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MODIFICATIONS OF PHYSICAL AND MECHANICAL CHARACTERISTICS INDUCED BY HEAT TREATMENT: CASE STUDY ON AYOUS WOOD (*Triplochiton scleroxylon* K. SCHUM).

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INTRODUCTION

- Ayous wood is obtained from the species *Triplochiton scleroxylon* K Schum, widely diffused in tropical areas of central western Africa with uneven annual rainfall distribution.
- Appreciation and diffusion for this wood on occidental market is due to the low cost compared to similar species produced in Europe. Important use of ayous wood is for realizing outdoor covering of the buildings, especially in northern center Europe.
- Ayous wood is a low durable wood; to improve the durability preservatives are generally needed, which can limit the effects caused by wood degradation agents. A valid alternative to chemical preservatives is the thermal modification of wood.

- Thermo treatment is a physical-chemical alteration realized exposing the wood to high temperature for some hours.
- Heat treated wood is low reactive with water due to lower quantity of free polar sites. Other effect of heat treatment is color alteration, that change in darker tones generally more appreciated, and increased durability.
- The aim of this study is to evaluate the ayous wood which was industrially subjected to thermal modification, in order to emphasize the influence of heat treatment at 215 °C on selected physical and mechanical characteristics with a comparison with untreated wood coming from the same area (Cameroon).

- Untreated and heat-treated samples were used. The thermally modification was conducted on planks of ayous in an industrial system that used a slight initial vacuum in an autoclave (Maspell WDE Model TVS 6000) and a treatment temperature of 215 °C for three hours.
- Laboratory tests were conducted following the reference standards UNI ISO 13061-1, UNI ISO 13061-2, ISO 13061-3, ISO 13061-13, UNI EN 1534, UNI ISO 3787 for the tests and UNI ISO 3129 for the sample realization.

- Analyzed physical characteristics were wood density, basic density, linear shrinkages and volumetric shrinkage. Samples dimension was measured with a digital caliper (± 0.01 mm), mass was recorded at a precision scale ±0.001 g. Sample were dried using a ventilated oven to 103 ±2 °C for 24+6 h, according to the reference standard. Demineralized water was used to reach the maximum swelling. Applied formulas to define physical properties were reported in the reference standards: UNI ISO 13061-1, UNI ISO 13061-2 and ISO 13061-13.

PHYSICAL CHARACTERIZATION

Physical properties	Sample n.	Mean	Standard dev.
Wood density [mc12%] (g/cm^3)	30	0.39	0.02
Basic density (g/cm^3)	30	0.33	0.02
Radial shrinkage (%)	30	2.76	0.27
Tangential shrinkage (%)	30	5.00	0.28
Volumetric shrinkage (%)	30	7.83	0.42

PHYSICAL PROPERTIES OF UNTREATED WOOD (MC= MOISTURE CONTENT).

Physical properties	Sample n.	Mean	Standard dev.
Wood density (g/cm^3)	30	0.32	0.02
Basic density (g/cm^3)	30	0.30	0.02
Radial shrinkage (%)	30	1.27	0.26
Tangential shrinkage (%)	30	1.92	0.25
Volumetric shrinkage (%)	30	3.32	0.45

PHYSICAL PROPERTIES OF HEAT-TREATED WOOD.

Determined mechanical properties were:

- axial compression strength
- static bending strength
- Brinell hardness

MECHANICAL CHARACTERIZATION

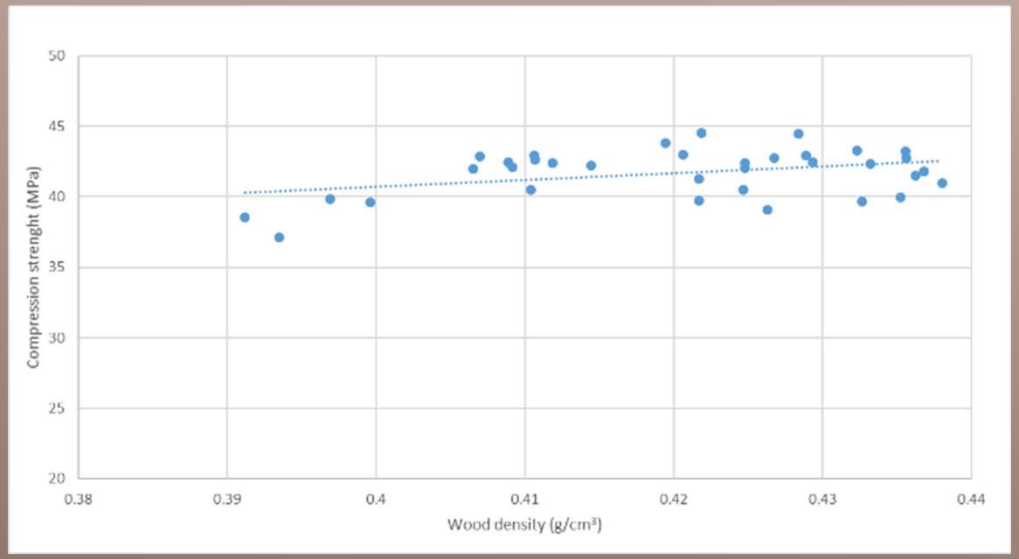
- For axial compression strength test samples were measured and weighed, then they were put between the steel plates of testing machine. The load was applied such that the sample was broken in 1,5-2 minutes. After the test, samples were weighed and dried in oven to 103°C for 24+6 h to determine moisture content and wood density according with reference standard. Applied formulas are reported in the reference standard UNI ISO 3787.
- For static bending strength test samples length and the median section were measured; the load was applied such that the sample was broken in 1,5-2 minutes. After test, from every samples were cut a piece used to determine wood density and moisture content. Applied formulas are reported in the reference standard ISO 13061-3.
- For Brinell hardness test samples were loaded with 1 kN for 25 seconds; the load was applied such that the maximum load of 1 kN was reached in 15 seconds from the start. The samples were left rest for at least three minutes after load application. Then two diameters of the indentation were measured, one parallel to fiber direction, and the second perpendicular to fiber direction. Applied formulas to define the Brinell hardness are reported in the reference standard UNI EN 1534.

