Gazi University Journal of Science
GU J Sci
23(3):357-362 (2010)

www.gujs.org

Principal Mechanical Properties of Cypress Wood (*Cupressus Sempervirens L.*) Naturally Grown in (Kahramanmaraş) Eastern Mediterranean of Turkey

İbrahim BEKTAŞ [1♠], Ramazan KURT [1]

[1] *Sütçü İmam University,, KSU Faculty of Forestry , Department of Forest Industry Engineering, 46100 Kahramanmaraş Turkey*

Received: 26.03.2009 Revised: 20.01.2010 Accepted: 28.01.2010

ABSTRACT

Some mechanical properties (compression, static bending, impact bending, shear strength and Janka hardness) of cypress wood (Cupressus sempervirenss L.) were evaluated in accordance with Turkish Standards and compared with other cypress' properties. Samples were taken from randomly collected logs naturally grown in Northeastern Mediterranean region (Kahramanmaraş) of Turkey. The results showed that the mean values of compression strength parallel to grain, static bending strength, impact bending strength, shear strength parallel to grain, Janka hardness (cross), Janka hardness (radial) and Janka hardness (tangential) were 45.8 N/mm², 76.8 N/mm², 0.051 J/mm², 6.5 N/mm², 623 N/ mm², 510 N/mm², and 543 N/mm², respectively. The relationship between strength and density was determined using regression analyses, and these were compared with other available published values in the literature. The results showed that cypress wood grown in Kahramanmaraş and the other cypresses have similar mechanical properties and density.

Key Words: *Cypress wood, compression strength, static bending strength, impact bending strength, shear strength, Janka hardness.*

1. INTRODUCTION

An important part of rarely cypress pure stands placed on World is in the southern part of Turkey, and only there are a few studies about it. The common name for this wood is cypress and its scientific name is *Cupressus sempervirens* L. It is a native of Greece and Crete, but is commonly planted for ornament in the Mediterranean region. Cypress grows mainly in northern Iraq, south of Caspian Sea coasts and eastern of Mediterranean Sea (Anatolia, Syria, Lebanon, Palestinian, Jordan, Rhodes, Cyprus, Crete and some of Aegean Islands). This species also is spread on Mediterranean coasts, western Anatolia and even Black Sea coasts of Turkey [1]. In addition, it can be seen locally in the other regions of Turkey where Mediterranean climatic conditions are present [2]. Cypress wood has a little economical value, and recent estimates have calculated that growing are of 1345 ha. in Turkey, equal to 0.006 % of Turkey's forest. This tree species has a 108502 m^3 wood value and 2371 m^3 annual

♠Corresponding author, e-mail: ibtas@ksu.edu.tr

allowable cut [3]. It has not been used efficiently since its uses are relatively unknown.

Height growth may exceed to 30.5 m with a bole diameter of 60 to 90 cm, sometimes reaching to 150 cm. Logs are usually well shaped, straight, and cylindrical [4]

Several studies were conducted in Turkey and around the world using locally grown cypress species to determine their properties. The results showed that the properties cypress wood from different regions were similar. Its texture is fine and uniform and its grains are usually straight. Density and strength of cypress wood is comparable to that of yellow-cedar (*Chamaecyparis nootkatensis* Spach.) or western hemlock (*Tsuga heterophylla* Sarg.). Cypress wood is versatile, easy to work with hand and machine tools, and possible to nail, stain, and polish well. It can be used for structural and nonstructural applications including general construction and furniture making purposes [5,6,7,8,9,10].

In this study, principal mechanical properties of cypress wood, naturally grown in Kahramanmaraş, were determined and with these data, suitable using areas of this wood were established.

2. MATERIALS AND METHODS

Two cypress trees were selected randomly according to Turkish Standard (TS) 4176 (1984) from Kahramanmaraş region (eastern Mediterranean region of Turkey) located in the southern part of Turkey. Table 1 gives more detailed information about selected stand and tree characteristics.

Table 1. Park and trees characteristics.

Stand	
Altitude (m)	530
Slope (%)	10
Exposure	South East
R. humidity (%)	68
A. rainfall (mm)	722
Min. to Max. temperature (^{0}C)	-9 to 42
Tree	
Mean age	78
Mean length (m)	13
Mean diameter (cm)	39

After felling trees, 1 m log sections were taken from at height of 2-4 m from the base according to TS 4176 (1984), and then, the cross sections of green logs were sprayed with a 10% solution of $CuSO_4$ to prevent staining. Lumbers were cut in different thicknesses from log sections and dried. Samples were prepared from dried lumbers and they were conditioned at 20 ± 2 ^{0}C and 65 ± 5 % relative humidity (RH) to the equilibrium moisture content of about 12% for principal mechanical tests.

