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Evaluation of some mechanical properties of Date Palm Trunk (Case Study: Mazafati, Rabbi and Zardan cultivars)

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ABSTRACT

Today the use of wood varieties has become widespread in many industries which can be used in the rail industry, shipbuilding, furniture manufacturing, etc. In this paper, some mechanical properties such as compressive strength in the longitudinal and transverse directions and flexural strength for three-dimensional wood species of the most important date cultivars of Sistan and Baluchestan province (Mazafati, Rabbi and Zardan), whose ages was between 10 and 50 years old has been measured. The results

showed that the compressive strength in the direction of the fiber is far more than the vertical orientation of the fiber, while the Mazafati variety has the highest compressive and flexural strength and the Zardan has the least compressive and flexural strength.

Keywords: Compressive strength, Flexural strength, Mechanical properties, Agricultural Engineering.

1. INTRODUCTION

About 7 million tons of dates are produced annually in the world, where our country has a special place with more than one million and 40 thousand tons of dates. Regarding the cultivating date in the country, most of the fertilized gardens are devoted to Kerman and the second level after Kerman, the highest cultivar of palm gardens belongs to Sistan and Baluchistan. In terms of yield per hectare, Sistan and Baluchestan province has the highest yield of 6.378 kg/ha among the provinces (Agricultural Statistics Ministry of Jihad-e-Agriculture 2014). So, many number of palm trees is dried annually or inefficient for any reason, and their wood can be used in various industries (Nourbakhsh et al., 2001, Sepehr, A., 2009 and Mirmahdi et al., 2010; Rajeshwar Man Shrestha, 2018; Ukpaka Chukwuemeka Peter and Okochi Godspower Ikechukwu, 2018; Monizi et al. 2018). Hence, knowing a series of physical and mechanical properties of the palm tree has various applications that can be referred to: mechanization of palm tree operations by designing different mechanical machines, using palm timber in the railway industry, shipbuilding, furniture making, building wooden parts, industrial parts and wagons. Therefore, in the first step, there is a need for comprehensive and complete information on the characteristics and conditions of the tree (Panahikordelaghari, M., 2002 and Sanadghol, R., 2000). In this paper, we aim to investigate some of the mechanical properties of date palm stems. For example, knowing the compressive strength and tensile strength of palm timber samples, it can be designed in different industries according to the pressure applied to optimize consumption. Because wood is a heterogeneous material, the strength of wood varies in every place and depends on the properties of that point. Tensile strength of the wood in the direction of perpendicular to the fiber is less than that in the direction of the fiber. Usually the wood is rarely placed in the direction of perpendicular to the fiber under tensile load. With regard to the compressive strength of wood, this resistance increases along the warp and, as the wood becomes more compact, its resistance increases. The greatest resistance of the wood is in a dense state when the volume is about 1/3 of the initial volume. Sometimes in a dense wood, we can reach 10 times the compressive strength in the direction of perpendicular to the fiber. The resistance of the wood in the direction of the fibers is approximately equal to its resistance in two directions perpendicular to each other. Wood can be bent by bending, twisting or laminating in different shapes and associate some made parts of it in different ways (Mohammad Ghofrani, Habib Noori, 2014 and Rouhani. Iraj., 1988).

2. MATERIAL AND METHODS

In this paper, in order to measure some of the mechanical properties of date palm stems, 100 dry wood samples of three cultivars of the most important date cultivars of Sistan and Baluchestan (Mazafati, Rabbi and Zardan), whose ages are between 10 and 50 years old was provided from gardens of the province. The sampling was done in such a way: after cutting palm trees by the electric saw, the tree trunk was converted into smaller pieces, and the cut pieces were transported to the cutting machine by a pickup truck and cut into cubes with an approximate size of 10 cm × 10 × 10 cm. Also, a series of specimens were considered at 40 cm in length. These specimens were used for bending tests (Fig. 1).

2.1. Compressive strength

To measure the resistance of wood, metal or plastic against pulling, compacting, cutting, bending, etc., the pull and push device (testing) are used. The main parts of this device are: Skeleton, Electromotor, Dynamometer and Hydraulic Jack with types of spiral bars, the performance of these devices is such that the clamp according to the type of test by the force generated by the electro-motor is subjected sample by pulling, pressing, bending and cutting, and simultaneously by applying the force, Dynamometer of the machine which interfaces between the clamp and the moving part of the machine, measures the resistance of the sample. The device used here to measure resistance is the ZWICK universal Strength gauge model1496-2 D (Fig. 2). The compressive strength is obtained by dividing the force over the cross-section (Akbarneya, 2007).

