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“Using recycled concrete as aggregate for producing Self-Compacting concrete”

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ملخص عربي:

الهدف من البحث هو الحصول على الخرسانة ذاتية الدمك باستخدام الركام الخشن المعاد تدويره الذي تم الحصول عليه من كسر الخرسانة و في هذه الدراسة تم استخدام 42 خلطة من خلال برنامج عملى يتكون من مرحلتين المرحلة الأولى: اختبرت الخلطات الخرسانية (30 خلطة) عمل تجريبي بنسب مختلفة من الركام المعاد تدويره ومحتوى الأسمنت. تم إجراء الاختبارات التالية اختبار الهبوط و T-50 واختبار مقاومة الضغط عند عمر 28 يومًا والمرحلة الثانية: تم قياس الخلطات المقبولة 12 خلطة بنسب مختلفة من الركام المعاد تدويره ، وأجريت الاختبارات التالية slump flow ، T50، J-ring، V-Funnel ، GTM screen stability ، تم اختبارها لمقاومة ضغط الخرسانة عند عمر 7 و 28 يومًا و قوة الشد عند عمر 28 يومًا. أظهر استبدال 25٪ من الركام الطبيعي بواسطة RCA أقصى تحسن في الخواص الميكانيكية .

ABSTRACT

Self-compacting concrete is the most widely used construction material at this time. In many developed countries, concrete infrastructure comprises about 60% of the construction industry. This study focused on a new self-compacting concrete produced from recycled construction materials to use in R.C. elements. In this study, we used 30 mixes divided into 2 phases. The materials used in this research are cement, sand, natural aggregate, recycled aggregate, water, silica fume and admixtures. The variable in this study were (0, 25, 50, 100) % Recycled aggregate replacement for the original aggregate, silica fume with (10&12) % addition to cement content, and cement content from 300 kg/m3 to 450 kg/m3.
For each mixing, we implemented the fresh concrete tests included the initial slump, T50, J-ring, V-Funnel, V-Funnel T50, and GTM screen stability. In addition, the hardened concrete tests included the compressive strength at the ages of 7, and 28 days and the tensile strength at the ages of 28 days.

KEYWORDS

Self-Compacting concrete (SCC); recycled aggregate; Slump; T50, J-ring. V-Funnel, GTM, Compressive strength; Tensile strength.

1. INTRODUCTION

Self-compacting concrete (SCC) is predicted to produce high workability without segregation and high durability with high fluidity. The success to production of high quality (SCC) lies within the optimum percentage of recycled aggregates. Self-compacting concrete does not demand vibrating after casting into the formwork, which this property is the leading of its properties. Self- compacting concrete's compaction is a masterful in all form parts, including the barely attainable parts, without any supplementary external force away from the gravity. The flow ability and constancy of self-compacting concrete in the fresh state can be determined by the following characteristics: flow- ability (slump flow), viscosity (estimated by rate of flow), passing ability and segregation resistance. The concrete mixes will be distributing as a self-compacting one, if all the mentioned characteristics are checked. Fine mineral additive-powder can be improving and enhancing characteristics of the self-compacting concrete such as silica fume and fly ash

1- RESEARCH PROGRAM

This research was conducted in two phases: Phase (I) focused on the experimental study of the fresh properties of SCC mixes. Forty-two concrete mixtures were designed. Three key mix design parameters namely cement content 350, 400, 450 kg/m^3, recycle aggregate percentage 0, 25, 50, 75, and 100% of coarse aggregate replacement, and silica fume content 10, and 12% of cement content were selected to study the influence on the properties of (SCC). The tested (SCC) fresh properties were, slump flow, T50, J-ring flow diameter/height difference, V-funnel flow time, GTM Stability screen. Phase (II) study of the hardened properties of SCC mixes for compressive strength at age of 7, 28 days and tensile strength for 28 days.

2. MATERIAL

Materials Ordinary Portland cement is CEM I 42.5 N and silica fume (SF) were used as the binder materials in the SCC mixtures. ASTM Type I Portland cement, with a fineness of 3520 cm2/g and density of 3150 kg/m3 was used. Accordingly, in this study, the coarse aggregate with nominal size of 10 mm sourced from a local Construction and Demolition (C&D) waste recycling facility was used. five types of SCC mixtures were made, where the recycled coarse aggregates were used as 0, 25, 50, 75 and 100% by weight replacements of the natural coarse aggregate. The Super plasticizer dosage were kept the same for all mixes Sika Viscocrete 3425 was used as viscosity enhancing agent (VEA) and use w/c 0.6 all in mixes .

