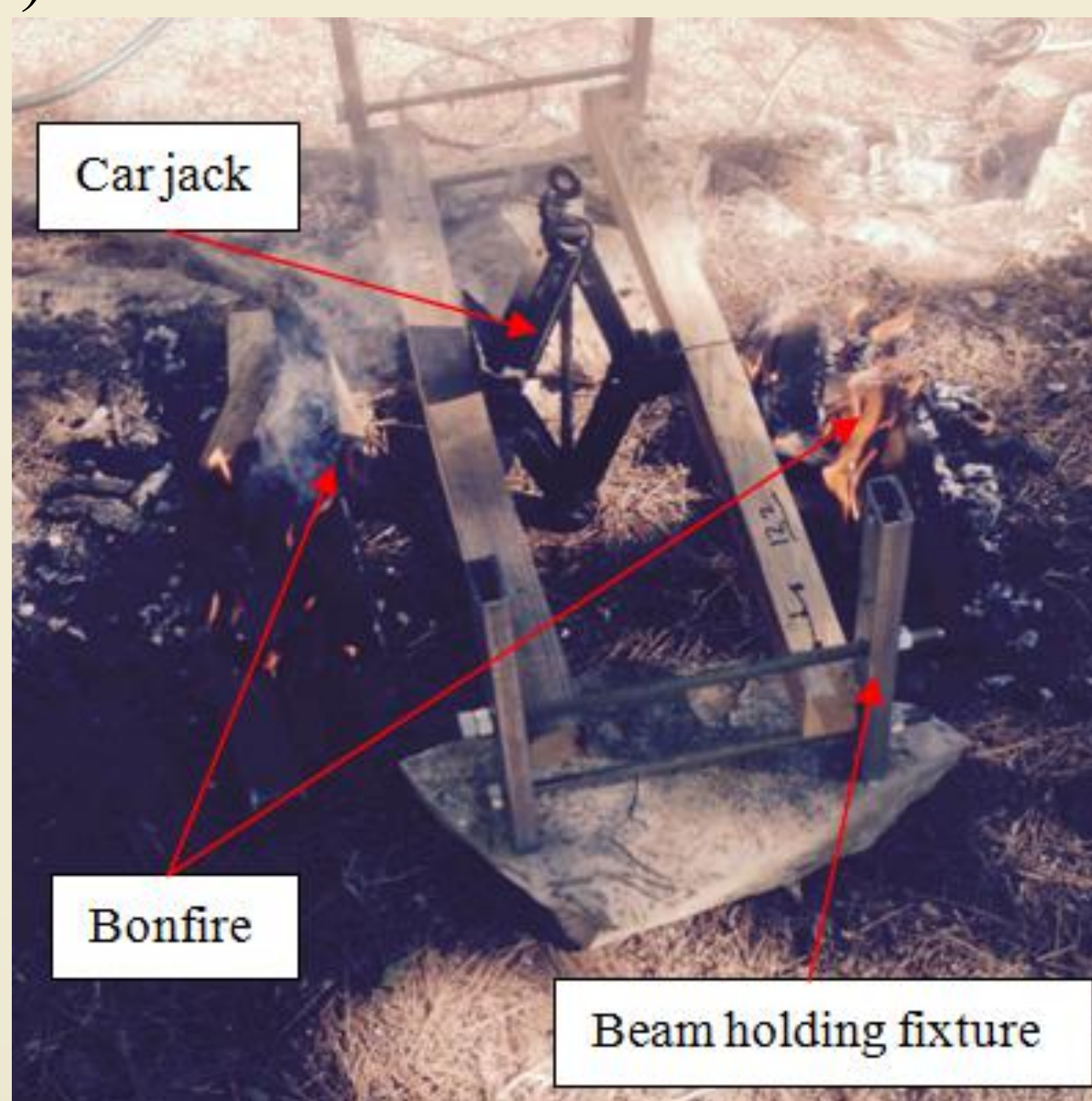


Fig. 3: Open fire heating set-up of beam specimen

## Results

The experiments show that every method had an adverse effect on the mechanical properties of the wood after cooling and drying. In addition, the residual stress in the planks was in the range of 50% to 130% of the expected failure value, which would have led to structural failure if the ship had not been built with high safety factors.



Fig. 4: Set-up of a beam bending test (According to ASTM D143-4)

## Conclusions

The direct open fire method was found to have the least adverse effect on mechanical properties, requiring minimum force for installation in place.

