PHYSICAL AND MECHANICAL PROPERTIES OF ATHEL WOOD *(TAMARIX APHYLLA)*

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ABSTRACT

The aim of this work was to determine the main physical and mechanical properties of athel wood (*Tamarix aphylla*), one of the least studied non-commercial wood species. Wood samples of *Tamarix aphylla* were collected from a small tree stand in Molyvos coastal area (Lesvos, Greece) and standard test methods were followed on small green specimens. Athel wood's air- and oven dry densities were determined at 0.73 and 0.66 g/cm^3, while maximum tangential shrinkage and swelling were approximately 10.8 and 12.1%, respectively. The volumetric shrinkage and swelling were estimated at 14.0 and 15.5%, respectively. Modulus of rupture, modulus of elasticity, compression strength parallel to grain and Janka hardness (perpendicular to grain) values were found to be 88.5 N/mm^2, 7,533 N/mm^2, 40.9 N/mm^2 and 33.7 N/mm^2, respectively.

Keywords*:* Wood, Tamarix *aphylla,* Mechanical properties, Density, Shrinkage, Swelling

1. INTRODUCTION

Tamarix is a genus of the family *Tamaricaceae* and is composed of 54 species native only in the old world, with one major center of speciation in the Pakistan - Afghanistan - Iran - Turkmenistan - southern Kazakhstan - western China area, and another in the eastern Mediterranean area (Baum, 1978). One of the most known species of this genus is *Tamarix aphylla* which is widespread throughout southeastern Europe, North Africa and Central Asia (Orwa et al., 2009). In Greece and Turkey, this non-commercial species is very common in the coastal areas, beaches and islands mainly in the form of shrubs (Voulgaridis, 2009).

Tamarix aphylla is a fast growing, moderate sized evergreen tree, up to 18 m high with erect tapering trunk, with a ~60-80 cm diameter at breast height and with many stout spreading purplish brown and smooth branches. Its wood is close-grained, light-coloured, fibrous, and fairly hard, with high shock resistance; it also splits readily when first cut and polishes well (Orwa et al., 2009).

Nasir and coworkers (2007) have reported on the general characteristics and structure of athel wood but not on the physical or mechanical properties of it.

Nowadays the end uses of *Tamarix aphylla* wood are diverse. In the USA, athel wood is used for fuel. It is also capable of taking a high polish and has been proposed for fence posts (Tesky, 1992). Moreover, it has been found to be a suitable raw material for making particleboards and can be used as biomass for sugar production (Zheng et al., 2006; Zheng et al., 2007).

Athel wood is additionally utilised for firewood and charcoal (Orwa et al., 2009). It may also be suitable for making ploughs, wheels, carts, tool handles, brush-backs, ornaments, turnery and fruit boxes. Its twigs are used for basket making, while its bark is a rich source of tannins and mordant for dyeing (Orwa et al., 2009). In Turkey, currently, there is not much information available on the properties of athel wood. Determining the properties of athel wood may provide an initial data to the researchers and offer interesting opportunities in future.

Up to date, there has not been any study concentrated on the properties of athel wood. The objective of this work therefore was to determine some of the main physical and mechanical properties of athel wood (*Tamarix aphylla*), of which not detailed previous research had been found in the literature.

2. MATERIALS AND METHODS

Samples of mature wood of *Tamarix aphylla* were cut from 3 trees in Molyvos coastal area, in the island of Lesvos, Greece. These trees had a ~40 cm diameter at breast height. After a slow air drying process of three months, small clear wood specimens were prepared from this material according to Table 1. Specimens were then conditioned at normal climatic conditions, that is, 20±1°C and 65±3% relative humidity (RH), for a period of twelve weeks.

Preparation of cross sections: Wood blocks (20 x 20 x 20 mm) taken from the specimens were softened by boiling in water for 4 h. After the complete softening of the wood blocks, cross sections were cut using a sliding microtome and prepared at a magnification of ~20X.

Measurements of physical properties: Density was determined according to DIN EN 52182 standard under two conditions: oven-dry (at ~0% moisture content) and air-dry condition. The maximum shrinkage, that is, the directional change from the fibre saturation point until the oven-dry condition, was measured in fifteen specimens according to DIN EN 52184 standard. Specimens with moisture content above the fibre saturation point were collected and their tangential and radial anatomical dimensions were recorded. Subsequently, the specimens were dried in an air-circulating oven at 103±2°C until constant mass weights.

Following the shrinkage tests, the maximum swelling of the same wood specimens was measured. Oven-dry volume and mass were recorded for each specimen during the first set of experiments (shrinkage tests). Thereafter, each specimen was slowly wetted with water using an absorbing paper. This allowed each specimen to slowly absorb water until it reached a point where its weight corresponded to a ~30% moisture content level (i.e. fibre saturation point), as projected out of its initial oven-dry mass.

Table 1. Information on the testing of *Tamarix aphylla* wood.

Property	Number of specimens	Dimensions of specimens*	Standard
Density, air-dry	15	40 x 20 x 20	DIN 52182
Density, oven-dry	15	40 x 20 x 20	DIN 52182
Shrinkage & swelling	15	10 x 20 x 20	DIN 52184
Static bending	15	360 x 20 x 20	DIN 52186
Axial compression	20	60 x 20 x 20	DIN 52185
Hardness (Janka test)	20	50 x 50 x 50	ASTM D143-94

* Longitudinal x radial x tangential direction (mm x mm x mm)

Measurements of mechanical properties: The cross section of *Tamarix aphylla* wood is presented in Fig. 1. The growth rings are distinct, and its vessels appear to be small to medium and variable in size, usually solitary and distributed unevenly. The rays are thick and broad conspicuous. These data are in very good agreement with the findings of Nasir et al. (2007).

