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THE EFFECT OF WATER-TO-CEMENT (W/C) RATIO ON THE PHYSICAL AND MECHANICAL PROPERTIES OF HEAVYWEIGHT CONCRETES

ABSTRACT

The some physical and mechanical properties such as compressive strength (CS), Schmidt hardness (SH), ultrasound velocity (UV) and unite weight (UW) of heavyweight concretes have been investigated. For this purposes the concrete were prepared in three different water-to-cement (W/C) ratio and different aggregate mixtured of them in different rate. Such way 15 different types of concrete were obtained and test were applied to investigate effect of different rate of W/C and different types of aggregate in the concrete. This would lead to find ideal w/c ratio and cement dosage in concrete.

Keywords: Heavy concrete, W/C, Physical Properties, Mechanical Properties, Concrete

SU/ÇİMENTO (S/Ç) ORANININ AĞIR BETONLARIN FİZİKSEL VE MEKANİK ÖZELLİKLERİNE ETKİSİ

ÖZET

Ağır betonların basınç dayanımı, Schmidt sertliği ultrases hızı ve birim ağırlık gibi bazı fiziksel ve mekanik özellikleri incelenmiştir. Bunun için betonlar üç farklı su/çimento oranında ve değişik oranlarda agrega karıştırılarak hazırlanmıştır. Bu şekilde 15 farklı beton türü elde edilmiş ve farklı oranlardaki S/Ç oranının betonların özelliklerine etkisinin araştırılması için test uygulanmıştır. Bu betonlardaki çimento dozajını ve ideal S/Ç oranının belirlenmesini sağlayacaktır.

Anahtar Kelimeler: Ağır Beton, S/Ç, Fiziksel Özellikler, Mekanik Özellikler, Beton

1. INTRODUCTION (GİRİŞ)

Heavyweight concretes can be used as a building material for critical building as it contains a mixture of many light and heavy elements. Concretes having specific gravities higher than 2600 kg/m^3 are called heavyweight concrete and aggregates with specific gravities higher than 3000 kg/m^3 are called heavyweight aggregate [1]. Using barytes as an aggregate in the concrete can produce one of the most approximately heavy or intermediate concrete. The main object using of barytes aggregate in concrete is producing the workable concrete with a maximum density and adequate structural strength and to ascertain the physical, chemical, thermal and structural properties of the concrete. Barytes contains a large proportion of relatively soft barium sulphate particles ($BaSO_4$). As the quantity of barytes ore reserve and its specific gravity are high in Turkey, it can be ideal choice to be used as an aggregate in concrete. However the aggregate is used in concrete, have to satisfy some physical, mechanical and chemical properties. Heavyweight concrete is principally used for radiation shielding, counterweights, and other applications where higher density is desired [2]. Except for density, the physical properties of heavyweight concrete are similar to those of normal - or conventional- weight concrete. To use concretes in building construction the physical and mechanical properties and the relation with the linear attenuation coefficient would be investigated. Thus the linear attenuation coefficient of different types of concrete were previously studied [3 and 4]. In this work the physical and mechanical properties of different types of concrete have been determined and the relation between w/c ratio and those of properties have also been investigated.

2. RESEARCH SIGNIFICANCE (ÇALIŞMANIN ÖNEMİ)

As the concrete is one of the mainly common used materials in building construction, it is surely important to produce concrete in ideal structure. This could be possible using ideal component in concrete. Besides other effect w/c ratio is the important parameter to produce concrete. This work represents effects of w/c ratio on physical and mechanical properties of the concrete.

3. MATERIALS AND METHODS (MATERYAL VE METOD)

In order to investigate effects of w/c ratio on the physical and mechanical properties of concrete 15 different types of concrete produced in five different series, were made mixing in different ratio of cement, water, aggregate and barytes. The mixing rate of 1 m^3 concrete is given in Table 1 where the indices of 2, 3, 4 represent the w/c ratio of 0.65, 0.51 and 0.43 respectively.