Principal mechanical properties were determined; including compression strength parallel to grain, static bending strength, impact bending strength, shear strength parallel to grain and janka hardness (cross, radial and tangential sections) according TS 2595 (1976), TS2474 (1976), TS2477 (1976), TS3459 (1980) and TS2479 (1976) respectively. Compression strength parallel to grain, static bending strength, shear strength parallel to grain and janka hardness tests were made using a universal testing machine (Losenhausen Model) and impact bending strength tests were made using an impact tester (Model HPSW 10).

In addition, q value (ratio of compression strength parallel to grain and air dry density of wood), p value (ratio of static bending strength and compression strength parallel to grain), dynamic quality value (ratio of impact bending strength and oven dry density of wood) and static quality (ratio of compression strength parallel to grain and 100× air dry density of wood) were calculated for evaluating the properties and use of cypress wood. Oven-dry and air dry density values were determined according to TS2472 (1976) by cutting specimens from tested samples. The density values were used to calculate q and dynamic quality values. Also, coefficients of correlation (r), coefficient of determination (r^2) in linear regression analysis were found. The linear equations were derived using the relationship between compression strength paralel to grain and air dry density, static bending strength and air dry density lastly janka hardness (cross section) and oven-dry density.

Annual growth ring widths measurements were made using 2 cm strands taken from 0.3 m tree sections that include the pith. A cross section was cleaned and a line was drawn from the pith to bark and measurements were taken using a microscope.

3. RESULTS AND DISCUSSION

Table 2 shows descriptive statistical values for compression strength parallel to grain (N/mm^2), air dry density of compression strengths' samples (g/cm^3), static bending strength (N/mm^2), air dry density of static bending strengths' samples (g/cm^3), impact bending strength (J/mm^2), shear strength parallel to grain (N/mm^2), janka hardness (N/mm^2) and oven dry density of Janka hardnesss' samples (g/cm^3).

The results of compression strength parallel to grain, static bending strength, impact strength, shear strength, air-dry density and annual ring width for Kahramanmaraş cypress wood are compared to other cypress woods' in Table 3.

Table 2. Descriptive statistical values of principal mechanical properties and densities of cypress wood.

Properties		N^{m}	Mean	SD	X_{min}^{n}	X_{max}^{p}
σ_{cpl12}^{a}		30	46.0	19.21	14.8	91.6
D_{12}^{b}		30	0.15	0.072	0.402	0.746
σ_{sbs12}^{c}		30	76.8	16.17	56.5	111.7
D_{12}^{d}		30	0.621	0.027	0.562	0.684
σ_{IS12}^{e}		30	0.051	0.01	0.050	0.080
σ_{ss12}^{f}		30	6.5	0.76	5.71	8.51
JH^{g}	Cross	30	623	93.52	360	792
	Radial	30	510	70.50	301	523
	Tangential	30	543	88.88	324	604
D_{0}^{h}		30	0.542	0.063	0.391	0.721

[a]Compression strength parallel to grain (N/mm^2); [b]The air dry density of compression strengths' samples (g/cm^3); [c]Static bending strength (N/mm^2); [d]The air dry density of static bending strengths' samples (g/cm^3); [e]Impact bending strength (J/mm^2); [f]Shear strength parallel to grain (N/mm^2); [g]Janka hardness (N/mm^2); [h]The oven dry density of Janka hardnesss' samples (g/cm^3); [m]Sample sizes; [n]Minimum value; [p]Maximum value;

Table 3. Comparison of some wood properties of Kahramanmaraş cypress wood with the other cypresses.

Tree species	$\sigma_{cpl12}^{\mathbf{a}}$	$q^{\mathbf{b}}$	$\sigma_{sbs12}^{\mathbf{c}}$	$P^{\mathbf{d}}$	$\sigma_{IS12}^{\mathbf{e}}$	$\sigma_{ss12}^{\mathbf{f}}$	$J_H^{\mathbf{g}}$	$D_{12}^{\mathbf{h}}$	$Arw^{\mathbf{k}}$	***Ref.*** [m]
C. sempervirens (K.maraş)	46.0	75	76.8	1.68	0.051	6.5	560	0.615	2.41	[TS][n]
C. sempervirens (Antalya)	41.0	68	86.4	2.10	0.047	6.2	570	0.600	2.58	[5]
C. lusitanica	44.5	87	74.6	1.68	-	7.0	510	0.512	-	[10]
C. lusitanica	-		85.5	-	-	-	460	0.538	-	[7]

[a]Compression strength parallel to grain (N/mm^2); [b]q value; [c]Static bending strength (N/mm^2); [d]P value; [e]Impact strength (Nm/mm^2); [f]Shear strength (N/mm^2); [g]Janka hardness (cross, N/mm^2); [h]Air-dry density of compression strengths2 samples (g/cm^3); [k]The annual ring width (mm). [m]References; [n]In this study.