The 'deformation to fracture' results indicate that this method has some advantage over soaking and boiling in fresh water.

The internal stresses absorb a certain amount of the wood's ability to resist load during ship's life. Unless the shipwright used a large safety margin, the hull structure could have failed. Using weighted averages to account for the relative importance of each attribute ('residual strength fraction' and 'deformation to fracture' having highest importance), soaking and boiling in fresh water attained the highest weight (Fig. 5).

## Acknowledgments

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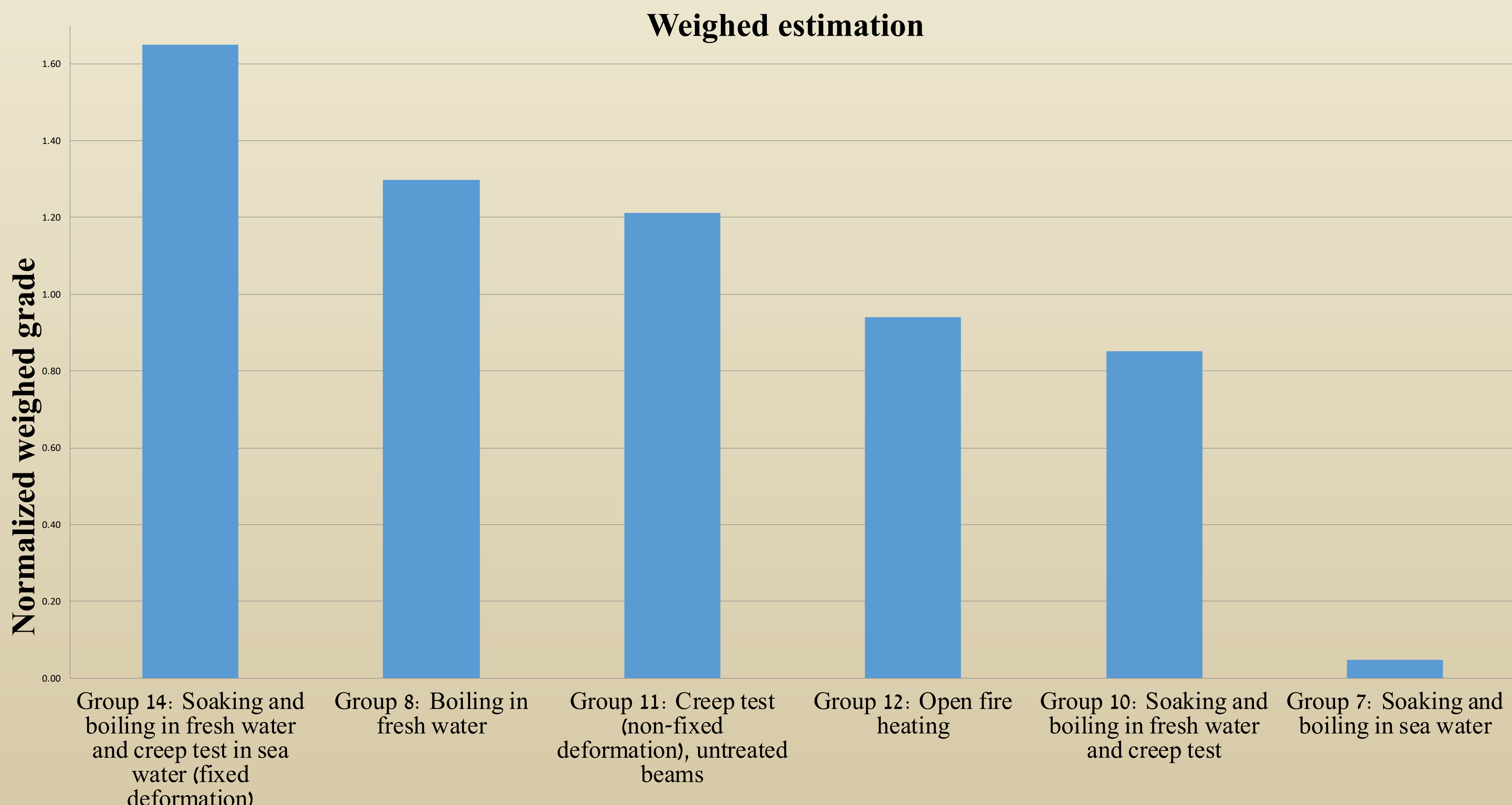


Fig. 5: The weighted averages calculation