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Impact of recycled gravel obtained from low or medium concrete grade on concrete properties

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KEYWORDS

Recycled gravel;
Concrete;
Silica fume;
Compressive strength;
Mass transport

Abstract This paper investigates the effect of recycled gravel obtained from low (Gl) or medium (Gm) concrete grade on fresh property of concrete (slump), mechanical properties (compressive-splitting tensile strength) and mass transport properties (ISAT-sorptivity) of concrete containing dolomite as a natural coarse aggregate. Concrete specimens were prepared with cement, water, sand and dolomite admixed with recycled gravel. The percentage of recycled gravel/dolomite was 0:100, 25:75, 50:50 and 75:25 at w/c = 0.50, 0.55 and 0.60. The effect of silica fume and bonding admixture at w/c = 0.55 on concrete properties were also considered. The results indicated that, increasing the percentage of recycled gravel/dolomite led to decreasing the slump. All mechanical properties of concrete discussed were inversely affected by increasing percentage of recycled gravel/dolomite from low and medium concrete. Adding 10% SF or bonding admixture increased the mechanical properties of concrete. Mass transport properties of concrete (ISAT-sorptivity) were enhanced by decreasing the percentage of recycled gravel/dolomite. The optimum percentage of recycled gravel/dolomite = 25%.

Introduction

The term RAC refers to the recycled aggregate concrete and it is defined as the concrete prepared by using recycled aggregates or the combination of recycled aggregates and natural aggregates. The recycled aggregates may be either fine recycled or coarse recycled aggregates which are obtained by crushing the waste/demolished concrete [1]. It is believed that RA has been used since 1945 in concrete production and started when World War II damaged large quantities of concrete structures and consequently, there was high demand of aggregates to rebuild the structures [2]. Waste arising from construction and demolition constitutes one of the largest waste streams within the Asian and many other countries. It is estimated that core waste amounts to around 180 million tons per year. The estimates for the UK are 30 million tons/year [3]. Re-use of waste concrete as RA in new concrete is beneficial from the view point of environmental protection [4]. Many studies [1,5,6]

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investigated the influence of RAC on slump. They reported that, the slump of concrete decreased when increasing RA. Many researchers studied the impact of recycled aggregate concrete on concrete compressive strength. Concrete containing recycled aggregates provided lower compressive strength than that of control specimen [5]. The compressive strength of RAC is lowered when replacement percentage of RA increased [6,8,10,11]. Not much significant difference was observed in compressive strength of RAC up to 50% replacement of coarse aggregates [1,3,4,9]. Other research studies showed that, the compressive strength of concrete was not affected when using recycled aggregates up to 25% of the total aggregate [7]. The effect of RCA on splitting tensile strength of concrete was investigated [6–8,12]. It was concluded that increasing RA decreased splitting tensile strength. Adding 10% SF increased the compressive and splitting strength of concrete [12–14]. It is noted that most of the study on recycled aggregate in concrete has been focused on the effect of recycled aggregate on fresh and mechanical properties of concrete and there is a lack of information on the impact of recycled coarse aggregates on mass transport properties of concrete, as well as, determine the optimum percentage of recycled gravel obtained from low or medium concrete grade to dolomite. This study focuses on the impact of using gravel as recycled aggregates obtained from low or medium concrete grade with dolomite as natural coarse aggregates on concrete properties. These replacements were 0:100, 25:75, 50:50 and 75:25. The w/c used for all mixes were 0.50, 0.55 and 0.60. The effect of replacement percentages of recycled coarse aggregates on slump, compressive and splitting tensile strength and mass transport properties of concrete (ISAT-sorptivity) were investigated. Moreover, the influence of 10% SF and bonding admixture on slump and compressive strength of concrete at w/c = 0.55 was studied.

Experimental program

Preliminary work

Two groups of concrete specimens were used in this work, the first group represents the low concrete grade of characteristic strength 180 kg/cm^2, whereas, the other group represents the medium concrete grade of 250 kg/cm^2 characteristic strength. The constituents of the two groups are presented in Table 1. Concrete specimens representing the groups were cast in cubes 15 × 15 × 15 cm, cured and then tested at the age of 28 days for compression. They were crushed manually using steel hammer and sieved, and the gravel obtained from these concrete specimens with the attached mortar was used in main experimental program.

Table 1 Composition of the concrete mixtures (kg/m^3) of preliminary work.

Group	Cement	w/c	Sand	Gravel	Water
Gl	250	0.60	600	1200	150
Gm	350	0.50	600	1200	175

Table 2 Chemical and physical analysis of cement.

Property	OPC
Chemical composition, %	
SiO_2	20.56
Al_2O_3	5.59
Fe_2O_3	2.65
CaO	63.13
MgO	1.94
Na_2O	0.22
K_2O	0.6
SO_3	2.61
Bogue compounds, %	
C_3S	61
C_2S	12.7
C_3A	8
C_4AF	9.1
b – physical properties	
Initial setting time, min	135
Final setting time, min	300
Specific surface, m^2/kg	370
Soundness, mm	2
c – compressive strength, kg/cm^2	
3 days	250
7 days	350

Main experimental program

Materials

Normal Portland cement was used in this investigation; it was delivered from "Beni-Suef cement company", Type CEMI 42.5 N. Testing of cement was carried out per the Egyptian Standard Specifications ESS 2421/2005 [15]. The chemical and physical analysis of cement is presented in Table 2. Natural siliceous sand with fineness modulus 2.73 was used as fine aggregates. Dolomite with 25 mm maximum nominal size was used as natural coarse aggregates. Gravel obtained from low or medium concrete grade of 20 mm maximum nominal size was used as recycled coarse aggregates. Silica fume was used as a cement replacement material, bonding admixture according to ASTM C 631-2009 [16] of density 1.08 gm/cm^3 was used and tap water was used for mixing and curing.

Mixture proportions

Forty mixtures were tested in this research, twenty mixtures for medium concrete grade (Gm) and the other for low concrete grade (Gl). These mixtures were made with percentage of gravel to dolomite = 0/100, 25/75, 50/50 and 75/25. Dolomite of 25 mm maximum nominal size was mixed with cement, sand, recycled gravel and water. The mix constituents were 350 kg cement, 1200 kg dolomite, and 600 kg sand per cubic meter of concrete at w/c = 0.50, 0.55 and 0.60. 10% SF was used in the mix at w/c = 0.55, and also bonding admixture of 1/7 mass of water was used at w/c = 0.55. These constituents of concrete were mixed in mixer for two minutes, and then placed in cube moulds 10 × 10 × 10 cm for ISAT, sorptivity, 15 × 15 × 15 cm for compressive strength testing, whereas, the specimens for splitting tensile testing were cylinders 15 × 30 cm. Table 3 presents the compositions of materials used (kg/m^3) .Table 4 shows the tests that were conducted, sizes of specimens and testing ages.

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