Effects of Colemanite Waste, Coal Bottom Ash, and Fly Ash on the Properties of Cement

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ABSTRACT: In this study, the physical properties of colemanite ore waste from concentrator, coal bottom ash, fly ash, cement+ash mixtures, cernent+colemanite ore waste, and their effects on the mechanical properties of concrete were investigated. These materials wifli different proportion were substituted with Portland cement. Physical properties such as setting time, volume expantion, and compressive strength were determined and compared to reference mixture and Turkish standards (TS). The results showed mat cement replacement materials had clear effects on the mechanical properties. The use of fly ash and bottom ash even at the concentration of 25% showed either comparable or better result compared to reference mixture. Although replacement of Portland cement by 9 wt % of colemanite ore waste causes reduction in the compressive strength, the values obtained are within the limit of TS. As a result, colemanite ore waste, fly ash, and bottom ash may be used as cemenùtious materials.

1 INTRODUCTION

Utilization of various types of waste materials such as coal fly ash (FA), coal bottom ash (BA) and, boron waste for their use in the production of cement has been the subject of several investigations in recent years (Majko & Pistilli,1984; Wei at all, 1994; Demirbaş & Karslıoğlu,1995; Conceand & George & Sorrenrio, 1981; Toutanji & Bayasi, 1999- They all examined the effects of different materials on cement such as class C fly ash, boric acid sludges containing borogypsum, steel slag).

Turkey has the 53% of boron ores of the world's boron reserve. The average boron ore production of Turkey was about 1.3 billion tonnes per year in the period 1980-1990. The most important boron minerals in Turkey are colemanite, ulexite, and tincal. In this study the use of colemanite waste as replacement material in cement industry was investigated. Incorporation of fly ash (FA) and bottom ash (BA) with colemamte waste was also examined.

2 MATERIALS AND METHOD

Clinker and gypsum were supplied from Set Cement Plant (Balıkesir , Turkey), colemanite waste from Etibank Boron Plant (Kiitahya-Emet, Turkey). The chemical compositions of cement, colemamte waste (waste passing a screen 25-mm aperture) were done by using X-ray fluoresence spectrometer . B2O3 in the colemanite ore waste was determined according to the MTA titration method (Institute of Technical Mine Searching, Ankara). The chemical compositions and physical properties of materials are given m Table 1.

Three series of mixtures and one reference mixture were prepared according to Turkish standans (TS 24) as described m the earlier studies (Turkish National Standards, TSE, TS 19 (1985), TS 24 (1985), TS 26 (1963), TS 639 (1975), Turkish Standard Institue, Ankara, Turkey). Reference mixtures was prepared out of Portland cement (PC) and designated as R.

Table 1 Physical and chemical charactenstics of the maienal

	Clinker	Colemanite waste	Fly ash	Bottom ash	GvDsum
Chemical analysis (wt%)					
SiOj	21,47	18,02	56,13	50,98	
$A1_2 0_3$	6,04	3,73	18.49	14.96	0,05
Fe_2Oj	3,78	0,98	11,38	9,63	—
CaO	65,49	22.83	2,52	2,63	32,93
MgO	1,44	6.99	3,79	4,01	0,04
SO_3	1.12	0,54	0,05	0,16	45.95
$Na_2 0$	—	2,02	0,71	-0,47	
$K_2 0$	0.93	1,41	2,17	1,30	0,01
$B_2 0_3$	—	17,65		—	—
Loss on ignition	0,20	22,75	4,20	15,70	21.13
Free CaO	0,85	—	—	—	—
Water	—	—	—	—	19,35
Physical analysis					
Fineness (wt %)					
+40 Jim	25,8	26,5	25,7	24,2	—
+90 um	2,3	13,4	5,9	5,6	
+200/im	0,3	0,4	0,5	0,3	
Specific surface (cır	2400	3602	6418	7200	—
Spesific gravity (g/	3,20	2,13	1,81	1,98	—

The other series of mixtures were designated as A, B and C. The weight percent of material used for each mixture are given m Table 2. The raw materials mixed in the required proportion were ground in a ceramic lined ball to a fineness of 25 mass% residue on a 40-^m size mesh. The physical tests of cement mixes were done according to TS 24 (1985).

