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CAPILLARITY OF CONCRETE INCORPORATING FOUNDRY SAND AS REPLACEMENT OF SAND

ABSTRACT

This paper presents the results of experimental research into concrete produced by replacing the natural aggregates with recycled aggregates coming from foundry industries. Little work has been done so far on the effect of used foundry sand on the durability of concrete especially water absorption. The main aim of this work was to determine capillary water absorption and methods of improvement. Capillary water absorption, compressive strength and ultrasonic pulse velocity at 28 days of curing were reported in this investigation. The natural was replaced with 0%, 30%, 60% and 100% with foundry sand. Coarse natural aggregate was used in all cases and the amount of cement and W/C ratio of 0.5 remained constant in the all mixes. There was an increase in capillary water absorption (C.W.A), a decrease in compressive strength and ultrasonic pulse velocity (U.P.V) with the increase in used foundry sand content in concrete.

Keywords: Absorption, Capillary Water Absorption, Foundry Sand, Strength, Waste

DÖKÜMHANE KUMUNUN NORMAL KUM YERİNE KULLANILMASI İLE ÜRETİLEN BETONUN KAPİLLARİTESİ

ÖZET

Bu makale, dökümhanelerden gelen atık kumun doğal agrega yerine kullanılmasıyla üretilen betonlar üzerine yapılan deneysel araştırmayı sunmaktadır. Bu zamana kadar dökümhane kumundan üretilen betonun su emme dayanıklılığı ile ilgili çok az çalışma yapılmıştır. Bu çalışmanın ana konusu kapiler su emme ve iyileştirme metotlarıdır. Bu araştırmada kapiler su emme, basınç dayanımı ve ultrasonik vuruş hızı 28 günlük kür sonunda elde edilmiştir. Doğal agrega %0, %30, %60 ve %100 olacak şekilde dökümhane kumu ile yer değiştirilmiştir. Doğal agrega ve çimento bütün karışımlarda kullanılmış ve su çimento oranı (W/C) 0.5 olarak bütün karışımlarda sabit tutulmuştur. Kapiler su emmede ve ultrasonik vuruş hızlarında artışlar, basınç dayanımlarında düşüşler kaydedilmiştir.

Anahtar Kelimeler: Su Emme, Kapiler Su Emme, Dökümhane Kumu, Dayanım, Atık

1. INTRODUCTION (GİRİŞ)

With ever increasing quantities of industrial by-products and waste materials, solid waste management has become the principal environmental concerns in the world. Scarcity of land-filling space and due to its ever increasing cost, utilization/recycling of by-products/waste has become an attractive alternative to disposal. Several types of by-products and waste materials are generated. Each of these waste products has specific effects on the properties of cement-based materials, for example Controlled Low-Strength Materials and Concrete. The utilization of such materials in concrete/controlled low-strength materials not only makes it economical, but also do help in reducing disposal problems [1 and 3].

In the metal casting industry, sand is used to for casting and after a certain number of times, this sand is renewed and the results is waste foundry sand. In recent years, there have been attempts to use waste foundry sand in construction applications. The leaching of concrete with foundry sand was found to be comparable to concretes with natural soils. If incorporated in concrete, foundry sand should be expected to have less leaching. The rate of strength gain was lower for foundry sand mixes than for conventional materials. They found that that flowable fill using up to 55.5% foundry sand as replacement of normal sand is an economic alternative to conventional compacted fills [4]. Also the use of fly ashes and foundry sands from ferrous castings should be environmentally acceptable when used in flowable fill applications [5].

Naik et al [6] conducted work on the use of foundry sand in flowable materials and found that foundry sand can be used in flowable fills to replace up to 85% of the fly ash used in the reference mixes. Khatib and Ellis [7] investigated the properties of concrete containing foundry sand as a partial replacement of sand. They concluded that; the strength of concrete decreased with the increase in foundry sand. Also length change of concrete increased with the increase in foundry sand.

Naik et al. [8] studied the utilization of Class F fly ash, coal combustion bottom ash, and used-foundry sand for the manufacture of bricks, blocks, and paving stones. The results of this investigation showed that; partial replacement of cement with fly ash (FA) consistently improved the strength and durability of concrete masonry units; 2) up to 25% of sand in blocks could be replaced with either bottom ash (BA) or used foundry sand (UFS) in cold regions, and up to 35% of sand in bricks and blocks could be replaced with either BA or UFS for use where frost action is not a concern. Also in 1993 and 1994 demonstration projects on flowable fill were initiated using waste foundry.

