Physical and mechanical properties of *Cupressus funebris* Endl. wood

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Abstract. In this paper, some selected physical and mechanical properties of *Cupressus funebris* Endl. wood was tested according to the guidelines of the China National Standards, which includes GB/T 1931-2009, GB/T 1933-2009, GB/T 1941-2009, GB/T 1936.2-2009, GB/T 1936.1-2009, GB/T 1935-2009, GB/T 1939-2009. Moisture content, basic density, end, tangential and radial surface hardness, modulus of elasticity, bending strength, compression strength parallel to grain, radial compression strength perpendicular to grain and tangential compression strength perpendicular to grain are 7.9%, 0.65g/cm³, 5333N, 4178N, 4066N, 8.2Gpa, 89.8Mpa, 45.8Mpa, 9.4MPa and 8.9MPa, respectively.

Keywords. physical properties, mechanical properties, *Cupressus funebris* Endl.wood.

1. Introduction

*Cupressus funebris* Endl., also known as Chinese weeping cypress, belongs to the genus *Cupressus* of the Lauraceae family and widely cultivated in central and south China, such as Gansu, Guizhou, Hubei, Hunan, Shaanxi, Sichuan and Chongqing [1]. Nevertheless, their distribution is virtually restricted to north Guizhou, west Hunan, east Sichuan and Chongqing and this may indeed be the only area where the species occurs naturally at present [2]. It may also distribute naturally in Vietnam [3].

At present, the researches on *Cupressus funebris* Endl. in China are mainly focused on the growth, cultivation and ecological benefits, rather than physical and mechanical properties of *Cupressus funebris* Endl. wood.

2. Materials and methods

*Cupressus funebris* Endl. wood were purchased from Shifang Furniture Co., Ltd. of Chengdu city of Sichuan province. The tree was 45-50 years old. Samples were sawed and slow air-dried according to China National Standard GB/T 1929-2009 [4], namely, method of sample logs sawing and test specimens selection for physical and mechanical tests of wood.

All test methods were carried out according to China National Standards. Moisture content, density, hardness, modulus of elasticity(MOE), bending strength, compression strength parallel to grain and compression perpendicular to grain were evaluated according to the GB/T 1931-2009 (Method for determination of the moisture content of wood) [5], GB/T 1933-2009 (Method for determination of the...
density of wood) [6], GB/T 1941-2009 (Method of testing in hardness of wood) [7], GB/T 1936.2-2009 (Method for determination of the modulus of elasticity in static bending of wood) [8], GB/T 1936.1-2009 (Method of testing in bending strength of wood) [9], GB/T 1935-2009 (Method of testing in compression strength parallel to grain of wood) [10] and GB/T 1939-2009 (Method of testing in compression perpendicular to grain of wood) [11], respectively.

3. Results and discussion
The results obtained on the moisture content (MC) of *Cupressus funebris* Endl. wood are shown in Table 1. The moisture content affects many physical and mechanical properties of wood, therefore, in the production and manufacture of *Cupressus funebris* Endl. wood furniture, the production, processing and maintenance of the furniture components is also directly affected by the moisture content of timber. A large amount of water vaporized in the drying of *Cupressus funebris* Endl. wood, and wood cannot be processed immediately after it is cut down. It is generally required for 15 days or so to alleviate the internal stress produced in the drying process, and better achieve the balanced water content equivalent to the actual application environment. It is better to achieve equilibrium moisture content equivalent to the actual application environment.

| Table 1. The moisture content test results of *Cupressus funebris* Endl. wood |
|-----------------------------|---------|----------------|----------------|------------------|
| Number of specimens Average value (%) Standard deviation Standard error Coefficient of variation(%) |
| 35 | 7.9 | 0.459 | 0.078 | 35 |

The results obtained on the basic density (BD) of *Cupressus funebris* Endl. wood are shown in Table 2. Wood density could be too high to be processed, or too low to meet the requirements of mechanical structure. Therefore, density is an important factor in wood material selection of solid wood furniture. Basic density average value of *Cupressus funebris* Endl. wood is 0.65 g/cm³, which is belong to moderate degree.

| Table 2. The basic density test results of *Cupressus funebris* Endl. wood |
|-----------------------------|---------|----------------|----------------|------------------|
| Number of specimens Average value (g/cm³) Standard deviation Standard error Coefficient of variation(%) |
| 35 | 0.65 | 0.033 | 0.006 | 5.04 |

The results obtained on the hardness of *Cupressus funebris* Endl. wood are shown in Table 3. Hardness of wood represents the ability of other rigid bodies to press into wood, and it is an important index to measure the nail-holding ability of wood. And wood was found to be heterogeneous orthotropic material, its physical and mechanical properties like hardness with the stress direction of wood grain and the angle between different, there is a great difference. Other studies have shown that the end face hardness is higher than that of tangential and radial ones [12]. Mostly, the hardness of tangential and radial faces are similar. In this study, the research results indicate that end face hardness, tangential face hardness and radial face hardness are 5333 N, 4178 N and 4066 N, respectively, which is consistent with a previous study [12].