2.2 Bending strength

For bending test we have used samples of 40 cm and 5 cm × 5 cm cross section. Using a Strength gauge machine, we have placed wooden samples under bending loading; the loading is started from the point of origin and is increased gradually until the failure of the sample, simultaneously by increasing the force, loaded wood piece is bending and changed (Fig. 3).

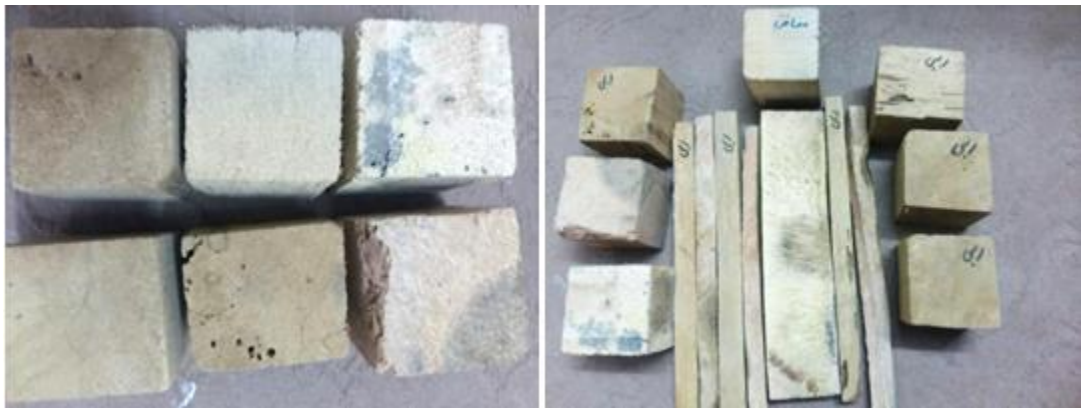

Figure 1 Prepared samples and cut from date gardens at the province

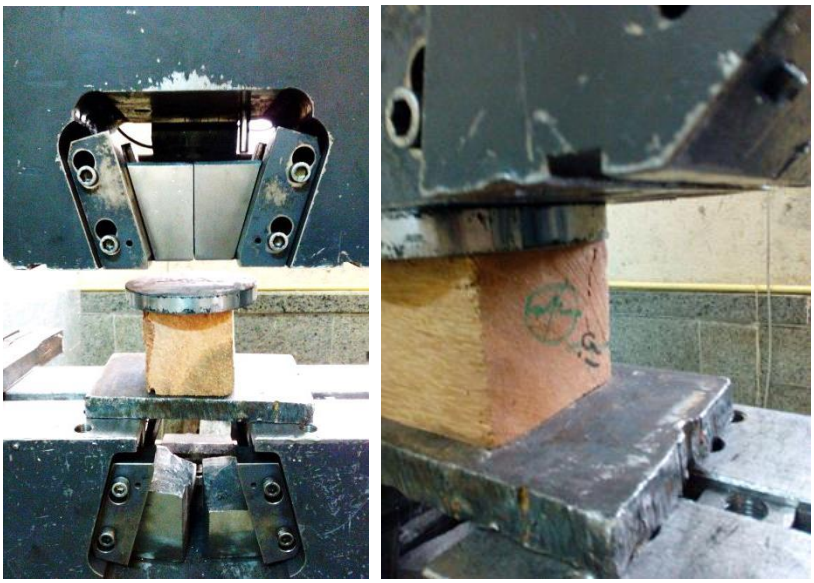

Figure 2 Parallel and perpendicular pressure tests on the machine fiber using the ZWICK universal strength model1496-2 D in ambient conditions 23 ± 5 ℃ - Max60% W.