Kahramanmaraş cypress has the highest compression and impact strength among all of the cypress species according to Table 3; but, static bending strength is lower than that of Antalya cypress's and *C. lusitanica*'s [7], and shear strength is lower than that of *C. lusitanica*'s [10], and also Janka hardness is lower than that of Antalya cypress's. However, the static bending of Kahramanmaraş cypress woods is higher than that of *C. lusitanica*'s [10] and shear strength is also higher than that of Antalya cypress's species, and Janka hardness is higher than that of cypressess' [7, 10]. Also, Kahramanmaraş cypress has higher air-dry density than that of the other species', but annual ring width is a little lower than Antalya cypress, which is listed in Table 3.

Panshin and Dezeeuw reported [12] that generally, there is a little correlation among age, annual ring width and density in diffuse porous wood; on the other hand, lower altitude can cause higher density. Since, cypress trees generally grows in lower altitude than 500-600 m in Turkey, thus it has a high density. Also, variation of mechanical properties in the same species may be due to different factors such as, soil, growth conditions, climate and ecological factors. Especially, exposure, altitude, soil and climate conditions can affect mechanical properties of wood [13]. For these reasons, some properties of Kahramanmaraş cypress wood showed little difference compared to that of other cypress species.

Softwoods, including cypress, can be classified according to static quality values and these are; fewer than 8 is a low quality, between 8 and 9.5 is a fair quality and above the 9.5 is a good quality [14]. The static quality value (7.44) of Kahramanmaraş cypress wood is low.

Softwoods, including cypress, can also be classified according to the value of dynamic quality [14]. If value of dynamic quality of a softwood is lower than 1, it is a low quality, between 1and 2 is a fair quality and above the 2 is a good quality wood. According to this classification, the dynamic quality value (1.58) of Kahramanmaraş cypress wood is fair.

Generally, p value is accepted as 1.75 [14]. The calculated p value is 1.68 for the Kahramanmaraş cypress wood that is lower than 1.75. Its p value is equal to that of C. *lusitanica's* [10], but, lower that that of of Antalya cypress's. Therefore, Kahramanmaraş cypress does not have a good quality wood according to the reference p value (1.75).

The value of q is another criterion for the evaluation of the wood properties [14]. According to this criterion, Kahramanmaraş cypress has higher q value than Antalya cypress, but, its q value is lower than that of C. *lusitanica's* in Table 3 [10].

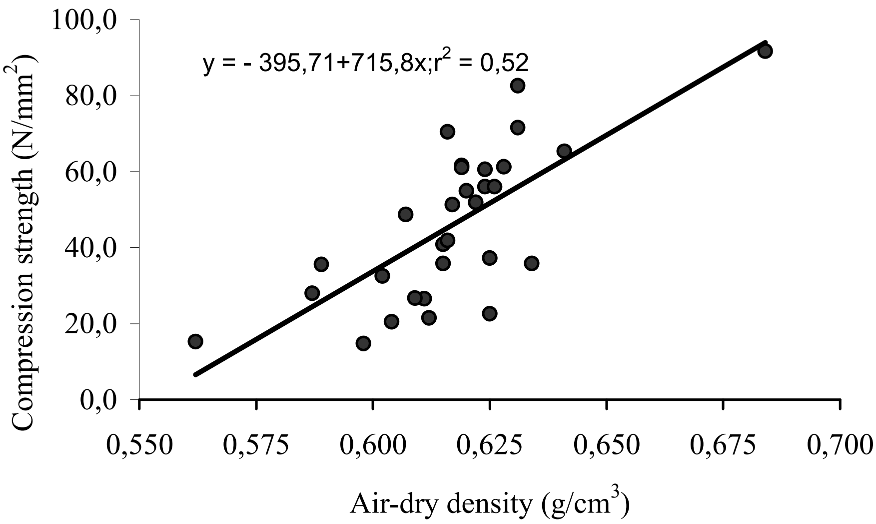

Figure 1. The relationship between compression strength and air-dry density.

