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The Utilization of Recycled Concrete Aggregates in Fiber-Reinforced Self-Compacting Concrete

Rachid RABEHI[1, *], Mohamed RABEHI[1], Mohammed OMRANE[2], and Mohamed AMIEUR[4]

[1]*Laboratory (LDMM), Civil Engineering Department, University of Djelfa, Algeria*
[2]*Applied Automation and Industrial Diagnostic Laboratory, University of Djelfa, Algeria*
[3]*Laboratory of Eco-materials: Innovation &Applications (EMIA), Civil Engineering Department, University of Djelfa, Algeria*
[4]*National School of Built and Ground Work Engineering, ENSTP, Alger, Algeria*

[*]*(rachid.rabehi@univ-djelfa.dz) Email of the corresponding author*

Abstract **–** Self-compacting concrete (SCC) is a highly flowable, non-segregating concrete that offers advantages such as faster construction, reduced noise pollution, and improved reinforcement cover and consolidation. However, the production of SCC requires large volumes of powder materials and chemical admixtures, raising environmental concerns. Recycling concrete aggregates (RCA) obtained from construction and demolition waste is a promising approach to enhancing the sustainability of SCC. This study investigates the fresh, mechanical, and durability properties of steel fiber-reinforced SCC incorporating RCA. Crushing leftover concrete from a nearby demolition site and sieving to remove particles larger than 20 mm produced RCA. The SCC mix was designed for a target 28-day compressive strength of 40 MPa with a water-binder ratio of 0.4. Straight steel fibers were added at 0%, 0.5%, 1, 1.5, and 2% by concrete volume to study their reinforcing effects. The SCC mixes utilized Portland cement of the CEM I 42.5 type, with natural aggregates consisting of two granular classes of gravel and natural sand. The superplasticizer was formulated using 30% dry extracts and polycarboxylates as the primary components. Pure, uncontaminated drinking water is used as the mixing water for the production of various SCCs. The results showed that increasing the RCA replacement ratio decreased the workability and mechanical properties of SCC. It became easier to work with, stronger, more flexible, and shrunk less when 0.5% steel fibers were added to 50% RCA. These properties were the same as the control SCC after the addition. The fiber reinforcement compensated for the weaker interfacial transition zone between new cement paste and recycled aggregates.

Keywords – Self-Compacting Concrete (SCC), Recycled Concrete Aggregates, Fiber-Reinforced.

I. Introduction

Self-compacting concrete (SCC) is an innovative type of highly flowable, non-segregating concrete that can flow into place, fill formwork, and encapsulate congested reinforcement without any mechanical vibration [1]. Compared to conventional vibrated concrete, SCC has several advantages including faster construction, reduced noise pollution, and improved reinforcement cover and consolidation [2, 3]. However, the production of SCC requires large volumes of powder materials and chemical admixtures which raises environmental concerns [4, 5]. Using recycled concrete aggregates (RCA) obtained from construction and demolition waste is a promising approach to enhancing the sustainability of SCC. This study investigates the fresh, mechanical, and durability properties of steel fiber-reinforced SCC incorporating RCA.

RCA was obtained by crushing waste concrete from a local demolition site and sieving to remove particles larger than 10 mm. The SCC mix was designed for a target 28-day compressive strength of 40 MPa with a water-binder ratio of 0.4. RCA replaced natural gravel at replacement levels of 0%, 25%, 50%, 75%, and 100% by volume. Straight steel fibers were added at 0%, 0.5%, 1, 1.5, and 2% by concrete volume to study their reinforcing effects. The workability, compressive strength, splitting tensile strength, modulus of elasticity, drying shrinkage, and rapid chloride permeability [4–12].

II. Materials and Method

The SCC mixes utilized Portland cement of the CEM II/A 42.5 type, which has a density of 3.15 and a fineness of 3270 cm^2/g. The natural aggregates used consist of two granular classes of gravel (3/8 and 8/16) and natural sand (0/5). The recycled aggregates were produced by crushing small slabs ($0.6 \times 0.6 \times 0.15\ m^3$) of concrete composed solely of large and fine natural aggregates using a jaw crusher. The experimental methodology forms the foundation for the formulation of a single cubic meter of natural concrete. The superplasticizer was formulated using 30% dry extracts, with a density of 1.07, and polycarboxylates as the primary components. Pure, uncontaminated drinking water is utilized as the mixing water for the production of various Self-Consolidating Concretes (SCCs).