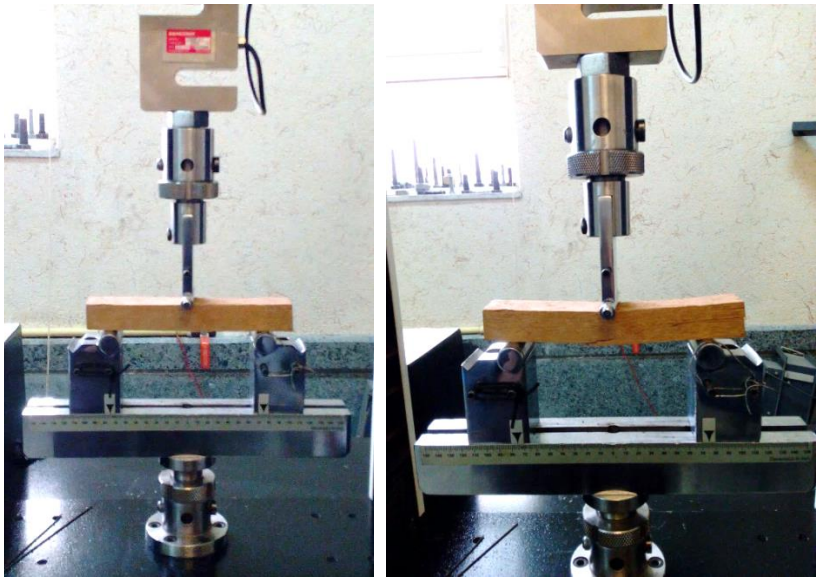

Figure 3 Bending test, loading steps on a wood sample and its deformation.

3. RESULTS AND DISCUSSION

3.1. Results of pressure test

After placing the specimen in the pressure test machine, the values obtained for tension in the direction of the fiber and perpendicular to the fiber for the three varieties like Mazafati, Rabbi and Zardan were recorded in tables 1 to 6. The comparison of the maximum and minimum compressive strength in the direction of perpendicular to the fibers of the three Mazatifi cultivars, Rabi and Zardan, is shown in figure 4 and 5 respectively. The results show that the compressive strength in the direction of the fiber is far more than the compressive strength perpendicular to the fiber in general (Fig.6). Also, by comparing the compressive strength in the direction of date palm straw of three kinds like Mazafati, Rabbi and Zardan (Tables 1, 2 and 3), we conclude that the compressive strength of Mazafati is significantly higher than the rest. Based on the tests, the mean compressive strength in the direction of fibers for Mazafati, Rabbi and Zardan were obtained 15.33, 8.53 and 6.68 MPa respectively. By comparing the compressive strength in the direction of perpendicular to the date palm fiber of the three cultivars Mazafati, Rabbi and Zardan (Tables 4, 5 and 6), we conclude that the compressive strength in the perpendicular direction of the Mazafati was significantly higher than the rest, as well as the average compressive strength in the perpendicular direction of the fiber for Mazafati, Rabbiand Zardan cultivar was 13.07, 5.31 and 4.36MPa respectively.

The maximum compressive strength in the direction of date palm fiber for Mazafati, Rabbi and Zardan was 16.64, 9.69 and 7.49MPa, respectively. The maximum compressive strength in the direction of perpendicular to the date palm fiber of three cultivars of Mazafati, Rabbi and Zardan was 13.8, 18.6 and 4.56MPa, respectively.

The minimum of compressive strength in the direction of date palm fiber for Mazafati, Rabbi and Zardan were found 14.72, 7.72 and 5.70MPa, respectively (Adhesives, Graduate degree, Faculty of Natural Resources, University of Tehran. Pages 58, 2009).

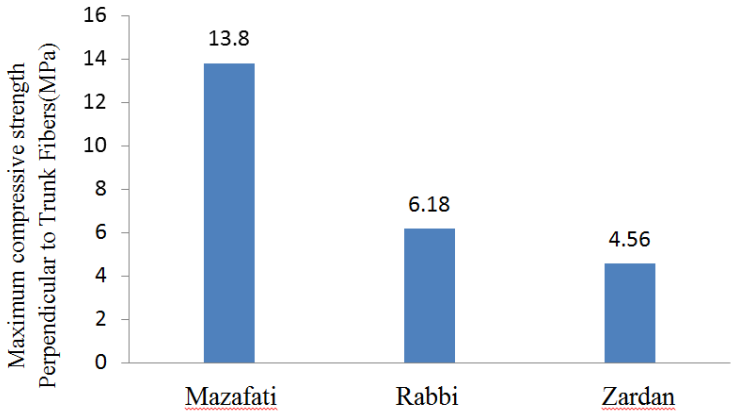

Figure 4 Comparison of the maximum compressive strength in the direction of perpendicular to the trunk fibers of the three varieties of dates like: Mazafati, Rabbi and Zardan.

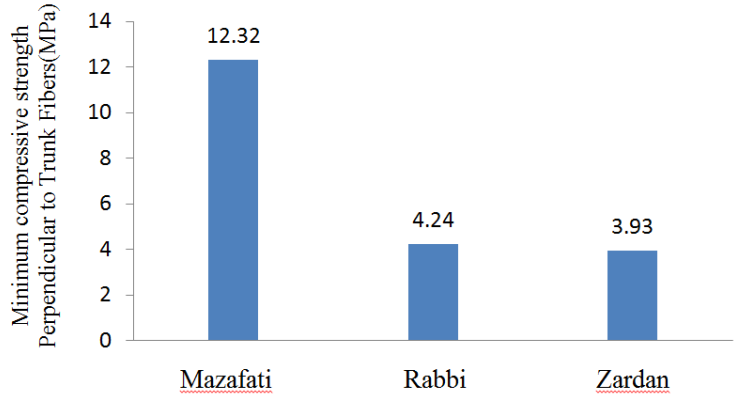

Figure 5 Comparison of the minimum compressive strength in the direction of perpendicular to the trunk fibers of the three varieties of dates like: Mazafati, Rabbi and Zardan.

