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Usability of Recycled Plastic Wastes for Particle Board Production as Construction Material

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Abstract: The aim of this study is to examine important physical and mechanical properties of particle boards which were produced by adding plastic waste grinded to a certain particle size into wood shavings and using urea formaldehyde glue. The following values were obtained from the samples which were prepared to have different mixture proportions: unit weight was 684-966 kg/m3, thickness increment after a 24 hour water exposure was 1% -12%, the amount of water absorption was 21% -85%, bending strength was 5.20-17.94 MPa, perpendicular tensile strength was 0.15-1.32 MPa and heat conduction 0.128-0.160 W/mK. According to the results of the study, it was concluded that most of the characteristics of particle boards which are suggested under the related standards could be improved by reusing plastic waste for the production of particle boards, and that, in addition to this, negative environmental consequences caused by wastes could be minimized by utilizing plastic waste in this way.
Keywords: Particle boards, polyethylene terephthelate (PED) bottle wastes, construction material

Plastik Atıkların Yonga Levha Üretiminde Yapı Malzemesi Olarak Değerlendirilme Olanakları

Özet: Bu çalışmanın amacı, odun yongasına belirli büyüklüğe kadar öğütülmüş atık plastik ilavesiyle üre formaldehit tutkalı kullanılarak üretilen yonga levhaların önemli fiziksel ve mekanik özelliklerini incelemektir. Farklı karışım oranlarına sahip olmak üzere hazırlanan örneklerin, birim ağırlık değeri 684-966 kg/m^3, 24 saat suda bekletme sonucu kalınlık artışı % 1-12, su emme miktarı % 21-85, eğilme direnci 5.20-17.94 MPa , yüzeye dik çekme direnci 0.15-1.32 kgf/cm^2 ve ısı iletim katsayısı 0.28-0.160 W/mK olarak elde edilmiştir. Araştırma sonuçları; yonga levha üretiminde plastik atığın kullanımı ile yonga levhanın ilgili standartta öngörülen bir çok özelliğinin iyileştirilebileceği ve bunun yanında atık plastiklerin bu şekilde değerlendirilmesiyle olumsuz çevresel etkisinin azaltılabileceği kanısına varılmıştır.
Anahtar kelimeler: Yonga levhalar, PET şişesi artıkları, yapı malzemesi

1. Introduction

The facts which are known about construction material today have come on the scene as a result of investigations and experiences of many researchers which have taken long years. Various methods and facts which will enable construction material to be used more economically and securely need revealing.

Wood has been used as construction material since mankind appeared. It is a widely used material in agricultural buildings because it is easily available and processable, and it has convenient strength, weight ratio, etc. It is now utilized widely in various fields both as massive and wood composites. As anisotrope structure of massive wooden material is inadequate in conditions where a wide surface is needed and there are some economical reasons, wood raw material is used to produce particle boards, fibre board, plyboard and the like wooden boards. Wood composites mean the material which is formed by mixing ligneous material with another ligneous material or glue. In addition, composites do not only mean board products, but they also mean the products shaped in a mold and the products produced by the combination of wood and other material.

A considerable part of structural members in agricultural buildings is produced from wood and similar material. By using artificial wood members in agricultural buildings as flooring and ceiling and wall covering material, it is possible to provide useful possibilities such as tight and strong surfaces, thermal insulation, minimum condensation, and water barriers bar (Espenschied, 1995). Nowadays, the use of this kind of material is becoming widespread because some of its features are better and cheaper in comparison with wooden material (McColly and Martin, 1995).

Every year in Turkey a considerable amount of waste material in various properties,

sizes and ratios accumulates and some studies are conducted so that this material can be brought in economy and environment pollution can be prevented by reusing it. Pet plastics form 8 % of the plastics in Turkey. 10.000 tons of PET bottles are collected and reused in Turkey, on the other hand, 150.000-200.000 tons of plastic waste is reused. The aim of this study is to produce particle boards which are cheap and have proper qualifications by reusing waste plastics (pet bottle wastes) and determine the chances to use it in agricultural constructions. To do this, pet bottle wastes were used as additives to produce artificial wooden boards. The physical and mechanical properties of the obtained artificial material were compared with the values which are indicated in standards.

2. Material and Method

The material of the study was wood shavings from open air-dried ground pine which passed through a sieve with 8 mm pores but didn't pass through a second sieve with 1mm pores, pet bottle wastes, and urea formaldehyde (55 %) glue as binding material. While the glue solution was being prepared, 1 % ammonium chloride (33 %) in proportion to dry shavings weight was added into the solution as hardening material. The pet bottle wastes that would be used in the samples were grinded to a definite size so that they could pass through a sieve with 4 mm pores.