Mechanical properties	Sample n.	Mean	Standard dev.
Compression strength (MPa) (MC 12%)	35	36.62	1.5
Static bending strength (MPa) (MC 12%)	40	61.07	7.71
Brinell hardness HB (N/mm^2)	73	12.21	2.09

MECHANICAL PROPERTIES OF UNTREATED WOOD (MC= MOISTURE CONTENT).

Mechanical properties	Sample n.	Mean	Standard dev.
Compression strength (MPa)	35	34.14	2.52
Static bending strength (MPa)	40	37.59	3.58
Brinell hardness HB (N/mm^2)	68	8.3	1.05

MECHANICAL PROPERTIES OF HEAT-TREATED WOOD.



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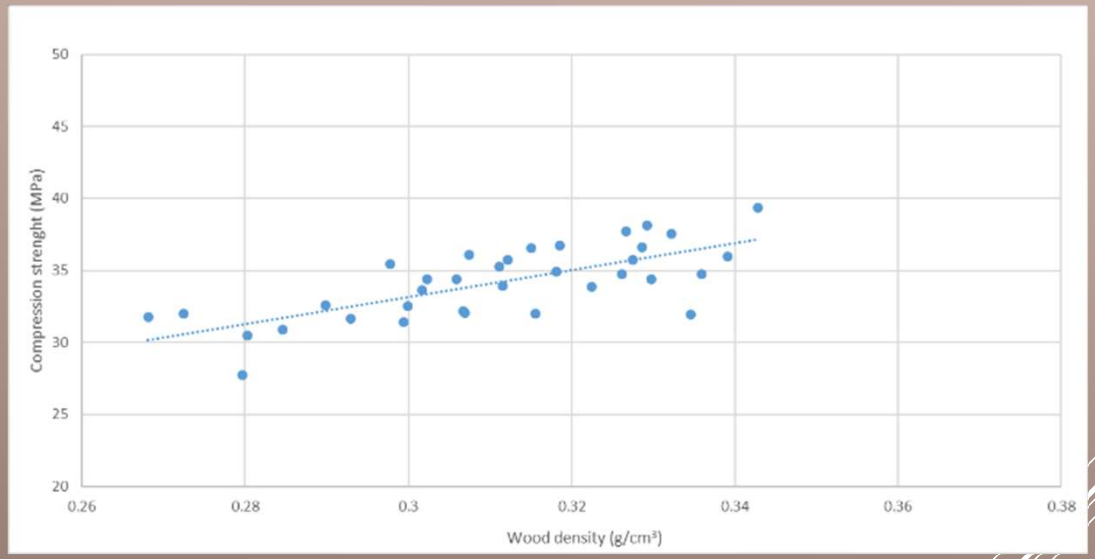
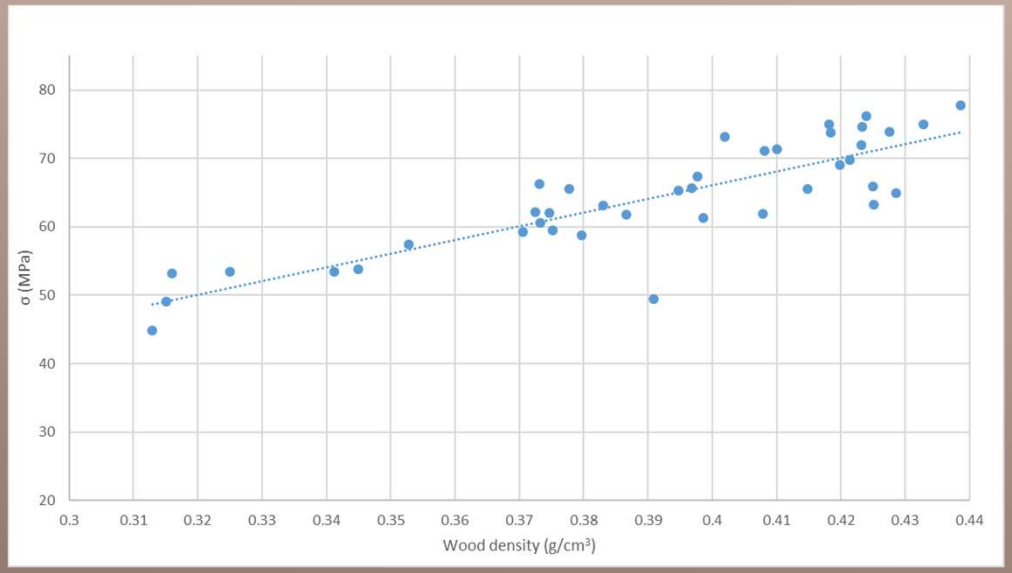
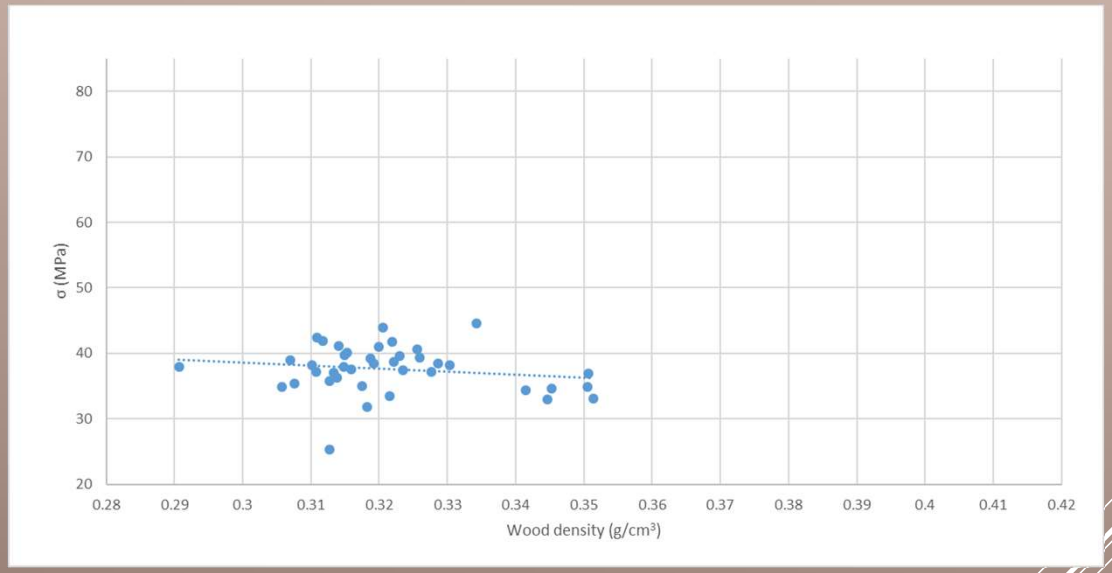