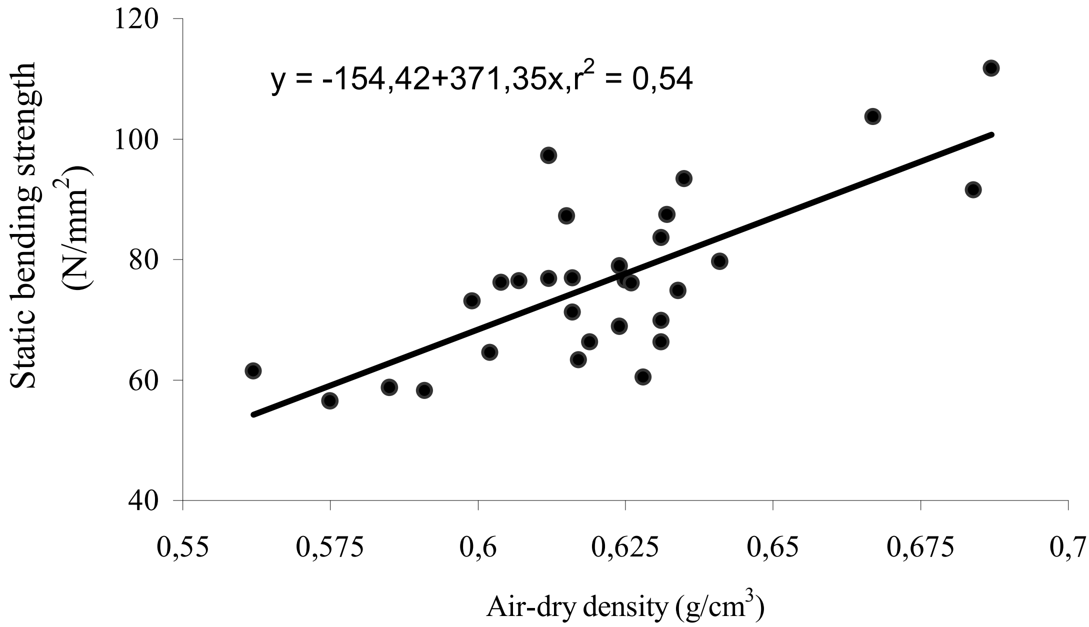

Figure 2. The relationship between static bending strength and air dry density.

The effect of density on compression strength, static bending strength and Janka hardness were statistically calculated by linear regression analyses. The linear equations were derived from all the linear regression analyses shown in Figures 1 through 3. The relationship between compression strength and air-dry density is presented in Figure 1, the relationship between bending strength and air-dry density is presented in the Figure 2, and the relationship between Janka hardness (cross section) and air-dry density is shown in Figure 3 for these analyses.

Figure 1 through 3 show that there are meaningful relationships between compression strength and air-dry density, static bending strength and air-dry density, Janka hardness (cross section) and oven-dry density. The coefficients of correlation (r) are 0.72, 0,73, and 0.71, and the coefficient of determination (r^2) are 0.52, 0.54, and 0.50 respectively.

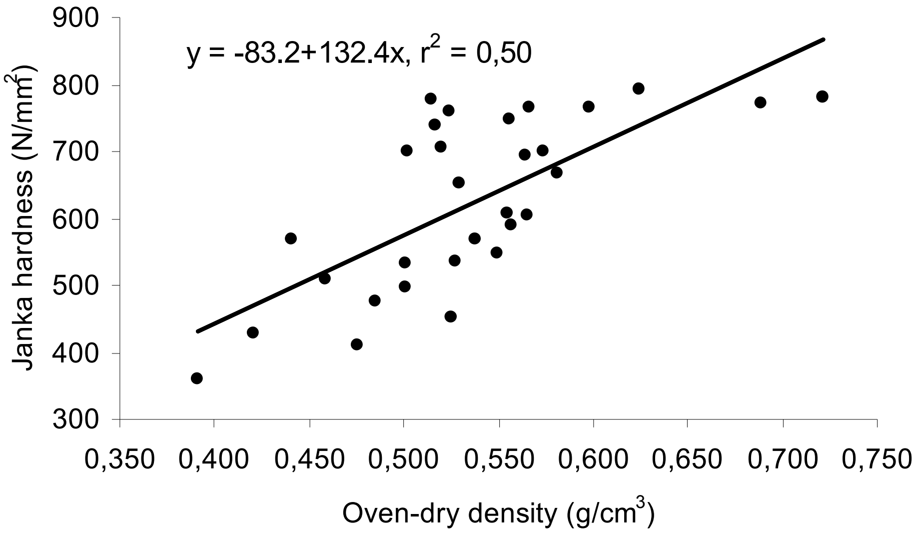

Figure 3. The relationship between janka hardness (cross) and oven - dry density.