Fig (1) Product is a rich silicon dioxide powder where the average particles size

XPERIMENTAL WORK

The research was investigated for two phases, Phase 1 test all specimens for slump flow and T50. Phase 2 test the accepted mixes to determine J-Ring, V-Funnel, and GTM Stability. The mixes were designed according to ECP 203-2018 Egyptian Code for Practice. Table 1 shows the materials quantities for each mix.

4.1 Mix Proportions

The mix proportions of each mix were calculated by assuming that all its ingredients have to produce a cubic meter of concrete. Various mixes with different cement content, crushed aggregate content, sand content, and pozzolanic admixture. The concrete has a 20 mm maximum aggregate size, cement content is 450 kg/m3, crushed aggregate content is 736 kg/m3, sand content is 981.5 kg/m^3 , and pozzolanic admixtures 12%.

4.2 Mixing and Preparation of the Test Specimens

Mixing was done in a small rotary drum mixer. The sand, coarse aggregate and cement are first mixed. Finally, the water is added. Mixing was continued until the mix became homogenous. Immediately after mixing, the batch was cast in the molds. Mixing was carried out at the materials laboratory of HBRC, Cairo.

3. RESULTS AND DISSCUSSION

3.1. Fresh characteristics of Phase (1)

Immediately after the mixing, the value of slump flow, T50 were determined by the following methods

Slump flow and T50 test

The slump flow test was used to evaluate the free deformability and flow ability of (SCC) in the absence of obstructions.

The result of slump flow for mixtures showed that an increase in the Recycled Aggregate content and significantly decreased of the slump flow However, T50 increasing with increasing of Recycled Aggregate content in the mix.

Great positive effect of the coupled parameters (Recycled Aggregate content and cement content) in increasing the slump flow.

1. Slump flow test:

Accepted mixes were 25% Recycled Aggregate content that is nearly to control mixes, table (1) show the slump flow for phase 2 mixes, and figure (1) show the chart of results of slump flow.

Table (1) Slump flow test for phase 2 mixes.

Mix. No. Control	Slump Flow (mm)	Mix. No. Rec.Agg. 25%	Slump Flow (mm)
A	660	A	650
B	680	B	658
C	687	C	665
D	695	D	680
E	715	E	695
F	725	F	715

Figure (2) Slump flow for control and 25% recycled aggregate mix

2. T50 test:

Accepted mixes were 25% Recycled Aggregate content that is nearly to control mixes, table (2) show the T50 for phase 2 mixes, and figure (3) show the chart of results of T50.

Mix. No. Control	T50 (Sec)	Mix. No. Rec.Agg. 25%	T50 (Sec)
A	3.21	A	3.25
B	3.19	B	3.24
C	3.20	C	3.22
D	3.15	D	3.17
E	3.12	E	3.14
F	3.10	F	3.13

Table (2) T50 test for phase 2 mixes.

From results, Cement content is the most effective factor to decrease T-50 test values, Mix A2 were 350 kg/m^3 cement content and its T-50 test value were 3.31sec. While Mix F2 were 450 kg/m^3 cement content and its T- 50 test value were 2.5 sec. The mixes of recycled aggregate 25% had been values on T-50 test more than control mixes

5-GTM screen stability test

Accepted mixes were 25% Recycled Aggregate content that is nearly to control mixes, table (7) show the GTM for phase 2 mixes, and figure (13) show the chart of results of GTM.

Table (7) GTM test for phase 2 mixes.

