USE OF WASTE CONCRETE IN CEMENT PRODUCTION

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Abstract

Use of waste concrete in tempered cement production was examined in this study. Waste concretes were used in limestone-tempered cement production. In tempered cement production, %5, %10, %15, %20 and %28 milled waste concrete was added instead of the limestone. As wate concrete, pressure experiments were performed on those and 15 cm cube samples were used. Compressive strength of waste concretes was 65MPa on average. At the end of the study, six (6) types of cement were produced, one being without waste concrete addition in total. Chemical, physical and mechanical properties of waste concrete tempered and waste concrete additive free concretes were examined. 2, 7 and 28 day pressure and Flexural strengths of the produced cements were tested. In compressive strength, it was seen that the waste concrete additive-free cement reached its compressive strength values. Waste concrete addition increased the Flexural strength of the cement. Waste concrete addition slightly decreased the water need of the cement. Not a large change was observed in the setting beginning and setting end values. %20 and % 28 waste concrete additions instead of limestone decreased the volume expansion value of cement. It slightly decreased its specific weight value. No big changes were observed in its chemical properties. It was concluded that waste concrete can be used instead of limestone especially in mixed cement production. Thus, waste concrete can be put in use for cement production and ecological balance can be contributed to. However, sortation should be made well in order to use waste concrete in cement production.

Keywords: Waste concrete, tempered cement, mechanical properties, physical properties, chemical properties.

1. Introduction

Taking the aggregate constantly from the nature causes ecological imbalance [1-4]. Construction sector is a source consumer and waste producer [5, 6]. Construction waste materials are generally used as filling material [7, 8]. Waste concrete comprise half of construction waste [9, 10]. Use of waste concrete in structural concretes is important in terms of the environment [11]. In Turkey, after the earthquake in 1999, 2 million tons of waste concrete was produced only in Adapazarı province. It was estimated that the waste concrete value was 5,5 million dollars [12]. This situation increased the studies for using waste concrete as aggregate in fresh concrete [13, 14]. Its most negative effect on use in structural concrete is the soil mixture cemented on it [15]. Grain dimension distribution of recycled aggregate in the concrete is an important factor [16]. Water absorption value is high in recycled aggregates [1, 6, 16-19]. Recycled aggregate and rubber pieces were used in green concrete production [20]. In order to improve the performance of the concrete produced using recycled aggregate, certain rates of minerals were added in the cement. [21, 22].

The way of using construction and demolition wastes without harming the environment is transforming those into aggregate. Recycled aggregates are put in use generally in construction foundations, coverings and basin stabilization [23]. The importance of using super-plasticizer in the concrete produced using recycled rough aggregate obtained from precast waste wastes was emphasized.[24].

In this study, use of waste concretes in cement production was examined. Experimental studies were carried out especially for its use in limestone tempered cement production. The target was put the waste concrete, which comprise the half of construction waste, in good use in tempered cement.

2. Test Programs

2.1. Materials and Specimens

In the experimental study, waste concretes were used instead of limestone in Cem II B-L limestone tempered cement production. As waste concrete, concrete pressure test was performed on it and 15 cm cube samples were used (Figure 1). The cement used in waste concrete production was Cem I 42,5 R. %5, %10, %15, %20 and %28 milled waste concrete was used instead of limestone additive in Cem II B-L limestone tempered cement production. C1 indicates the limestone cement, C2, C3, C4, C5 and C6 indicate %5, %10, %15, %20 and %28 milled waste concrete tempered cements, respectively. Limestone, Clinker, Gypsum and Waste Concretes were milled in laboratory type millers (Figure 2).

Mixing materials were milled in 27*30 min. interval. 6 types of cements were produced in total, 5 being waste concrete tempered and one being additive free. The study was carried out in laboratory. Waste concrete tempered cement compound rates are given in Table 1.