Table 1. Amounts of heavyweight concrete composition and ratio of w/c
(Tablo 1. Karışıma giren malzeme miktarları ve s/ç oranı)

Concrete	w/c	Water	Cement	Fine Aggregate	Coarse Aggregate	Fine Barytes	Coarse Barytes
A2	0.65	201	310	697	1092		
B2						1113	1700
AB2				697			1700
BA2					1092	1113	
K2				349	545	557	850
A3	0.51	184	362	697	1092		
B3						1114	1701
AB3				697			1701
BA3					1092	1114	
K3				349	547	558	850
A4	0.43	183	425	679	1061		
B4						1083	1653
AB4				679			1653
BA4					1061	1083	
K4				338	531	542	826

The cement of PC 42.5 obtained from Goltas cement factory were used and barytes aggregate were obtained from Sarkikaragac-Isparta region at south of the Sultandagları barytes region. Ordinary aggregate were used from Atabey aggregate mine. In Table 2 the physical and mechanical properties of normal and barytes aggregate are tabulated [5]. Each quantity, shown in last column of table 2, are measured according to method described by Turkish standard [6 and 7]. Both barytes and aggregate were graded according to their sizes 0-0.200, 0.200-0.250, 0.250-0.500, 0.500-1, 1-2, 2-4, 4- 8, 8- 16 mm by sieving analyses. Barytes and normal aggregate have to be kept from moisture and humidity.

Table 2. Physical and mechanical properties of normal and barytes aggregate[2]
(Tablo 2. Agrega ve baritin fiziksel ve mekanik özellikleri [2])

Properties	Test			Barytes Aggregate	Normal Aggregate	Turkish standards
Physical	Specific Gravity (gr/cm^3)	Oversize 4 mm		4	2.66	TS 707
		Undersize 4 mm		4	2.50	
	Unit Weight (gr/cm^3)	Oversize 4 mm	Compact	2.85	1.47	TS 3529
			Loose	2.19	1.77	
		Undersize 4 mm	Compact	2.85	1.48	
			Loose	2.53	1.75	
	Fineness modulus (m)			6.23	3.89	TS 706 EN 12620
	Fine Material Content (%)			0.5	3.46	TS 3527
Mechanical	Pressure MPa (Cube and Surface Area 50 cm^2)			26.25		TS 10465
	Los Angeles Abrasion Loss (%) (100 cycles)			58	26	TS EN 1097-2
	Soundness Rate (%) (Chemical Method – $NaSO_4$)			2.82	3.55	TS EN 1367-1

All samples cylindrical standard specimen with diameter of 15x30 cm were used in the experiment. These were installed in three steps during the filling of concrete specimens and at each step were vibrated on shaking tables. The specimens were then kept in a 20°C±2 curing room having 95±5% relative humidity for 24 h after which they were preserved for 27 days which is the time when experiment is performed. The experimental works for physical and mechanical properties were carried out at the construction materials laboratory at the Suleyman Demirel University [8].

3. RESULTS AND CONCLUSIONS (TARTIŞMA VE SONUÇLAR)

The physical and mechanical properties of 15 different types of heavyweight concrete have been obtained and the effects of w/c on some physical and mechanical properties of concrete were investigated. The variation of CS measured by axial tests on 7^{th}, 28^{th} and 90^{th} days as a function of w/c ratio is displayed in Figure 1.

