Pergamon

Cement and Concrete Research, Vol. 28, No. 8, pp. 1101–1104, 1998

0008-8846/98 $19.00 + .00

PII S0008-8846(98)00064-7

EFFECTS OF GROUND HAZELNUT SHELL, WOOD, AND TEA WASTE ON THE MECHANICAL PROPERTIES OF CEMENT

A. Demirbaş[1]* and A. Aslan†
*Black Sea Technical University, Fatih Education Faculty, 61335 Akçaabat, Trabzon, Turkey
†Celal Bayar University, Department of Chemistry, Manisa, Turkey

(Received November 25, 1997; in final form April 20, 1998)

ABSTRACT

In this study, the mechanical properties of Portland cement mixes with an admixture such as ground hazelnut shell, spruce and beech woods, and tea waste were studied. The compressive and bending strengths test results obtained from these mixes were investigated with comparing to the control mix. From results, it was obtained that especially ground hazelnut shell and beech wood can be used as additives or partial replacement for Portland cement.

Introduction

Lignocellulosic solid wastes create serious problems for both farmers and environmentalists. Solid waste admixtures such as ground hazelnut shell, wood sawdust and tea waste may be used as cement aggregates.

Wood-cement composites were investigated by different researches (1–5). Cement-bonding particle board has the potential for forming a sound, durable, and weatherable panel product suitable for a number of applications generally reserved for polywood or phenolic resin-bonded particleboard (6). Wood-cement particle board development has been slowed, in part, by a lack of basic understanding in the mechanisms involved in bonding (7,8).

In general, the addition of lignocellulosic material to cement decreases compressive strength values. The compressive strength values for Portland cement and wood aggregate (size: 16–18 mesh) and Portland cement mixture (wood:cement ratio was 40:60 by weight) were determined as 35.6 and 6.1 N/mm^2, respectively (1).

In this work, ground hazelnut shell, spruce and fagus woods, and tea waste were used as additives, and the mechanical properties of the additives and cement mixtures were studied. The objective of this study is to compare the mechanical properties of Portland cement with those of the additive and cement mixtures.

Communicated by A.K. Chatterjee.
[1]To whom correspondence should be addressed.

TABLE 1
Mechanical properties of PC-ground hazelnut shell mixes.

	Hazelnut shell-cement ratio				
	0.0%	2.0%	5.0%	7.5%	10.0%
Compressive strength (MPa)					
1-day	13.8	12.9	11.7	10.4	8.8
7-day	36.7	32.3	25.7	21.5	18.6
28-day	49.6	43.7	35.9	30.7	26.5
90-day	52.0	46.5	40.2	36.2	32.4
Bending strength (MPa)					
1-day	3.6	3.4	3.2	3.0	2.2
7-day	5.0	4.6	3.8	3.5	2.8
28-day	8.3	7.0	6.1	5.6	4.4
90-day	9.2	7.6	6.5	6.0	5.0

Experimental Methods

Raw Materials Used

Hazelnut (*Corylus avellena var. pontica* C. Koch), Oriental beech (*Fagus orientalis*), and Oriental spruce (*Picea orientalis*) samples were obtained from the Eastern Black Sea Region in Turkey. The sample of tea waste was supplied from black tea factory of the Nurçay Foundation in Rize, Turkey. An ordinary Portland cement (PC) analyzing 62.8% CaO and 20.8% SiO_2 was used for the studies. The PC was ground to < 0.09 mm particle size.

TABLE 2
Mechanical properties of PC-ground spruce wood mixes.

	Spruce wood-cement ratio				
	0.0%	2.0%	5.0%	7.5%	10.0%
Compressive strength (MPa)					
1-day	13.8	10.2	8.6	8.0	7.4
7-day	36.7	17.2	14.0	13.2	12.6
28-day	49.6	24.5	21.1	19.6	18.0
90-day	52.0	27.0	24.5	22.0	20.7
Bending strength (MPa)					
1-day	3.6	3.1	2.6	2.4	2.1
7-day	5.0	4.2	3.0	2.6	2.4
28-day	8.3	6.0	4.9	4.1	3.8
90-day	9.2	6.8	5.3	4.7	4.4

TABLE 3
Mechanical properties of PC-ground beech wood mixes.