2. RESEARCH SIGNIFICANCE (ÇALIŞMANIN ÖNEMİ)

Used foundry sand is currently disposed off in landfill. The authors have published work on the basic properties of concrete containing waste foundry sand. The current work is intended to allow greater utilisation of waste foundry sand. Capillary water absorption is a key physical properties that affect the durability of concrete. Therefore, in this paper results on water absorption by capillary action are reported at the age of 28 days of curing. Also strength and ultrasonic pulse velocity data were reported at the same age of curing.

3. EXPERIMENTAL METHODS (DENEYSEL ÇALIŞMA)

The control mixture had a proportion of 1 (cement): 2 (sand): 4 (coarse aggregate). The normal sand was replaced with 0%, 30%, 60% and 100% of used foundry sand (Table 1). The water to cement ratio for all mixes was of 0.5.

Table 1. Details of mixtures
(Tablo 1. Karışımın detayları)

Mixture Number	WFS* (%)	Mixture constituents (kg/m³)				
		Cement	Free Water	Coarse Aggregate	Sand	WFS*
1	0 (Control)	320	160	1278	639	0
2	30	320	160	1278	511	192
3	60	320	160	1278	383	384
6	100	320	160	1278	0	639

* Waste foundry sand (% by mass of sand)

The cement used was Portland cement (PC) and the sand (fine aggregate) used complied with class M of BS 882: 1992. The coarse aggregate was 10 mm nominal size. The waste foundry sand (WFS) was obtained from a foundry in the West Midlands, UK. The particle size distribution of sand and WFS is given in Figure 1.

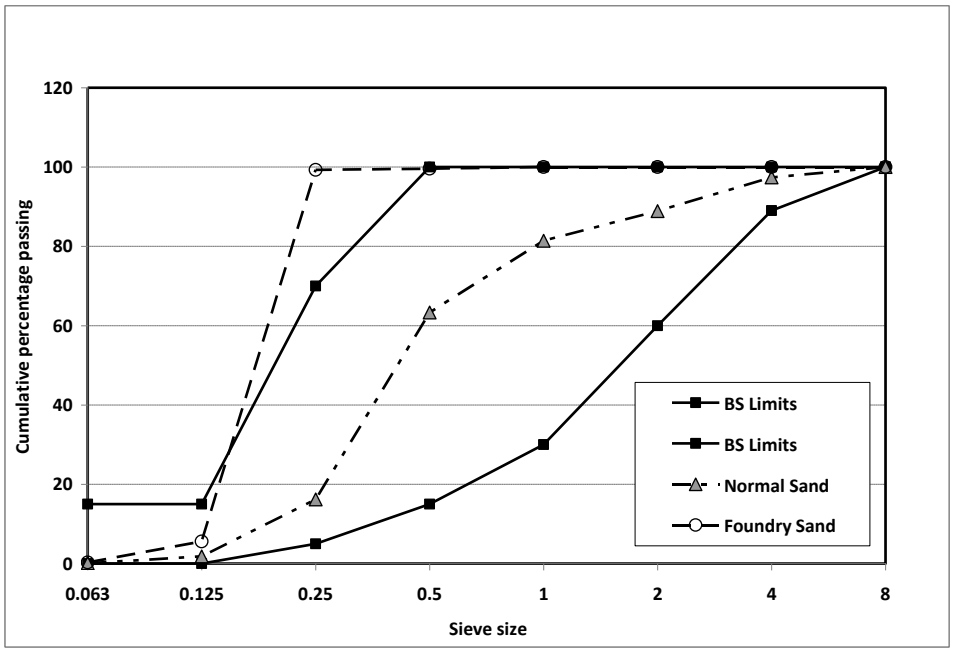

Figure 1. Particle size distribution of normal sand and foundry sand
(Şekil 1. Normal ve dökümhane kumunun elek analizi değerleri)

Specimens were cast in steel moulds. Cubes of 100mm in size were used for the determination of compressive strength, ultrasonic pulse velocity. For capillary water absorption specimens of 100mmx100mmx50mm in

size were used. After casting specimens were covered and left in the laboratory at for 24 hours. After that demoulding took place and specimens were placed in water. Testing was conducted at 7, 14, 28 and 56 days but in this investigation, only the data at 28 days of curing were reported. For capillary water absorption test, samples were dried in at 80°C until a constant mass and were then cooled in an airtight container at 20 °C before testing. In this test, the mass resulting from absorption of water as a function of time when only one surface of the specimen is exposed to water is monitored. Further details about the test are reported elsewhere [9 and 10].

