The Effect of Coarse Aggregate on Fresh and Hardened Properties of Self-Compacting Concrete (SCC)

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In concrete technology, self-compacting concrete (SCC) is considered to be one of the most important innovations. It is a highly workable concrete that can flow through congested reinforcing under its own weight and sufficiently fill voids without tending to segregation or excessive bleeding and without the need for vibration to consolidate it. The aggregates, which form more than 60% of the volume of concrete, play a main role in affecting its fresh as well as hardened properties. SCC is very sensitive to changes in aggregate characteristics (shape, texture, maximum size, grading and morphology), so the aggregate should be chosen carefully before using it in SCC.

As the study of aggregate characteristics is considered very necessary in using SCC, many researchers have examined coarse aggregate properties and their effect on SCC properties in the fresh and hardened states.

Tviksta (2000) stated that it is possible to use natural, rounded, semi-crushed or crushed aggregates to produce SCC. The aggregates' characteristics should be taken into consideration for the performance required for fresh and hardened concrete (Neuwald, 2004 and Janssen, and Kuosa, 2001). The shape and size of coarse aggregate has a vital influence on the necessary mortar and paste volume to cover all particles. Naturally uncrushed gravel often needs less mortar or paste than does limestone. Granite, on the other hand, requires more mortar volume. Crushed aggregate tends to reduce flow because of the interlocking of the angular particles, whilst rounded aggregate improves the flow because of lower internal friction (Alexander and Prosk 2003). The key to successfully producing economical SCC, it should be observed, is to use a well-graded aggregate source. SCC mixes can use a poorly graded aggregate but this requires providing more viscosity to avoid segregation problems (Neuwald 2004). A high maximum size leads to decreased passing ability. Hence, decreasing the coarse aggregate content will be required. The choice of maximum size depends on the amount of reinforcement bars and the gaps between them, where higher proportions of higher maximum size may lead to aggregate blocking in the congested area with reinforcement bars. The optimum coarse aggregate content depends on two parameters. The first parameter is the maximum size, where lower values of maximum size lead to increased possibility of using high coarse aggregate content. The second parameter is the shape of the coarse aggregate, whether it's crushed or rounded, where a higher content of rounded shape leads to increased possibility of using a high coarse aggregate content (EFNARC 2002). While Petersson (1997) considered that the maximum size of aggregate (10mm and 20mm) that is suitable to produce SCC.

The objectives of the present study of the SCC System were to study the effect of three types of aggregate (crushed gravel, uncrushed gravel and crushed limestone), the maximum size (10 and 20), and the texture of the aggregate. Firstly, it was done by making a comparison among three types of local aggregate and their influence on the fresh and hardened properties of SCC. Secondly, the effect of sizes 10 and 20mm on the properties of SCC also were studied. Both the uncrushed and crushed aggregate were used to study the effect of texture surface of aggregate on the properties of SCC.

EXPERIMENTAL WORK MATERIALS

The cement used was ordinary Portland cement Type (I) (C), metakaolin (MK) was used as a partial replacement for cement with the percentage of replacement at (10%), and the fineness of MK being (17000) cm^2/gm. Table (1) shows the chemical properties of this cement and metakaolin. Natural sand (S) was used (fineness modulus was 2.41, specific gravity: 2.62, absorption 0.83%, loose bulk density: 1730 kg/m^3). In this study the three types of coarse aggregate (CA)were uncrushed gravel, crushed gravel, and crushed limestone with a maximum size of 20 mm and specific gravity (2.68, 2.62 and 2.58) and absorption (0.6,0.64 and 2%), respectively. And the range of Grading of theses types of aggregate in the range of grading of BS 828-1992. The superplasticizer (SP) that was used was Glenium 51. Glenium 51 is considered one of the new generations of copolymer - based superplasticizers. ASTM C494-Type F designed for the production of SCC was used in this study. Glenium 51 has a light brown, a relative density of 1.1 @ 20 C_o and a viscosity of 128 □ 30 CPS @ 20 $_o$C.

EXPERIMENTAL PROGRAM

In order to achieve the aim of the study, the work was divided into 12 mixes and all details are shown in Table (2). These mixes were designed, mixed, tested for fresh properties and cast.

MEASUREMENTS AND PROCEDURE

The mix design method used in the present study is according to (EFNARC 2002) . The mix design has limited material proportion used in this study. The proportions of materials are (1:1.73:1.77) by weight. Where, the coarse aggregate content is 0.34 of the total volume of concrete. After determining the suitable mixture proportioning method and the materials for this study, no changes were made to all materials except the dosage of super-plasticizer and w/c to maintain the required workability.

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