Figure 1. Waste Concrete



Figure 2. Clinker

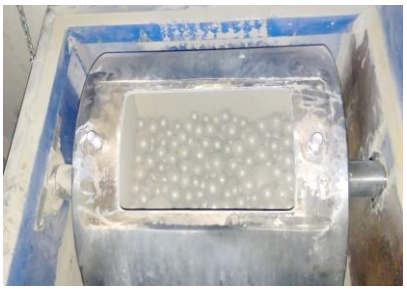


Figure 3. Laboratory type millers

Table1. Waste Concrete Tempered Cement Compound Rates

Cement Type	Clinker (%)	Limestone (%)	Trass (%)	Gypsum (%)	Waste Concrete (%)
C1	63	28	5	4	0
C2	63	23	5	4	5
C3	63	18	5	4	10
C4	63	13	5	4	15
C5	63	8	5	4	20
C6	63	0	5	4	28

2.2. Waste Concrete Compounds

Waste concrete unit weight was 2395 kg/m^{3}'. Total aggregate amount was 1830 kg/m^{3}'. The cement type used in waste concrete was CEM I 42,5 R. Cement amount was 400 kg/m^{3}. Water amount was 165 kg/m^{3}. In the waste concrete production, plasticizer chemical additive was used at the rate of %1,3 of cement amount. Approximately %93 of waste concrete was cement and aggregate in weight.

3. Cement Experiment and Findings

Chemical, physical and mechanical properties of waste concrete added limestone tempered cements were examined. Experiment results are given in Table 2 and Table 3. Limestone tempered cement's (Cem II B-L) and limestone tempered waste concrete added cement's chemical, physical and mechanical properties were compared. Not very big changes were observed in Blaine values of the cements. While volume expansion value was measured as same in C1, C2, C3 and C4 cement types, they were measured as half in C5 and C6 cement types (Table 2).

Table2. Physical and Mechanical Properties of Waste Concrete Tempered Cements

Property	C1	C2	C3	C4	C5	C6
Milling Duration (mn)	30	29,5	29	28	28	27
Blaine (g/cm²)	4,33	4,40	4,41	4,43	4,43	4,41
Special weight (gr/cm³)	3,01	3,02	2,99	2,93	2,92	2,94
Screen analysis (32µm)	31,0	28,4	30,3	32,0	30,5	29,5
Water need (%)	28,0	27,8	27,8	27,4	27,5	27,5
Setting beginning (dk)	190	180	180	195	200	210
Setting end (dk)	250	240	240	250	260	270
Volume expansion	1,0	1,0	1,0	1,0	0,5	0,5
Compressive strength (2Day/Mpa)	15,0	17,2	15,0	15,3	14,8	14,7
Compressive strength (7Day/Mpa)	24,1	26,2	24,0	22,8	23,3	24,0
Compressive strength (28Day/MPa)	30,3	33,0	30,4	29,9	29,7	30,6
Flexural strength (2Day/Mpa)	2,97	3,43	2,93	3,03	3,10	2,87
Flexural strength (7Day/Mpa)	4,27	4,13	4,27	4,23	4,23	4,23
Flexural strength (28Day/MPa)	4,97	5,23	5,37	5,13	5,00	5,23

When the chemical properties of cements were examined, Aluminum oxide and ferrous oxide values were increased in waste concrete tempered cements. There was no great change in CaO ve SiO_2 contents. Insoluble residue amount decreased in waste concrete tempered cements (Table 3).

Table3. Chemical Properties of Waste Concrete Tempered Cements

Property	C1	C2	C3	C4	C5	C6
$SİO_2$	15,99	16,26	16,12	16,09	15,86	15,84
AL_2O_3	4,35	4,39	4,42	4,39	4,41	4,46
Fe_2O_3	2,41	2,48	2,44	2,44	2,43	2,47
CaO	59,11	59,23	58,82	58,95	58,88	59,13
MgO	1,58	1,60	1,59	1,61	1,61	1,63
Na_2O	0,12	0,13	0,11	0,13	0,13	0,13
K_2O	0,46	0,48	0,46	0,47	0,45	0,46
SO_3	2,46	2,40	2,51	2,55	2,61	2,68
Insoluble Residue	3,34	3,00	3,13	3,08	2,74	2,32
Ignition Loss	13,66	12,73	13,48	13,36	13,64	13,41

Setting beginning durations of the cements differed between 180-210 minutes. Setting beginning duration of waste concrete free cement was 190 minutes. In %5 and %10 waste concrete additions instead of limestone, setting beginning duration of cement decreased to 180 minutes. In %15, %20 and% 28 waste concrete additions instead of limestone, setting beginning duration of cement increased. The highest setting beginning duration was 210 minutes in C6 cement with %28 waste concrete addition.