4. FINDINGS AND DISCUSSIONS (BULGULAR VE TARTIŞMALAR)

The amount of water absorbed per unit area for concrete containing foundry sand (FS) at the age of 28days of curing, is shown in Figure 1 during the first hour and in Figure 2 during the first 48 hours. There is higher amount of water uptake with the increase in foundry sand content. Also the rate of water uptake is higher (i.e. the slope of the initial part of the curve which is referred to as the water absorption coefficient). This indicates there is higher capillary water absorption when foundry sand is incorporated in the mixes. Further details about the determination of water absorption coefficient are reported elsewhere [9 and 10]. Mixes containing 60 and 100% foundry sand as replacement of sand show substantially higher water uptake and the higher water absorption coefficient.

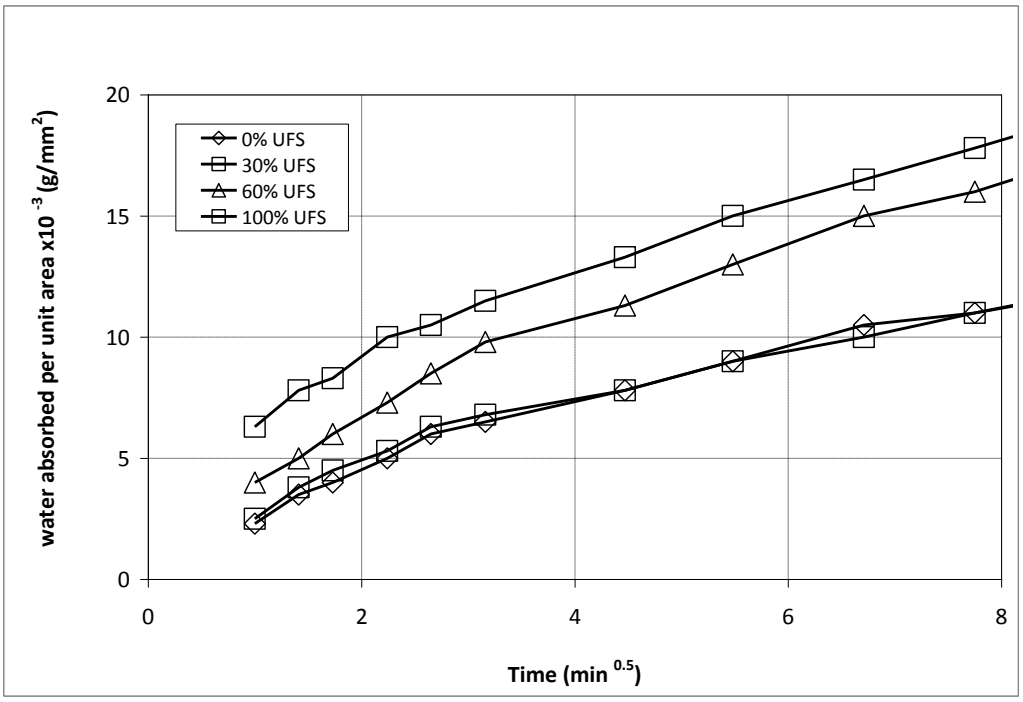

Figure 2. Capillary water absorption of concretes containing varying amounts of foundry sand at 28 days of curing - First 1 hour of absorption
(Şekil 2. Değişik oranlarda dökümhane kumundan üretilen betonların 28 günlük kürde elde edilen ilk 1 saat için kapiler su emme değerleri)

The compressive strength at the age of 28 days of curing for concretes containing varying amounts of foundry sand is shown in Figure 4. Although there is an acceptable strength for all concrete with and without foundry sand, there is a systematic decrease in compressive strength as the amount of foundry sand is increased. For example, the strength for the control mix (i.e. 0% Foundry sand) is 40 N/mm2 and this drops down to under 20 N/mm2 for the mix containing 100% foundry sand as a replacement of natural sand. The percentage decrease in strength is 19%, 40% and 54% for mixes containing 30%, 60% and 100% of foundry sand respectively. The trend is similar for the ultrasonic pulse velocity as shown in Figure 5. Comparing Figures 4 and 5 with Figures 2 and 3, it can be observed that an increase in the amount and rate of water uptake is associated with lower strength and lower ultrasonic pulse velocity.