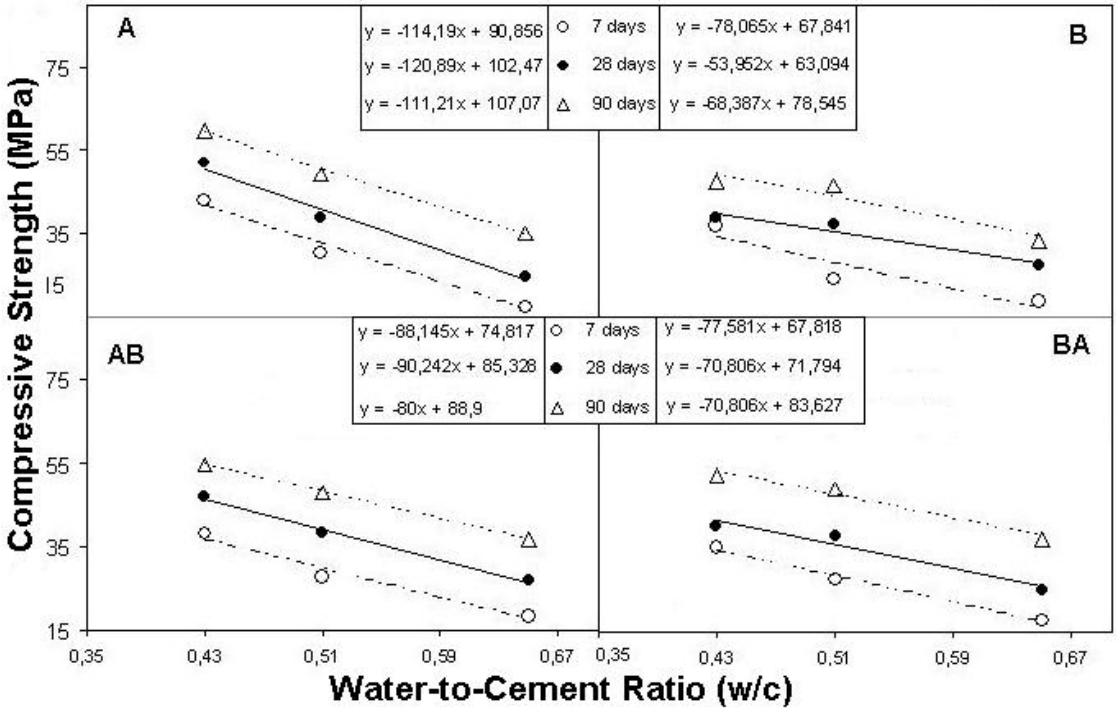

Figure 1. The variation of Compressive Strength with the w/c ratio in different types of concretes
(Şekil 1. Betonların basınç dayanımı ve s/ç oranının değişimi)

As can be seen from this figure that there is no big differences between different types of concretes in terms of physical and mechanical properties, the CS is about 30% lower for B4 than for A4. It can also be seen from this figure that the CS has higher value for 90, 28 and 7 days period respectively. It is also clearly seen from

this figure that the CS decreased with increasing w/c ratio of all types of concrete. As the SH related with the CS, it also decreased with the increasing w/c ratio as shown in Figure 2. The similar results of CS for the w/c of 0.65 and 0.51 have been obtained for the different types of concrete and this similarity is at 0.51 for SH. The variation of UW with the w/c ratio is shown in Figure3 where there is no big variations observed for different w/c ratio.

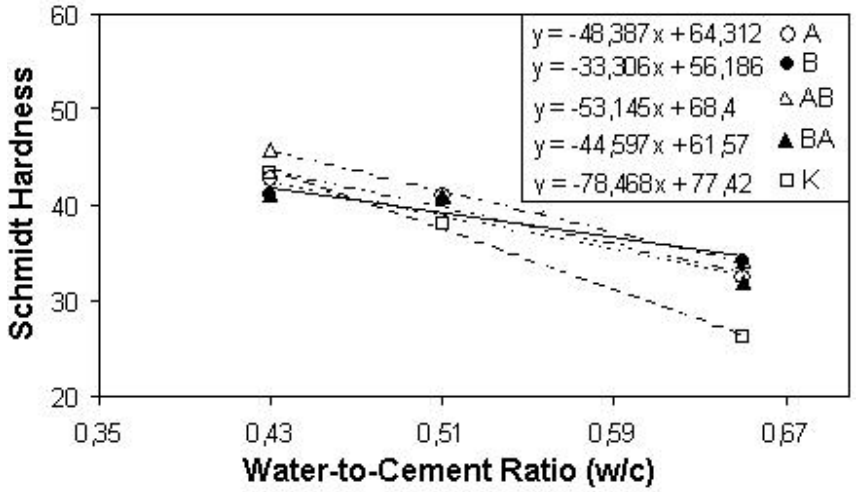

Figure 2. The variation of Schmidt hardness with w/c ratio
(Şekil 2. Schmidt sertliği ve s/ç oranı değişimi)