A. *Formulation for all SCC*

Five SCCs were created by substituting recycled aggregates and sands for a portion of the natural aggregates (0%, 25%, 50%, 75%, and 100%) in weight in order to investigate the impact of recycled aggregates on the behavior of the SCC. We established the S/M ratio at 0.50, the W/L ratio at 0.38, and the Sp/L ratio at 1.5% for each of the concrete mixes that were utilized. Because it ignores the crucial components of admixtures and additions, the Dreux-Gorisse method is deemed inappropriate and impracticable for self-compacting concrete (SCC) [13–19]. The majority of self-consolidating concrete (SCC) formulas are currently developed primarily through empirical methods [20–24].

Through strict adherence to established protocols and the integration of expert literature recommendations, we were able to attain self-compactability in our concrete mix designs. In order to ascertain the component proportions required for one cubic meter of concrete, comparable data for the parameters listed in references [25–26] must be obtained.

III. SCC Fresh State Characteristics

Following the procedures outlined by the international reference, the various assessments were completed immediately following the concrete mixing process [25]. Utilizing the slump test to gauge the concrete's spreadability, the L-box and J-Ring apparatus to gauge flow, and a sieve to gauge stability are the methods used in the assessments. These tests are intended to identify the static and dynamic segregation properties of self-consolidating concrete (SCC) as well as to gauge the material's flowability.

The fresh properties of the self-compacting concrete (SCC) mixtures are found to be within acceptable ranges for successful performance, as indicated by visual observation and test results. According to measurements of slump flow, J-ring, and L-box that satisfied suggested standards, all SCC formulations exhibited good flowability and deformability. The concrete's spreading pattern and surface appearance following slump flow testing revealed that none of the mixtures had any evident flaws. This provided additional solid proof that the concrete was both sturdy and capable of filling voids. The full stability characterization program demonstrates that these SCC mixtures are workable, passable, fillable, and do not separate at the initial stage, allowing them to appropriately self-consolidate.

Additionally, it was noted that higher values were obtained by increasing the amount of recycled sand and gravel by 25%. These values consistently fell within the range of internationally recommended standards [25–29]. This favorable result was noted.

Additional testing on the characteristics of hardened concrete will demonstrate whether uniform, long-lasting SCC elements following casting and curing are a result of good performance of fresh concrete.

IV. Conclusion

The utilization of recycled concrete aggregates in fiber-reinforced self-compacting concrete the results showed that increasing the RCA replacement ratio decreased the workability and mechanical properties of SCC. But when 0.5% steel fibers were added to 50% RCA, the workability, compressive strength, tensile strength, elastic modulus, and drying shrinkage were all improved to the same level as the control SCC. The fiber reinforcement compensated for the weaker interfacial transition zone between new cement paste and recycled aggregates. This study demonstrates that combining RCA and steel fibers at optimal dosages can produce sustainable SCC with adequate mechanical performance.

REFERENCES

[1] Okamura, H., & Ouchi, M. (2003). Self-compacting concrete. Journal of advanced concrete technology, 1(1), 5-15. https://doi.org/10.3151/jact.1.5

[2] Grabiec, A. M. (2013). Influence of viscosity modifying agent on some rheological properties, segregation resistance and compressive strength of self-compacting concrete. Journal of Civil Engineering and Management, 19(1), 1-8. https://doi.org/10.3846/13923730.2012.737830

[3] Bachtiar, E. (2018). KARAKTERISTIK SELF COMPACTING CONCRETE (SCC) TANPA CURING (CHARACTERISTIC OF SELF COMPACTING CONCRETE (SCC) WITHOUT CURING). https://doi.org/10.31227/osf.io/5u2y8

[4] Limbachiya, M., Meddah, M. S., & Ouchagour, Y. (2012). Performance of Portland/Silica Fume Cement Concrete Produced with Recycled Concrete Aggregate. ACI Materials Journal, 109(1).