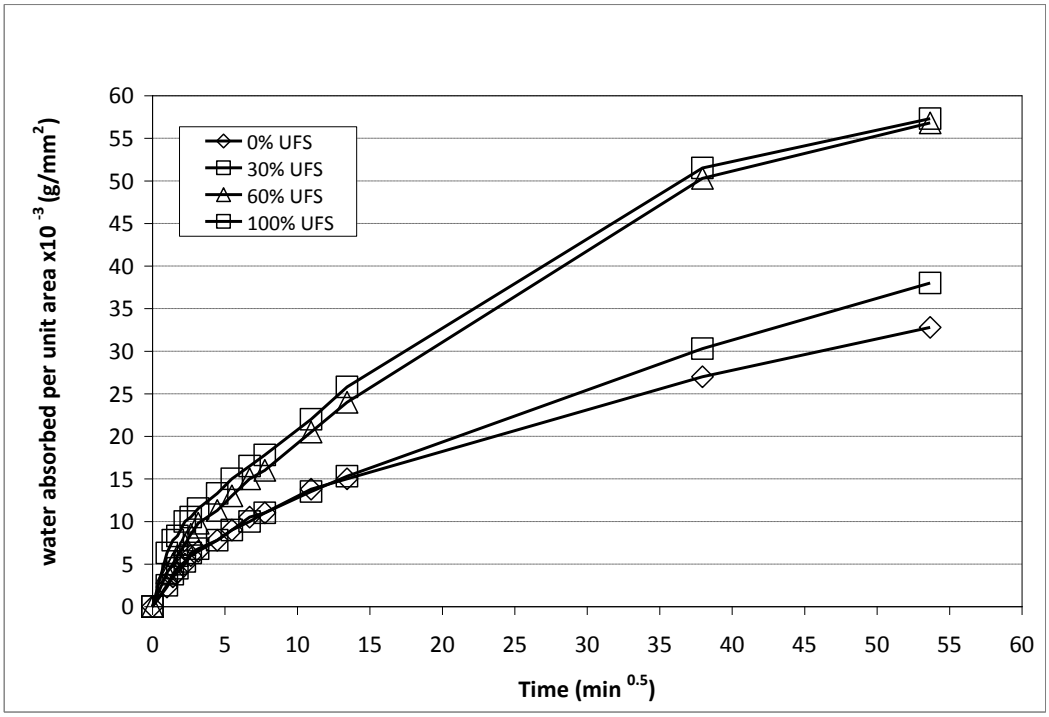

Figure 3. Capillary water absorption of concretes containing varying amounts of foundry sand at 28 days of curing – First 48 hours
(Şekil 3. Değişik oranlarda dökümhane kumundan üretilen betonların 28 günlük kürde elde edilen ilk 48 saat için kapiler su emme değerleri)