The specimen were prepared with cements (0.450 kg) + Rilem Cebureau standard sand (1.350 kg) + tap water (0.225 kg). The cement-water mixtures were stirred at low speed for 30 s, then, with the addition of sand, the mixture were stirred for 5 min. Three 40 x 40 x 160-mm prismatic specimens for compression testing were made from each mixture. The specimens were cured at 20°C with 95% humidity for 24 h after that, placed in tap water, and cured up to 90 days. Then they were tested in accordance with TS 24 (1985).

3. RESULTS AND DISCUSSION

Water percent, volume expansion, and setting time test result foe cement mixtures are shown m Table 3. The compressive strength of cement mixes at various ages are shown in Fig. 1-3. At 2 days, the compressive strength of specimens containing supplementary materials was less than that of control for all batches. In addition, the mixture A_5 has the lowest value of the compressive strength at the age of 2 days.

1. At the age of 7 days, there was continuing improvement in the performance of the mixtures and all observed values comply with TS 639 requirement (1975). When curing extented to 28 days, increasing replacament of colemanite waste (CW) resulted to a dramatic decrease in the compressive strengm.

CONCLUSION

By the results above, the following conclusion can be made:

1. The effect of colemanite ore waste was significant on the mechanical properties of concrete mixture tested. Up to a certain level of replacement of colemanite ore waste with Portland cement (3%), the compressive strength of mixture was significantly improved at the age of 28 days.
2. The mixtures containing either fly ash or bottom ash mixtures showed higher compressive strength than mixture containing now additive material at the age of 28 days.
3. At early ages, reference mixture showed higher strength than mixture containing cement replacement material. The drfference between the mixture became significantly small as curing was extended beyond 7 days. At 90 days, both ash and fly ash mixtures showed the best result, but all the other mixtures exhibited comparable results.