[5] N. Su, B. Miao, A new method for the mix design of medium strength flowing concrete with low cement content. Cement and Concrete Composites, 25-2 (2003) 215-222 https://doi.org/10.1016/S0958-9465(02)00013-6

[6] H. J. H. Brouwers, H. J. Radix, Erratum to" Self-Compacting Concrete: Theoretical and experimental study" (Cement and Concrete Research 35 (11) (2005) 2116-2136. Cement and concrete research, 37(9), 1376-1376. (2007), https://doi.org/10.1016/j.cemconres.2005.06.002

[7] Rabehi, R., Mohamed, R., & Mohammed, O. (2023). Study of the durability of self-compacting concrete made from recycled gravel. The Journal of Engineering and Exact Sciences, 9(4), 15927-01e. https://doi.org/10.18540/jcecvl9iss4pp15927-01e

[8] Rabehi, R., Rabehi, M., & Omrane, M. (2023, April). Steel fiber's effects on the physical and mechanical characteristics of selfcompacting concrete (SCC) made of recycled gravel. In International Conference on Scientific and Innovative Studies (Vol. 1, No. 1, pp. 295-301). https://doi.org/10.59287/icsis.616

[9] Rabehi, R., Rabehi, M., & Omrane, M. (2023). Physical-mechanical and fresh state properties of self-compacting concrete based on different types of gravel reinforced with steel fibers: Experimental study and modeling. Construction and Building Materials, 390, 131758. https://doi.org/10.1016/j.conbuildmat.2023.13175

[10] BENZERGA, A. L., AMIEUR, M., & RABEHI, R. (2023, May). Reinforcement of concrete with composite materials based on fiberglass. In International Conference on Contemporary Academic Research (Vol. 1, No. 1, pp. 42-47). https://doi.org/10.59287/iccar.736

[11] Rabehi, R., Mohamed, A., Mohamed, R., & Mohammed, O. (2023). Effect of additions on the self-compacting concrete's absorption. The Journal of Engineering and Exact Sciences, 9(6), 16058-01e. https://doi.org/10.18540/jcecvl9iss6pp16058-01e

[12] RABEHI, R., AMIEUR, M., & RABEHI, M. (2023, May). Characterizations of self-consolidating concrete (SCC) from a physicalmechanical perspective with various additions. In International Conference on Recent Academic Studies (Vol. 1, pp. 58-63). https://doi.org/10.59287/icras.672

[13] RABEHI, R., AMIEUR, M., & RABEHI, M. (2023, July). The effect of finely ground dune sand on the properties of self-compacting concrete. In International Conference on Recent Academic Studies. (2023, July). (Vol. 1, No. 1, pp. 984–988). https://doi.org/10.59287/icaens.1120

[14] Lamine, B. A., Mohamed, A., & Rachid, R. (2023). Concrete reinforcement using composite fiberglass-based materials. The Journal of Engineering and Exact Sciences, 9(7), 16530-01e. https://doi.org/10.18540/jcecvl9iss7pp16530-01e

[15] RABEHI, R., AMIEUR, M., & RABEHI, M. (2023). Evaluation of self-compacting concretes (SCC) made with brick powder using non-destructive and destructive tests. All Sciences Abstracts, 1(5), 13-13. https://doi.org/10.59287/as-abstracts.1432

[16] RABEHI, R., OMRANE, M., BELAKHDAR, A. R., & AMIEUR, M. (2023). Crushed dune sand (cds) and superplasticizers effects on self-compacting concrete fresh properties. AS-Proceedings, 1(1), 27–30. https://doi.org/10.59287/as-proceedings.29

[17] MESSAOUD, M., BOUAZZA, M., & RABEHI, R. (2023, June). Analytical modeling of the behavior of nano-plates by the theory of nonlocal elasticity. In International Conference on Pioneer and Innovative Studies (Vol. 1, pp. 455-461). https://doi.org/10.59287/icpis.873