| Table 3. The hardness test results of *Cupressus funebris* Endl. wood |
|-----------------------------|---------|----------------|----------------|------------------|
| Number of specimens Test surface Average value (N) Standard deviation Standard error Coefficient of variation(%) |
| 25 | end | 5333 | 311.563 | 62.313 | 5.84 |
| 25 | tangential | 4178 | 284.615 | 56.923 | 6.81 |
| 25 | radial | 4066 | 466.302 | 93.260 | 11.47 |
The results obtained on the modulus of elasticity (MOE) of *Cupressus funebris* Endl. wood are shown in Table 4. The modulus of elasticity of wood is a number that measures wood's resistance to being deformed elastically when a stress is applied to it. It is an important index to measure the ability of wood to resist bending and deformability. In solid wood furniture production, structural components often be processed parallel to grain, so MOE parallel to grain is particularly important to strength of furniture structure.

**Table 4.** The modulus of elasticity test results of *Cupressus funebris* Endl. wood

| Number of specimens | Average value (Gpa) | Standard deviation | Standard error | Coefficient of variation(%) |
|---------------------|---------------------|--------------------|----------------|-----------------------------|
| 25                  | 8.2                 | 1.184              | 0.237          | 14.42                       |

The results obtained on the bending strength of *Cupressus funebris* Endl. wood are shown in Table 5. There is a linear relationship between MOE and bending strength of wood [13]. Bending strength represents the ultimate bearing capacity of wood when it is subjected to bending damage. It is of great significance for wood materials election in solid wood furniture manufacture.

**Table 5.** The bending strength test results of *Cupressus funebris* Endl. wood

| Number of specimens | Average value (Gpa) | Standard deviation | Standard error | Coefficient of variation(%) |
|---------------------|---------------------|--------------------|----------------|-----------------------------|
| 25                  | 89.8                | 6.936              | 1.387          | 7.72                        |

The results obtained on the compression strength parallel to grain of *Cupressus funebris* Endl. wood are shown in Table 6. Compression strength parallel to grain is often used as a basic data for judging and evaluating material properties, which is a measurement of the wood’s maximum crushing strength when force is applied to the ends of the wood, that is, compression is parallel to the grain.

**Table 6.** The compression strength parallel to grain test results of *Cupressus funebris* Endl. wood

| Number of specimens | Test surface | Average value (N) Standard deviation | Standard error | Coefficient of variation(%) |
|---------------------|--------------|--------------------------------------|----------------|-----------------------------|
| 25                  | radial       | 9.4                                  | 1.305          | 0.261                       | 14.67                       |
| 25                  | tangential   | 8.9                                  | 1.209          | 0.242                       | 12.85                       |

The results obtained on the compression strength perpendicular to grain of *Cupressus funebris* Endl. wood are shown in Table 7. Compression strength perpendicular to grain is a measurement of the wood’s maximum crushing strength when force is applied to the perpendicular to grain of the wood, which includes two situations: radial test and tangential test. Other studies have shown that radial compression strength perpendicular to grain is greater than tangential compression strength perpendicular to grain, and compression strength parallel to grain is greater than both radial and tangential compression perpendicular to grain, which is consistent with the this study as shown in table 6 and 7 [12].

**Table 7.** The compression perpendicular to grain test results of *Cupressus funebris* Endl. wood
4. Conclusion
According to the results obtained for some selected physical and mechanical properties of the *Cupressus funebris* Endl. wood, which can be used as use construction material or furniture material for structures. Regarding its physical properties, it had basic density 0.65g/cm³ and moisture content 7.9%, and the studied mechanical properties presented characteristic values in end, tangential and radial surface hardness equal to 5333N, 4178N and 4066N, respectively. Other mechanical properties of *Cupressus funebris* Endl. wood have been obtained, including modulus of elasticity, bending strength, compression strength parallel to grain, radial compression strength perpendicular to grain and tangential compression strength perpendicular to grain were 8.2Gpa, 89.8Mpa, 45.8Mpa, 9.4MPa and 8.9MPa, respectively.

Acknowledgments
The authors are grateful for the support of the Project of National Science & Technology Pillar Program during the Twelfth Five-year Plan Period, Grant No. 2011BAC09B05, and the German Government Loans for Sichuan Forestry Sustainable Management Project, Grant No. G1403083. The authors would like to thank the reviewers for their comments, and to test samples makers for their support and help. This research was carried out at the Sichuan Provincial Colleges and Universities Wood Industry and Furniture Engineering Key Laboratory, Sichuan Agricultural University.

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