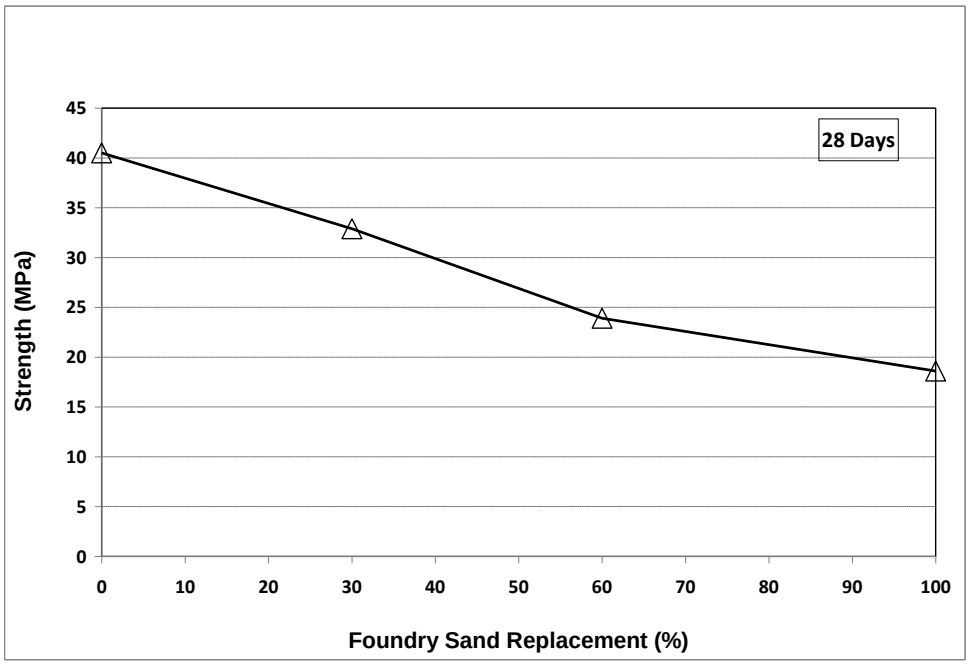

Figure 4. Compressive strength of concretes containing varying amounts of foundry sand at 28 days of curing
(Şekil 4. Değişik oranlarda dökümhane kumundan üretilen betonların 28 günlük kürde elde edilen basınç dayanımları)

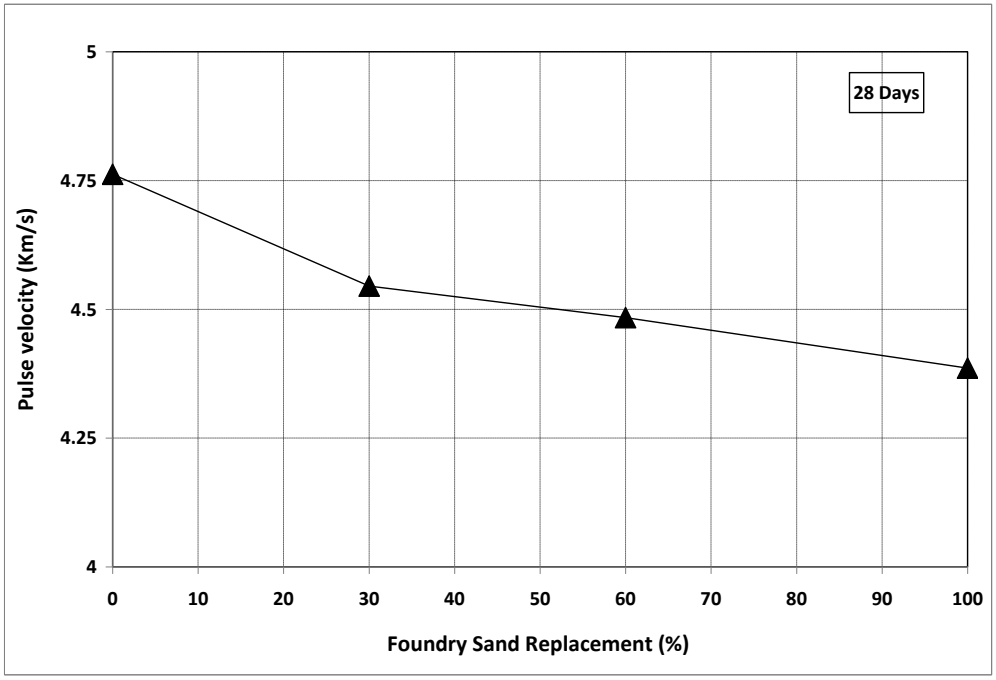

Figure 5. Ultrasonic pulse velocity (UPV) of concretes containing varying amounts of foundry sand at 28 days of curing
(Şekil 5. Değişik oranlarda dökümhane kumundan üretilen betonların 28 günlük kürde elde edilen ultrasonik vuruş hızları (UVH))

5. CONCLISIONS (SONUÇLAR)

There is a tendency for the capillary water absorption (as indicated by the water absorption coefficient) to increase when normal sand is replaced with increasing amounts of foundry sand. This is complemented with a decrease in strength and ultrasonic pulse velocity. The level of decrease depends upon the replacement level of foundry sand. However, adequate strength can be achieved using an appropriate replacement level of foundry sand. With appropriate mix design, the utilisation of foundry sand in concrete production is possible.

NOTICE (NOT)

Bu makale, 28-30 Eylül 2011 tarihleri arasında Elazig Fırat Üniversitesinde yapılan "Inetnational Participated Construction Congress" IPCC11'de tebliğ sunulmuştur.

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