The grinded pet bottles were added into wood shavings in ratios 0%, 10%, 20%, 30% and 100%, and after they were mixed with urea formaldehyde glue homogeneously, they were put into molds in 5x25x2 cm size. The molded material was pressed under 1.96 MPa pressure in 130 ^{o}C temperature for 10 minutes. Later, the boards were taken out of the molds and they were kept in a place with 20±2 ^{o}C temperature and 65±5 relative humidity until their weights were stable. The following experiments were done on the samples which had 10 items for each group: unit weight, water absorption, swelling (thickness increment), bending strength, upright tensile strength. Nail holding strength was determined by observation and the values obtained were compared to the values which are indicated in standards. Anonymous (1999a), Anonymous (1999b), Anonymous (1999c), Anonymous (1999d), Muszynski and McNatt (1984), Eroğlu (1994), and Örüng and Şahin (1998) were taken into consideration while preparing the samples and determining their properties.

3. Results and Discussion

The values of unit weight, water absorption and swelling amount within 24 hours, bending strength, and upright tensile strength obtained from the artificial wood experiment samples produced by reusing pet bottle wastes were found by calculating the mean of the samples prepared (Table 1).

Table 1. Physical and mechanical properties of the samples produced by adding grinded pet bottle waste

Waste PET bottles (%)	Unit Weight (kg/m^3)	Water absorption within 24 hours (%)	Swelling within 24 hours (%)	Bending strength (MPa)	Upright tensile strength (MPa)	Heat conduction (W/mK)
0	684	85	12	13.04	0.43	0,128
10	731	72	9	15.50	0.94	0,133
20	805	65	8	17.16	1.22	0,142
30	869	58	7,5	17.94	1.32	0,151
100	966	21	-	5.20	0.15	0,160

The values relating to physical and mechanical features which were obtained from artificial wood samples produced by reusing pet bottle wastes were compared to the values found in literature and values relating to particle boards as there were no existing standards relating to the material produced by wastes at issue.

The unit weights of the samples for 0%, 10%, 20%, 30% and 100% mixture proportions were found to be 684, 731, 805, 869 and 966 kg/m^3 respectively. These values are within the range of hard and high density medium hard board group as indicated in Anonymous (1998).

The water absorption amounts of the samples in proportion to their dry weights in furnace for 0%, 10%, 20%, 30% and 100% mixture proportions were found to be 85 %, 72 %, 65%, 58 % and 21 %. These values are a bit above the

values which were suggested by Kollman et all (1975).

The thickness increment (swelling) values of the samples kept in water for 24 hours for 0%, 10%, 20% and 30% mixture proportions were found to be 12 %, 9 %, 8 %, and 7,5 %. There was no swelling in the samples with 100 % mixture proportion. According to the results, the 24 hour swelling values were found to be mostly 14 % under the values suggested by Anonymous (1999e). There is no information about swelling values in particle board standards.

The average bending strength values which were found by calculating every experiment piece for 0%, 10%, 20%, 30% and 100% mixture proportions were found to be 13.04; 15.50; 17.16; 17.94; and 5.20 MPa respectively (Table 1). The minimum bending strength for particle boards is suggested to be 11.28 MPa in Anonymous (1999a). Taking this into consideration, the bending strength values of the samples with 0%, 10%, 20% and 30% mixture proportions can be said to be below the values suggested in standards.

Upright tensile strength values of the samples, one of the mechanical features of artificial wooden material, for 0%, 10%, 20%, 30% and 100% mixture proportions were found to be 0.43; 0.94; 1.22; 1.32 and 0.5 MPa. Upright tensile strength value for particle boards is stated to be minimum 0.24 MPa in Anonymous (1999a), and 0.34 MPa in Anonymous (1999b). According to this, upright bearing strength values were above the standards except for one sample.

Heat conductivity of particle board varies depending on the amount of pores in wood composites and its unit weight. Heat conductivity values of the samples for 0%, 10%, 20%, 30% and 100% mixture proportions were found to be 0.128; 0.133; 0.142; 0.151 and 0.160 W/mK.

Nail and screw holding strength of the samples which is one of the important properties of particle boards was examined by observation and it was found to be similar to that of wooden boards from natural ground pine and manufactured artificial boards. In addition to good nail and screw holding quality, all the samples had a better quality with respect to sticking to wooden and other similar surfaces.

4. Conclusion

Further studies can be conducted to improve some of the properties of the samples which were obtained by reusing pet bottle wastes. Therefore, it may be possible to produce much more qualified artificial wood boards with these wastes. It may be thought that generalizing the production of this kind of material is necessary as it has some advantages such as availability of pet bottle wastes and less adhesive material use. Given the unfavorable environmental influence of plastic wastes increasing daily at present, it will provide huge benefits with this respect as well.

There are also chances that this material which is likely to have much lower production costs by reusing waste plastics can be used in agricultural constructions as ceiling and wall covering material. In this way, more economical and qualified agricultural constructions can be built. It is also possible to benefit from this material in agricultural constructions where there is humidity problem as plastic added artificial wood board does not absorb water or swell much.

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