(b)

COMPRESSIVE STRENGTH AS A FUNCTION OF DENSITY IN AYOUS
(a) UNTREATED WOOD;
(b) THERMALLY TREATED WOOD.



(a)



(b)

BENDING STRENGTH AS A FUNCTION OF DENSITY IN AYOUS
(a) UNTREATED WOOD;
(b) THERMALLY TREATED WOOD

- It was observed that equilibrium moisture content of untreated wood was 10%, whereas heat-treated wood reached 4% of moisture content, exposed to the same laboratory environmental condition. This evidence was due the chemical modification that make the treated wood less reactive to humidity.
- Heat-treatment adversely influenced the physical properties. In details, wood density was reduced from 0,39 to 0,32 g/cm^3; basic density from 0,33 to 0,30 g/cm^3; volumetric shrinkage from 7,8% of untreated wood to 3,3% of heat-treated wood. The heat treatment performed therefore induced a decrease of these characteristics of 18, 9, and 58% respectively.
- Likewise the physical features, a general reduction of studied mechanical properties was observed in heat-treated wood, as widely reported in other wood species. Axial compression strength was reduced from 36,6 of untreated wood to 34,2 MPa; of heat-treated wood static bending strength from 61,1 to 37,6 MPa; Brinell hardness from 1,24 kg/mm^2 to 0,85 kg/mm^2. The reduction was respectively 18, 41 and 32%.

CONCLUSION

The modification of mechanical and physical properties was related to alteration induced by the industrial thermal treatment at 215 °C.

The physical characteristics benefit from the heat treatment above all for the reduction of shrinkage and for the greater stability to thermo-hygrometric variations.

These effects are due to deterioration of chemical structure and cell wall compounds induced by the high temperature.

Confirm of this hypothesis comes from the reduction of the equilibrium moisture content of the material. Further studies about this issue can contribute to determine the influence of the specific thermal cycle on the physical and mechanical properties of ayous.

ACKNOWLEDGMENTS

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