Mix. No. Control	GTM (%)	Mix. No. Rec.Agg. 25%	GTM (%)
A	6.30	A	7.80
B	6.15	B	7.40
C	6.02	C	7.30
D	5.97	D	7.10
E	5.88	E	7.00
F	5.70	F	6.90

Figure (5) GTM test for control and 25% recycled aggregate mixes

3. J-ring test:

The J-ring test is used to determine the passing ability of the (SCC) as shown in figure (9). Accepted mixes were 25% Recycled Aggregate content that is nearly to control mixes, table (5) show the J-ring for phase 2 mix

Mix. No. Control	J-ring (mm)	Mix. No. Rec.Agg. 25%	J-ring (mm)
A	3	A	2.7
B	2.7	B	2.4
C	2.5	C	2.1
D	2.3	D	1.95
E	2	E	1.85
F	1.80	F	1.75

Figure (6) J-ring test for control and 25% recycled aggregate mix

- Mixes were the same value approximately for J-ring test for control mix and 25%Rec.Agg mix, respectively

4. V-funnel flow test

The V-funnel test is used to determine the deformability through restricted area, maximum increase of parameters resulted in a substantial reduction of the V-funnel flow time the test was carried out for (SCC).

Mix. No. Control	V-funnel (mm)	Mix. No. Rec.Agg. 25%	V-funnel (mm)
A	6.6	A	6.4
B	6.45	B	6.30
C	6.30	C	6.20
D	6.15	D	6.10
E	6.06	E	6.00
F	6	F	6

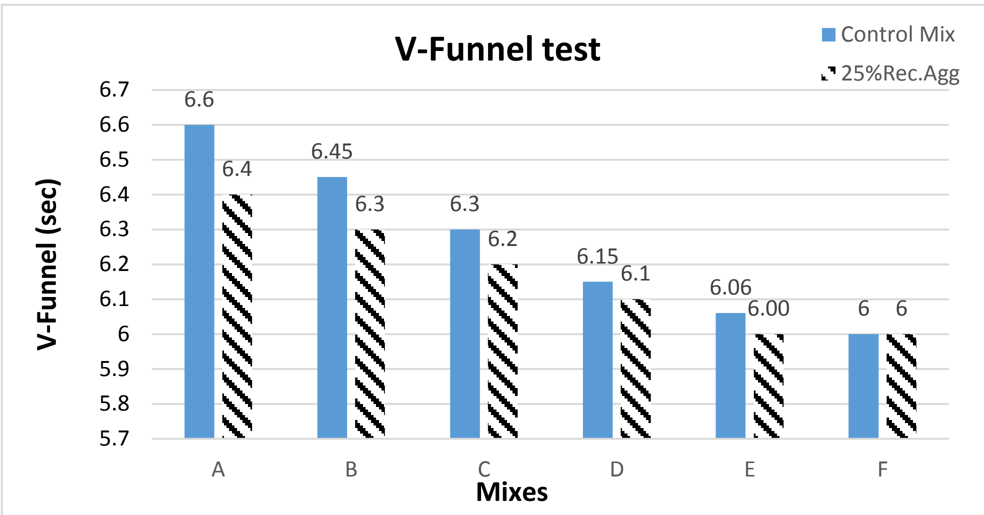

Figure (7) V-Funnel test for control and 25% recycled aggregate

6. CONCLUSION

1. Increase of the percentage of recycled aggregate reduces the fresh and hardened properties of concrete, which is the optimum value to recycled aggregate is 25%.
2. The quality of used recycled aggregate has a direct effect on the compressive hardness. If the quality aggregate is used, of a consistent composition, the differences in compressive strength between the control and test concretes with as much as 25% of coarse recycled aggregate can be small.
3. Usage of recycled aggregate for making of SCC is justified. By an appropriate choice of material and design of the mixture, high-performance concretes can be obtained, with a prominent environmental component aside from the mechanical ones.
4. Utilization of recycled aggregates reduced the slump flow. In addition, the use of recycled aggregates in self-compacting recycled concrete showed acceptable

passing ability in the J- ring, V-Funnel tests.

5. The compressive strength generally decreased when the percentage of recycled aggregate increased in all tested ages. It was 25 N/mm^2 for 100% RA at 28 days, compared with a mix of 0% RA was decreased by 36% tested at 28 days. This is may be due to the higher values of water absorption of RA.
6. The tensile strength generally is the same in in case of control mixes and for 25% Recycled Aggregate.
7. The cost of mixes with 25, 50, 75 and 100% recycled aggregate decreases by 0.65%, 1.9%, 3.2% and 2.58% compared to control mix.

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