4. CONCLUSIONS

Because of the hardness and durability of cypress it could be used in many applications outside the home, such as exterior siding, shingles, and landscape design elements. Given a suitable surface treatment, which provides UV and moisture protection, cypress has excellent durability when compared to other species of wood siding.

In the light of the other researches which were done for the different cypress woods and the results of this current research which was done to determine principal mechanical properties of cypress where naturally grown in Kahramanmaraş, following conclusions can be stated that regarding to the using areas of cypress wood. Test results proved that cypress has medium-though durable and good quality wood. Cypress may found wide utilization areas among the other softwoods. Specific quality value of cypress wood has been found suitable for high strength required areas such as plane, bridge, and tower and construction applications. Cypress wood's dynamic quality value showed that this wood can be used some areas like some part of the construction applications, including flooring and roofing where moderate impact strength is very important. Especially, under the importance of longitudinal stresses such as beams, headers and poles (treated). Cypress wood can be used because it is 'q' value (ratio of compression strength parallel to grain/density) can permit that kind of job applications. Cypress wood with narrow annual growth rings, with respect to the strength and density properties, may be suitable for decorative veneering which is desired wood density should be between 0.450- 0.750 g/cm^3.

REFERENCES

[1] Yaltırık, F., "Dendrology II", Publications of Faculty of Forestry of Istanbul University, Istanbul, 109-116 (1993).

[2] Goker, Y., "Mediterreanen's Forests of Turkey and approachings scientifically on these Forests", Pub. ORUAREN of Faculty of Forestry of University of Istanbul, İstanbul, 170-180 (1992).

[3] Anonim, "The capacity of Turkish forests", ***The Publication Institutions of Turkish Forestry Research***, Ankara, Turkey, 25-48 (1987).

[4] Anonim, “South American Hardwoods: Tree and wood characteristics”, ***http://beachshack.ai/woods.html***(15.06.2009).

[5] Bozkurt, A.Y., Göker, Y., "The Researchings on properties of physical and mechanical of *Cupressus sempervirens* var. *horizontalis*’s wood and its usage areas”, Doğa Journal, TU Tar ve Or. DC 12, S 1, TUBITAK-ORUTAR Project, Ankara, (1988).

[6] Göker, Y., As, N., “The Elastisity Modul of *Cupressus sempervirens* var. *horizontalis* ‘s wood”, ***Journal of İ.Ü, Faculty of Forestry, Serial: A***, İstanbul, 40(1):28-39 (1990).

[7] Chudnoff, M., **“**Agriculture Handbook”, The Pub. of USDA Forest Service. Pub.No: 607, Washington, DC, 78-110,(1984)

[8] Gonzalez T., Gonzalez, G.E., “Propiedades fisicas, mecanicas, usos y otras caracteristicas de algunas maderas comercialmente importantes en Costa Rica”, Parte I. Laboratorio de Productos Forestales, San Pedro, 140-145 (1973).

[9] Record, S.J., Hess, R.W., “Timbers of the new world”, ***Yale University Press***, New Haven, Conn, 102-105 (1949).

[10] USDA, “Wood handbook”, Pub.of Forest Products Society; ISBN: 1892529025, Washington DC, 420-428 (1999).

[11] As, N., “The effect of different origins on the physical, mechanical and technological properties of *Pinus pinaster*”, Ph. D. Thesis, The Scientific Institute of Istanbul University, İstanbul, 280-299 (1992).

[12] Panshin , A.J., Dezeeuw, C., “Textbook of Wood Techonolgy”, Fifth ed. Vol. 1, ***McGraw Hill***, New York, 125-198 (1980).

[13] Bektas, I., Alma, M.H., As, N., Gundogan, R., “Relationship Between Site Index and Several Mechanical Properties of Turkish Calabrian Pine (*Pinus brutia* Ten.)”, ***For. Prod. J.***, 53 (2), Ankara, 27-31(2003).

[14] Bektaş, İ., “The physical and mechanical properties of Calabrian pine (*Pinus brutia* Ten.) and their variations according to regions”, Ph. D. Thesis, ***The Scientific Institute of Istanbul University***, Istanbul, 200-249 (1997).