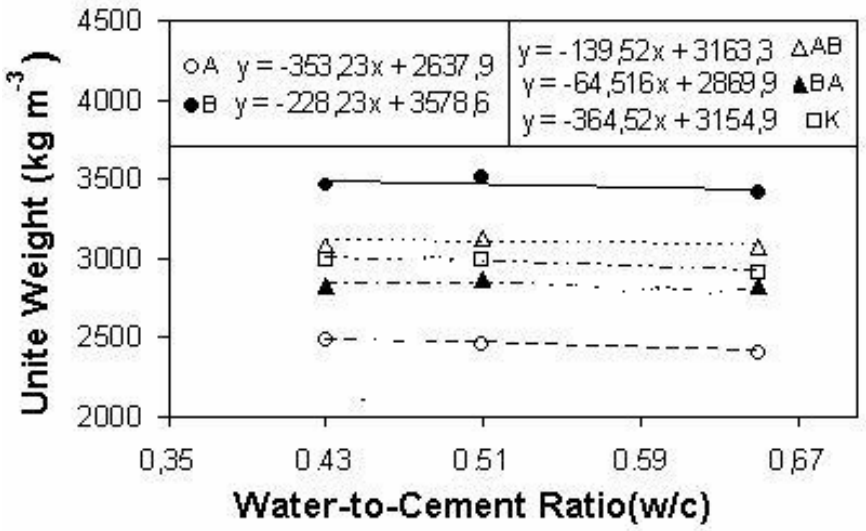

Figure 3. The variation of unit weight with w/c ratio
(Şekil 3. Birim ağırlık ve s/ç oranı değişimi)

As can also be seen from this figure that the UW increased with the increasing barytes rates in concrete and the maximum value of UW is 3507 kg/m^3 for B types concretes at 0.51 of w/c ratio. The relation between UV and w/c is plotted in Fig.4 where it can be seen that the UV decreased with the increasing w/c ratio for all types of concrete. The maximum ultrasound velocity is for the value of 0.43 w/c for A

series concrete and at the w/c ratio of 0.51 for B series and at the ratio of 0.65 for K series.

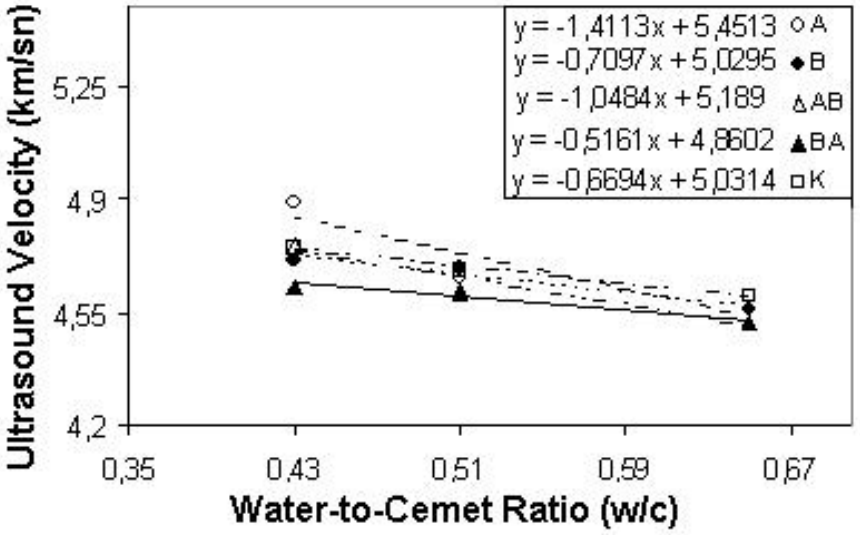

Figure 4. The variation of ultrasound velocity with w/c ratio
(Şekil 4. Ultrases hızı ve s/ç oranı değişimi)

It can be concluded from this work that the w/c ratio is important for concrete production and the physical and mechanical properties of concretes decreased with the increasing w/c ratio in the concrete.

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