Setting end durations of the cements differed between 240-270 minutes. Setting beginning duration of waste concrete free cement was 250 minutes. In %5 and %10 waste concrete additions instead of limestone, setting beginning duration of cement decreased to 240 minutes. In %15, %20 and% 28 waste concrete additions instead of limestone, setting beginning duration of cement increased. The highest setting beginning duration was 270 minutes in C6 cement with %28 waste concrete addition (Figure 4)

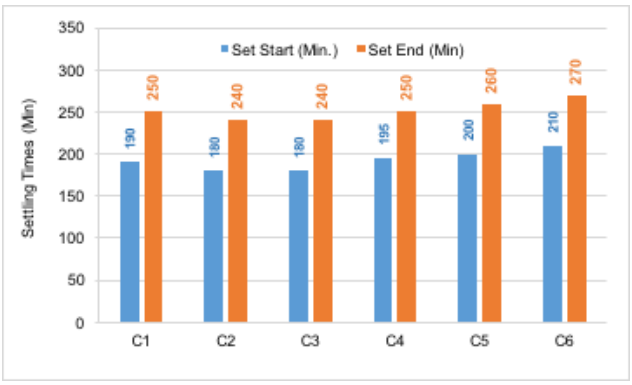


Figure 4. Settling Times

Special weight value of waste concrete free cement was calculated to be 3,01 g/cm^3 . Special weight values of waste concrete tempered cements differed between 2,92 and 3,02 g/cm^3 . Special weight value of cement with %5 waste concrete addition instead of limestone (C2) increased compared to the waste concrete free cement (3,02 g/cm^3). Special weight value decreased in C3, C4, C5 and C6 cements compared to the waste concrete free cement. The lowest special weight value was in %20 waste concrete tempered cement (C5) with 2,92 g/cm^3 (Figure 5)

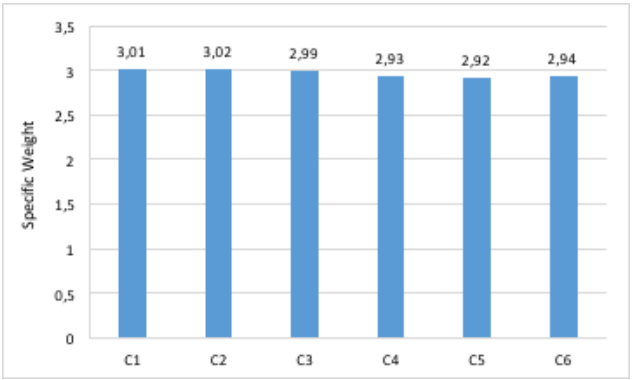


Figure 5. Specific Weight

The highest compressive strength was calculated in %5 waste concrete tempered cement (C5). 2, 7 and 28 day compressive strengths of cements were tested. 28 day compressive strengths of cements differed between 29,7-33,0 MPa.28 day compressive strengths of C2, C3 and C6 cements increased compared to the compressive strength of waste concrete free cement. 28 day compressive strengths of C4 and C5 cements decreased compared to the compressive strength of waste concrete free cement. The lowest compressive strength is in C5 cement (Figure 6). 2 and 7 day compressive strength results were also similar.