The mechanical properties of *Tamarix aphylla* wood were evaluated on specimens free from defects under normal climatic conditions (65±3% RH and 20±1°C) in accordance with DIN EN 52180-1 standard. The results obtained were compared with the properties of ash wood (*Fraxinus sp.*), a commercial species with a similar density.

The static bending tests were performed according to DIN EN 52186 standard. The static modulus of elasticity (MOE) was determined on fifteen specimens by testing static bending strength; the testing for evaluating the modulus of rupture (MOR) was performed with a Zwick-Roell Z020 testing machine. The load was applied at a rate of 5 mm/min. The compression strength in parallel direction to the fibre (axial compression) was evaluated according to DIN EN 52185 standard. In addition, the modified Janka hardness in transverse direction was measured according to ASTM D143-94 standard.

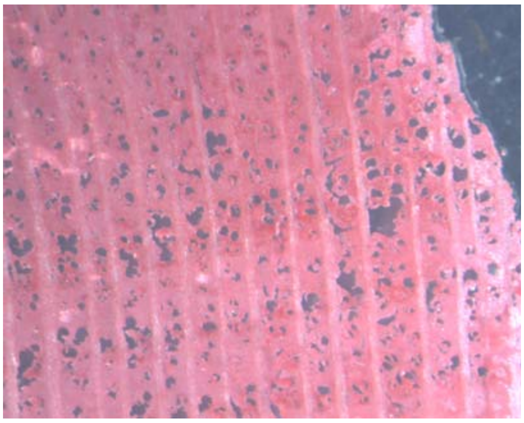

Figure 1. Cross section of *Tamarix aphylla* wood (magnification of ~20X).

3. RESULTS AND DISCUSSIONS

The physical and mechanical properties obtained of *Tamarix aphylla* wood samples are shown in Table 2. The corresponding property values of ash wood (*Fraxinus sp.*) as reported by Tsoumis (1991) are also shown in Table 2 for comparative purposes.

Table 2. Physical and mechanical properties of *Tamarix aphylla* wood and comparative literature values of *Fraxinus sp*. wood.

Property	*Tamarix aphylla* wood[1]	*Fraxinus sp.* wood[2]
Wood density (g/cm^3)		
oven-dry	0.66 (0.03)	0.66
air-dry	0.73 (0.03)	0.70
Shrinkage (%), maximum		
radial	3.2 (1.0)	5.2
tangential	10.8 (2.1)	8.3
ratio T/R shrinkage	3.8 (1.4)	1.6
Swelling (%), maximum		
radial	3.4 (1.0)	-
tangential	12.1 (2.5)	-
MOE (N/mm^2)	7,533 (1,008)	13,130
MOR (N/mm^2)	88.5 (5.2)	118
Axial compression (N/mm^2)	40.9 (2.3)	51
Janka hardness		
transverse (N/mm^2)	33.7 (2.8)	59

[1] Average value ± standard deviation. [2] Data from Tsoumis (1991)

Athel wood's air-dry and oven-dry densities were determined at 0.73 and 0.66 g/cm^3, respectively. Volumetric shrinkage was determined at 14%; a little higher as compared with that of ash (13.5%), a wood species with the same density.

Tangential shrinkage (10.8%) and swelling (12.1%) of this wood were found to be very high, that is, much higher than its radial shrinkage (3.2%) and swelling (3.4%). Notably this resulted in an extraordinary high tangential/radial ratio (3.8) for this species. For comparison (Table 2), the maximum shrinkage values of ash wood have been reported to be 8.3% in the tangential direction and 5.2% in the radial direction (i.e. tangential/radial ratio: 1.6).

The average MOE of *Tamarix aphylla* wood was 7533 N/mm^2; the average MOR value was 88.5 N/mm^2. These values are very low as compared with those of ash wood (MOE: 13,130 N/mm^2, MOR: 118 N/mm^2) reported by Tsoumis (1991).

The axial compression of athel wood was found to be 40.9 N/mm^2 on the average. Tsoumis (1991) has reported a value of 51.0 N/mm^2 for axial compression strength of ash wood, which is quite higher than that of athel wood found in this work. The Janka hardness was estimated at ca. 33.7 N/mm^2 in the transverse direction. This value seems extremely low. Ash wood has been reported in the literature to show much higher Janka hardness values, e.g. 59 N/mm^2 (Tsoumis, 1991).

4. CONCLUSIONS

This work focused on the main physical and mechanical properties of *Tamarix aphylla* wood. The results showed that the mechanical properties (MOR, MOE, axial compression, Janka hardness) of this wood species are very low as compared with those of ash wood, a known commercial species with equivalent density. In addition, the tangential shrinkage and swelling of *Tamarix aphylla* wood exhibited high values, while the anisotropy between radial and tangential shrinkage estimated to be extremely high. Consequently, *Tamarix aphylla* wood cannot be considered as useful timber for technical uses. Nevertheless, more work on the chemical properties of this wood for its potential for other uses (e.g. biomass, fuelwood) may be of interest..

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