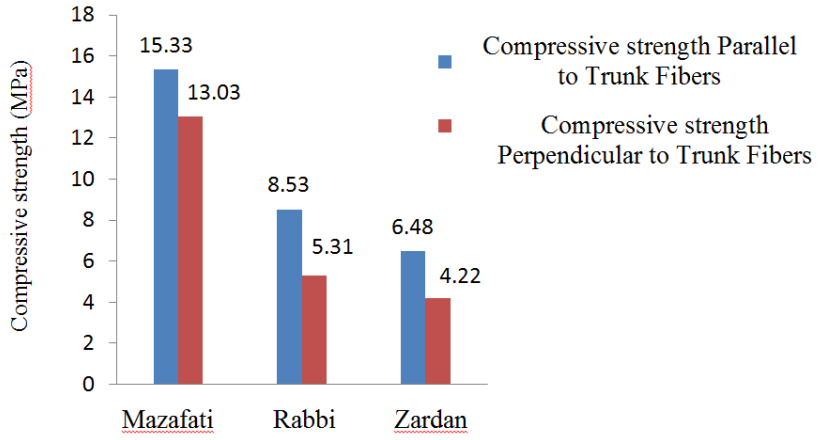

Figure 6 Comparison of the compressive strength in the direction of the trunk fibers and perpendicular to the trunk fibers of three varieties of Mazafati, Rabbi and Zardan.

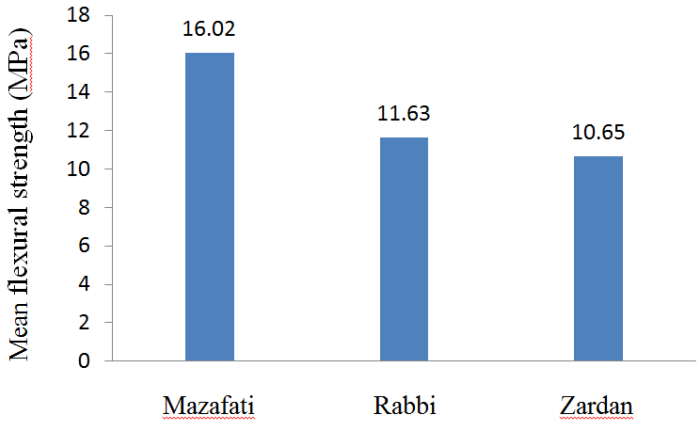

Figure 7 Comparison of the mean flexural strength of Mazafati, Rabbi and Zardan.

Table 1 Results of the pressure test in the direction of the fiber (Mazafati) under environmental conditions 23 ± 5 ℃ - max60% W by universal strength meter.

Mazafati cultivar	Surface(cm^2)	Maximum force (KN)	Compressive strength(MPa)
1	$9.6cm \times 9.8cm$	153.62	16.34
2	$9.6cm \times 10\ cm$	142.56	14.85
3	$9.8cm \times 10.1cm$	148.32	15.13
4	$9.7cm \times 9.9cm$	150.12	15.63
5	$9.5cm \times 10cm$	139.87	14.72
Mean			15.33
SD			0.59

Table 2 Results of the pressure test in the direction of the fiber (Rabbi) under environmental conditions 23 ± 5 ℃ - max60% W by universal strength meter.

Rabbi cultivar	Surface(cm^2)	Maximum force (KN)	Compressive strength(MPa)
1	$10.1cm \times 10\ cm$	87.32	8.64
2	$9.7\ cm \times 10.1\ cm$	79.58	8.20
3	$9.5\ cm \times 9.8cm$	90.13	9.69
4	$9.8\ cm \times 10\ cm$	75.67	7.72
5	$10.1cm \times 9.6\ cm$	80.98	8.43

Mean	8.53
SD	0.65

Table 3 Results of the pressure test in the direction of the fiber (Zardan) under environmental conditions 23 ± 5 ℃ - max60% W by universal strength meter.