	Beech wood-cement ratio				
	0.0%	2.0%	5.0%	7.5%	10.0%
Compressive strength (MPa)					
1-day	13.8	10.8	10.0	9.0	8.2
7-day	36.7	21.6	18.2	16.4	15.6
28-day	49.6	29.2	25.3	23.7	21.8
90-day	52.0	32.4	28.6	24.9	23.5
Bending strength (MPa)					
1-day	3.6	3.3	2.9	2.6	2.3
7-day	5.0	4.5	3.3	3.1	2.8
28-day	8.3	6.8	5.6	5.1	4.2
90-day	9.2	7.4	6.0	5.8	4.8

Preparation of Cement Test Mixes

The specimens were prepared with PC (0.450 kg) + Rilem Cembureau standard sand (1.350 kg) + tapwater (0.225 kg). The admixtures hazelnut shell, beech, spruce, and tea waste were ground to < 0.9mm (2.3% of total sample) and < 0.6 mm (8.4% of total samle) particle size, and the addition rate was 2.0, 5.0, 7.5 and 10.0% by weight of cement. The cement-water mixtures with and without admixture were stirred for 5 min. The specimens were then cured at room temperature ($\sim$22°C) for 1 day and after that placed in tapwater and cured up 90 days.

Strength Measurements

For compressive and bending strenth tests five measurements were performed for each mixture and averaged to obtain the mean strength values. The physical tests were carried out according to TS 24 (9–11).

TABLE 4
Mechanical properties of PC-ground tea waste mixes.

	Tea waste-cement ratio				
	0.0%	2.0%	5.0%	7.5%	10.0%
Compressive strength (MPa)					
28-day	49.6	4.5	1.2	0.6	–
90-day	52.0	5.0	1.4	0.7	–
Bending strength (MPa)					
28-day	8.3	1.3	0.7	0.3	–
90-day	9.2	1.4	0.8	0.3	–

Results and Discussion

The compressive and bending strength measurements of Portland cement with various ratios of admixture mixes are given in Tables 1–4. As can be seen in Tables 1–4, the overall effect of the lignocellulosic admixtures on the mechanical properties of cement is negative.

For the characterization of a lignocellulosic material as a binding agent for concrete it is not sufficient to determine the compressive and bending strengths. Its physical properties such as specific gravity, specific surface, grain size distribution, aggregate to cementitious material ratio, fineness, water demand, and moisture content should be available. Moreover, for the introduction of a new material it is advisable to inform its micro structure using SEM analysis, chemical and phase composition. In addition, the total heat evolved by hydration of cement mix should be studied (12).

The data in Tables 1–3 show that the compressive and bending strengths generally decrease with the increase in the admixture ratio of the mixes. As can be seen in Table 1, the decrease in the strength measurementsd of the mixes with ground hazelnut shell relatively is lower than those of the other lignocellulosic admixtures (Tables 2 and 3). Table 4 shows that the effect of tea waste on the mechanical properties of the cement is very negative. This effect might be a result of its long and fermented fibres.

The effect of cement/wood ratios on compressive strength of wood-cement mixtures made from six wood species was investigated (13). Results indicated that as cement/wood ratio was decreased from 13/1 to 4/1, compressive strengths were reduced from 7.7% to 29.1% for Southern pine and from 8.0% to 44.0% for hardwoods, respectively.

Conclusion

The results demonstrate that the lignocellulosic materials samples could not be used as a cementitious material in manufacturing of concrete. Ground hazelnut shell and beech wood can be used as a partial replecement or additive in the Portland cement. However, using of tea waste as an additive or aggregate is never suitable.

References

1. D.R. Prestemon, Forest Prod. J. 26, 43 (1976).
2. W.Y. Ahn and A.A. Moslemi, Wood Sci. 13, 77 (1980).
3. F. Albiac, Wood-filled Concrete, French patent 1,176,755, April 15, 1959.
4. A. Elmendorf, Forest Prod. Res. Soc. 5, 155 (1951).
5. F. Fischer, O. Wienhaus, M. Ryssel, and J. Olbrecht, Holztechnologie 15, 12 (1974).
6. N.D. Anonymous, Wood-Cement Building Boards, Bison System Board Plants, Bison-Werke, Springer, W. Germany.
7. W. Sandermann and R. Kohler, Holzforschung 18, 53 (1964).
8. R. Takano, M. Kayahara, and H. Nakagawa, Fukui-Ken Mokuzai Shikenjo 31, 1 (1977).
9. Y. Erdoğan, H. Genç, and A. Demirbaş, Cem. Concr. Res. 22, 841 (1992).
10. A. Demirbaş and S. Karslğlu, Cem. Concr. Res. 25, 1381 (1995).
11. Turkish Standard Institution, Physical Testing Methods of Cement, TS-24, TSE, Ankara, 1974.
12. A. Demirbaş, Cem. Concr. Res. 26, 1737 (1996).
13. A.W.C. Lee, Z. Hong, D.R. Phillips, and C.Y. Hse, Wood Fiber Sci. 19, 262 (1987).