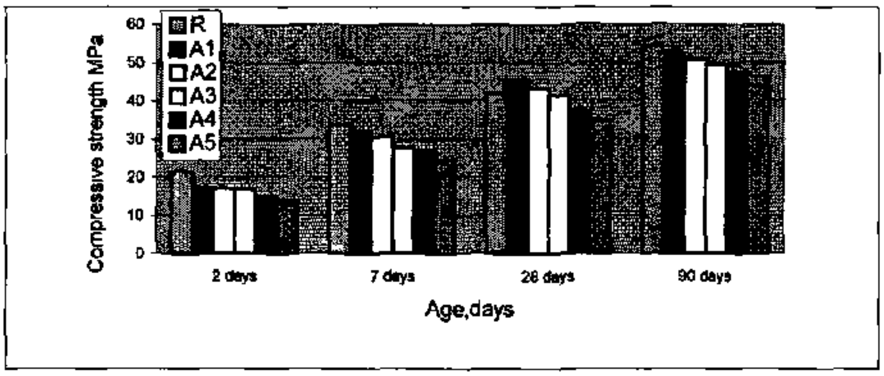

Figure 1 Compressive strength of the concrete containing CW and PC

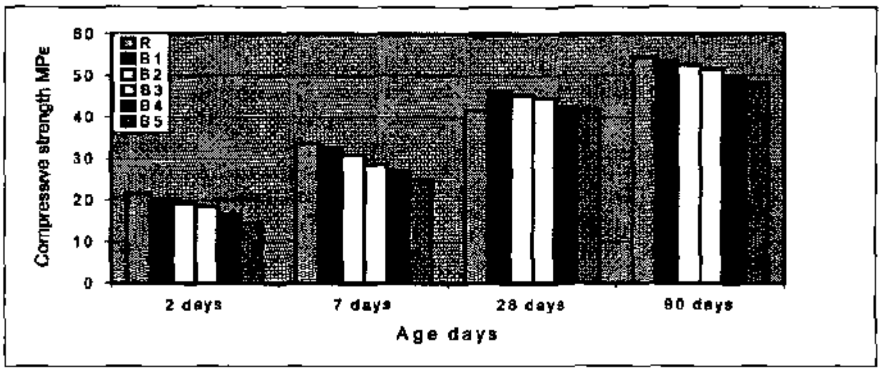

Figure 2 Compressive strength of the concrete CW FA and PC

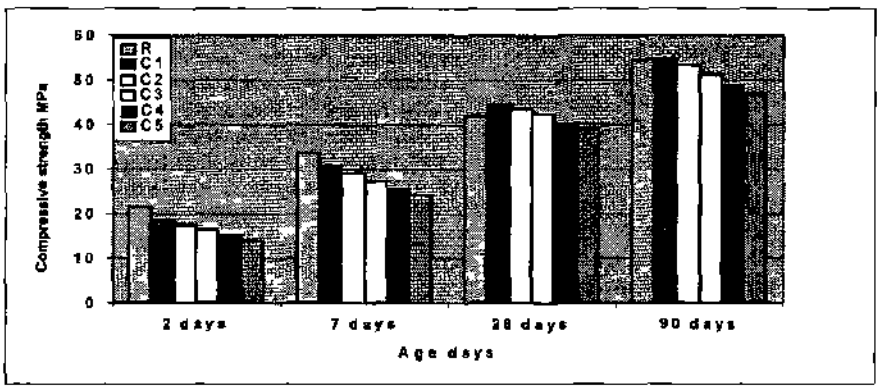

Figure 3 Compressive strength of the concrete containing CW BA and PC

Table 2 Physical charactenstics of cementıUous mixtures

Symbol	Cement mixes	Fineness (wL%) +40fim	+90/iin	SpeslGc surface (cmVg)	Specific gravity (gW)
R	Reference row	250	**1 1**	2965	**3** 23
A,	1% CW + 99% PC	250	10	3139	**3** 14
A₂	3 % CW + 97% PC	25 **1**	**1 1**	3183	311
A,	5 % CW + 95% PC	24 **9**	0 8	3223	306
A<	7%CW + 93%PC	24 **8**	0 8	3228	**3** 02
A,	9%CW + 91%PC	25 **1**	10	3445	296
B,	1 % CW + 4% FA + 95% PC	249	0 9	3326	**3** 12
B,	3 % CW + 7% FA + 90% PC	**25 1**	10	3402	**3** 05
B,	5 % CW + 10% FA + 85% PC	**25 0**	10	3588	300
B₄	7 % CW + 13% FA + 80% PC	250	10	3882	294
B,	9 % CW + 16% FA + 75% PC	24 **8**	0 8	4099	**2 88**
c,	1 % CW + 4% BA + 95% PC	**25 1**	0 9	2891	298
Cl	3 % CW + 7% BA + 90% PC	25 **0**	**1 1**	2928	**2 95**
C)	5 % CW + 10% BA + 85% PC	248	0 9	3052	**2** 93
e.	7%CW+13%BA + 80%PC	249	**0 8**	3192	**2** 80
c_s	9 % CW + 16% BA + 75% PC	252	10	4257	**2 87**

BA • Bottom Ash
PC Portland Cement
CW Colemamte Waste

Tabic 3 Water percent, volume expansion, and setting time test result for cement mixtures

Cement	Water (%)	Setting time (1 nun) Initial	Final	Volume expansion Cold	Hot	Total
TS 639	—	minimum 1-0	maximum 10-0	-	—	maximum 10
R	27 6	240	3 30		1	2
A,	26 7	2 30	3 10		1	2
A₃	27 2	2 36	3 25		1	2
A₃	28 5	240	240		0	1
A4	30 1	245	3 55		1	2
Aₛ	304	2 55	4 15		0	1
B,	27 3	2 30	3 05		1	1
Bi	28 5	3 10	4 50		1	2
B,	29 2	3 50	5 40		1	2
B<	317	4 20	625		0	1
B,	32 0	500	740		1	2
c,	27 6	3-00	3 55		0	1
Q	28 4	3 50	4 30		0	1
c,	29 8	4 35	5 35		1	2
C<	33 1	520	6 55	2	1	3
Q	34	6 05	7 55	2	1	3

4 Combined action of both fly ash+colemarute ore waste and bottom ash+colemamte ore waste as cement replacement material resulted to better performance in the compressive strength compared to mixtured containing colemamte ore waste

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