Zardan cultivar	Surface(cm^2)	Maximum force (KN)	Compressive strength(MPa)
1	$9.9cm \times 10.1cm$	59.32	5.99
2	$9.7cm \times 10cm$	68.95	7.10
3	$9.7cm \times 9.9cm$	54.78	5.70
4	$9.8cm \times 10.2cm$	61.13	6.11
5	$10cm \times 9.8cm$	73.41	7.49
Mean			6.48
SD			0.69

Table 4 Results of the pressure test in the direction of perpendicular to the fiber (Mazafati) under the environmental conditions of 23 ± 5 ℃ - max60% W by the universal strength meter.

Mazafati cultivar	Surface(cm^2)	Maximum force (KN)	Compressive strength(MPa)
1	$9.9cm \times 10\ cm$	136.68	13.8
2	$9.6\ cm \times 10.1cm$	129.38	13.47
3	$9.4\ cm \times 9.8\ cm$	119.15	12.95
4	$10.2\ cm \times 10\ cm$	125.74	12.32
5	$9.4\ cm \times 10\ cm$	120.88	12.85
Mean			13.07
SD			0.55

Table 5 Results of the pressure test in the direction of perpendicular to the fiber (Rabbi) under the environmental conditions of 23 ± 5 ℃ - max60% W by the universal strength meter.

Rabbi cultivar	Surface(cm^2)	Maximum force (KN)	Compressive strength(MPa)
1	$10.4\ cm \times 10\ cm$	58.83	5.65
2	$9.8\ cm \times 10\ cm$	49.97	5.09
3	$10.1cm \times 9.6\ cm$	40.76	4.24
4	$9.7cm \times 10.2cm$	53.14	5.42
5	$9.9\ cm \times 10.1\ cm$	61.23	6.18
Mean			5.31
SD			0.64

Table 6 Results of the pressure test in the direction of perpendicular to the fiber (Zardan) under the environmental conditions of 23 ± 5 ℃ - max60% W by the universal strength meter.

Zardan cultivar	Surface(cm^2)	Maximum force (KN)	Compressive strength(MPa)
1	$10cm \times 9.6\ cm$	42.16	4.39
2	$9.8\ cm \times 10.2\ cm$	39.68	3.97
3	$9.5\ cm \times 9.9\ cm$	40.21	4.27
4	$10.1\ cm \times 10\ cm$	46.12	4.56
5	$9.5\ cm \times 10\ cm$	37.31	3.93
Mean			4.22
SD			0.24

Table 7 Results of bending test (Mazafati, Rabbi and Zardan) under environmental conditions 23 ± 5 ℃ - max60% W by Universal strength meter device

Specimen	flexural strength for **Mazafati cultivar** (MPa)	flexural strength for Rabbi **cultivar** (MPa)	flexural strength for Zardan **cultivar** (MPa)
1	16.21	12.38	10.18
2	15.78	11.12	9.82
3	16.48	11.52	11.122
4	15.97	12.17	10.87
5	15.64	10.98	11.25
Mean	16.02	11.63	10.65
SD		0.55	0.62

3.2. Results of flexural strength

After placing specimens of 40 cm in length and 5 cm * 5 cm cross section and performing a bending test, the values obtained for the three cultivars Mazafati, Rabbi and Zardan were recorded in Table 7. The results show that Mazafati has the highest flexural strength and Zardan has the least flexural strength (Fig.7).

4. CONCLOUSIN

The results of the experiments show that:

1. By comparing the compressive strength in the direction of the date palm fiber of the three varieties of Mazafati, Rabbi and Zardan, we conclude that the compressive strength of the Mazafati was significantly higher than the rest. Based on the tests, the mean compressive strength in the direction of fibers for Mazafati, Rabbi and Zardan were obtained 15.33, 8.53 and 6.68 MPa respectively.
2. By comparing the compressive strength in the direction of perpendicular to the date palm fiber of the three varieties of Mazafati, Rabbi and Zardan, we conclude that the compressive strength in the perpendicular direction of the Mazafatei is significantly higher than the rest, as well as the average compressive strength in the perpendicular direction of the fiber of the Mazafati, Rabbi and Zardan were 13.07 and 13.75, and 4.22MPa respectively.
3. Compressive strength maximum in the direction of perpendicular to the palm date fiber of three varieties dates like Mazafati, Rabbi and Zardan were 13.8, 6.18, and 4.56MPa respectively.
4. The maximum flexural strength was related to Mazafati (16.02 MPa) and the lowest flexural strength was related to Zardan (10.65 MPa).

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Conflict of Interest:
The authors declare that there are no conflicts of interests.

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Data and materials availability:
All data associated with this study are present in the paper.

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