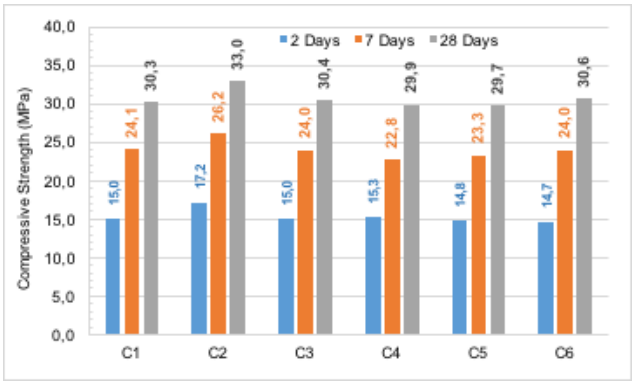


Figure 6. Compressive Strength

2, 7 and 28 day Flexural strengths of cements were tested. 28 day Flexural strengths of cements differed between 4,97-5,37 MPa. The highest Flexural strength was calculated in %10 waste concrete tempered cement (C3). The lowest Flexural strength was in waste concrete free cement. Waste concrete addition increased the cement's Flexural strength (Figure 7).

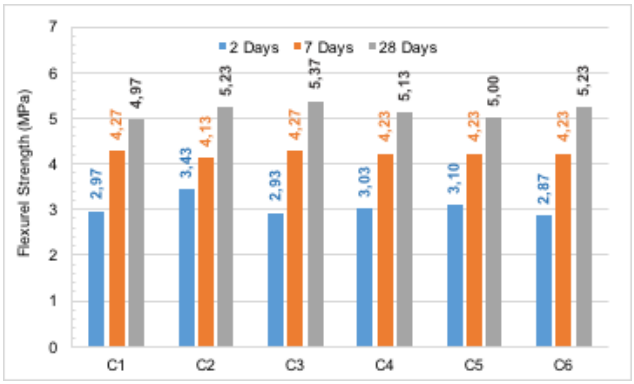


Figure 7. Flexurel Strength

Water need of cements differed between %27,4 and %28. The highest water need was calculated in waste concrete free cement with %28. The lowest water need was calculated in %15 waste concrete tempered cement (C4). Waste concrete addition in the cement slightly decreased the water need of the cement (Figure 8).

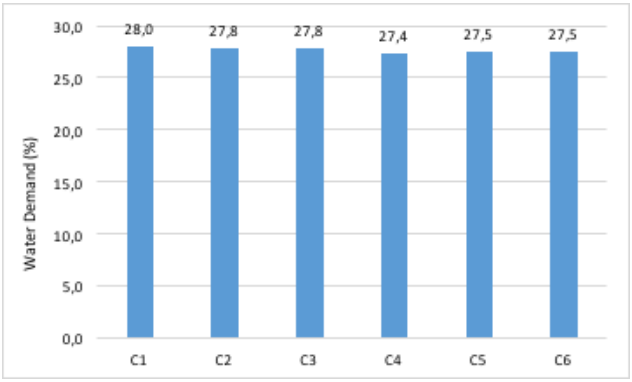


Figure 8. Water Demand

4. Results

Waste concrete addition in tempered cement didn't cause very big differences in the chemical properties of cement. Especially CaO amount remained in same values. Approximately %93 of waste concrete added in the cement instead of limestone was cement and aggregate in weight. Aggregate and cement are also limestone and derivatives.

Waste concrete addition in the cement instead of limestone decreased the special weight value of the cement. Only in %5 waste concrete tempered cement (C2) the special weight value increased. 2,7 and 28 day compressive strengths of waste concrete tempered cements were close to the waste concrete free cement's compressive strengths. Especially in C2 cement, 28 day compressive strength increased by %10 compared to the waste concrete free cement. Waste concrete addition increased the Flexural strength of the cement.

Water need of cements is an important factor in concrete mix calculations. It is a factor which directly affects the properties of the fresh concrete. According to this, the water need of the concrete and the need for chemical additives are determined. Waste concrete addition slightly decreased the water need of the cement. While the water need of waste concrete free cement was %28, the water need of waste concrete tempered cement decreased to the value of %27,4.

In tempered cement production, waste concretes can be used instead of limestone. It will be useful to experiment this laboratory study in industrial production and compare the results. Especially the capacity of laboratory type miller and milling quality may change the properties of the cement. In order to put waste concrete in use for cement production, construction waste concretes should be well purified. Thus, waste concretes can be used in cement production and ecological balance can be contributed to.

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