[18] RABEHI, R., AMIEUR, M., & RABEHI, M. (2023). Evaluation of self-compacting concretes (SCC) made with brick powder using non-destructive and destructive tests. All Sciences Abstracts, 1(5), 13-13. https://doi.org/10.59287/as-abstracts.1432

[19] Abdelkader, F., Mohamed, R., Cheikh, K., & Rabehi, R. (2023). Mechanical properties of compressed earth blocks reinforced with glass fibers and palm fibers: Experiments and simulation. The Journal of Engineering and Exact Sciences, 9(5), 15916-01e. https://doi.org/10.18540/jcecvl9iss5pp15916-01e

[20] Rabehi, M., Rabehi, R. (2021). Physico-mechanical Characterizations of the Compressed Earth Block (CEB) Stabilized with Lime-Based Fibers (Waste Tyre Rubber-Glass). In: Chiba, Y., Tlemçani, A., Smaili, A. (eds) Advances in Green Energies and Materials Technology. Springer Proceedings in Energy. Springer,

Singapore. https://doi.org/10.1007/978-981-16-0378-5_6

[21] Meymouna, M., Bachir, G., Othmane, A., & Rabehi, R. (2023). Contribution to the non-destructive evaluation of bituminous mixes by electrical measurements. The Journal of Engineering and Exact Sciences, 9(8), 16003-01eup. https://doi.org/10.18540/jcecvl9iss8pp16003-01eup

[22] RABEHI, R., OMRANE, M., RABEHI, M., BELAKHDAR, A. R., DIMIA, M. S., & AMIEUR, M. (2023). Pozzolan (poz) effects on self-compacting concrete fresh properties. AS-Proceedings, 1(2), 490–493. https://doi.org/10.59287/as-proceedings.232

[23] Rachid RABEHI, Mohamed RABEHI, Mohammed OMRANE, Abdelkader FIDJAH, Ahmed Rafik BELAKHDAR and Mohamed AMIEUR. (2023). Analysis of the use of self-compacting concrete in Algeria: opportunities and challenges. 4th International Conference on Engineering and Applied Natural Sciences. https://doi.org/10.59287/as-proceedings.313

[24] Rachid RABEHI, Mohamed RABEHI, Mohammed OMRANE, Said ZAOUAI and Mohamed AMIEUR. (2023). The role of fibers and mineral admixtures in self-compacting concrete. 4th International Conference on Engineering and Applied Natural Sciences. https://doi.org/10.59287/as-proceedings.353

[25] Rabehi, M. (2014). Apport à la caractérisation de la porosité ouverte du béton d'enrobage par l'utilisation des tests d'absorption capillaire (Doctoral dissertation, Université Mohamed Khider Biskra). http://thesis.univ-biskra.dz/id/eprint/1172.

[26] RABEHI, R., RABEHI, M., OMRANE, M., ZAOUAI, S., & AMIEUR, M. (2023). Influence of recycled concrete gravel and sand in self-compacting concrete (SCC). AS-Proceedings, 1(6), 522-525. https://doi.org/10.59287/as-proceedings.522

[27] MESSAOUD, M., GLAOUI, B., ABDELKHALEK, O., & RABEHI, R. (2023). Electrical measurements' contribution to the non-destructive assessment of bituminous mixtures. AS-Proceedings, 1(1), 406–410. https://doi.org/10.59287/as-proceedings.102

[28] Rabehi, R., & Amieur, M. R. E. M. Effet Des Ajouts Sur La Résistance A La Compression Et L'absorptiond'eaude Bétonautoplaçant (BAP). In 1st International Congress on Advances in Geotechnical Engineering and Construction Management (p. 853). https://www.researchgate.net/profile/Rabehi-Rachid/publication/371307573_VolumeII/links/647e5ff279a7223765137023/VolumeII.pdf#page=302.

[29] Rachid, R., Mohamed, R., & Mohammed, O. Study of the durability of self-compacting concrete made from recycled gravel Estudo da durabilidade do concreto autoadensável de brita reciclada. https://www.academia.edu/download/104359755/7994.pdf.