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Stabilization of limestone dust in self-compacting concrete and its effect on workability, mechanical and durability properties

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ABSTRACT: Limestone dust is the by-product of limestone grinding in the process of concrete aggregate production. Such waste material causes various environmental problems. The present experimental study has focused on stabilization of limestone dust in self-consolidating concrete (SCC) in order to decrease its negative environmental effects; the workability, mechanical and durability properties of different SCC samples were investigated. With that regards, nine SCC mixtures containing different percentages of limestone dust, Portland cement and silica fume were devised and casted. Overall, compressive strength, indirect tension, rapid chloride penetration, density, absorption, voids, slump flow, and L Box tests were performed on all mixtures. Considering the results, concrete mixtures which contained 10 percent limestone dust performed the best compared to the control sample and other blends form the point of view of workability, compressive and tensile strength, absorption, and resistance against chloride ions penetration. Accordingly, in addition to stabilization of limestone dust in concrete, which well satisfies the global approach towards sustainable development, workability, mechanical, and durability properties of SCC samples were considerably improved.

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1. INTRODUCTION

Today, one of the most important challenges in both developed and developing countries is the environmental issues related to the disposal of waste materials, because direct disposal of these materials in the environment would negatively affect the environment [1]–[6]. One of the disposal approaches towards waste materials is their usage in the production of other products and materials that is known in the research literature as the stabilization of wastes [7].

One of the waste products derived from the processing of limestone in rock mines for the production of aggregates in concrete is limestone dust [8]. The disposal of this waste material in the environment causes various problems; therefore, its stabilization in concrete can be a green solution in terms of sustainable development [9], [10]. Considering the reduction of waste disposal costs, the use of these materials will have economic benefits in addition to environmental justification [11], [12]. Therefore, the use of limestone dust residue as a substitute for aggregate in concrete results in a reduction in demand for the production and extraction of natural materials, resulting in reduced energy consumption, reduced emissions of environmental pollutants and reduced environmental damage [13].

In this research, the workability, mechanical and durability properties of self-compacting concrete (SCC) containing various percentages of limestone dust is evaluated.

2. EXPERIMENTAL PROGRAM

In order to compare and investigate the effect of limestone dust on the workability, mechanical and durability properties of SCC, 9 mix designs containing various cement replacement percentages of limestone dust as well as silica fume were designed in three groups. The total mass of cementitious materials in all mixtures was constant and equal to 450 kg/m^3. The ratio of water to total cementitious materials in all mixtures was the same and equal to 0.27. The details of the mix designs are shown in table (1).

In order to evaluate the workability properties of SCC, the Slump-flow test was performed to measure the filling ability and the L-box test was performed to measure the passing ability of SCC in accordance with European standards [14]. The test of the Visual Stability Index of freshly SCC was performed according to the ASTM standard for measuring the resistance to segregation [15]. To measure mechanical properties, the compressive strength test was performed according to the European Standard [16] and Splitting Tensile Strength test was performed according to ASTM [17]. With regards to the durability properties, chloride ion penetration test (RCPT) and open porosity were performed according to

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Table 1. Details of the mix designs

Group		A			B			C		
Mix design / element		LD0-SF0	LD10-SF0	LD20-SF0	LD0-SF8	LD10-SF8	LD20-SF8	LD0-SF15	LD10-SF15	LD20-SF15
% Cement Material	Cement	100	100	100	92	92	92	85	85	85
	Silica fume	0	0	0	8	8	8	15	15	15
% Aggregates	Sand	60	50	40	60	50	40	60	50	40
	Limestone Dust	0	10	20	0	10	20	0	10	20
	Gravel	40	40	40	40	40	40	40	40	40
W/CM		0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
%superplasticizer		1.5	1.5	1.5	1.72	1.8	1.5	1.5	1.5	1.5

ASTM standards [18], [19].

3. RESULTS AND DISCUSSION

According to the results of the slump-flow test, it can be inferred that with increasing the replacement percentage of sand with limestone dust, the workability of the mixture has increased. This result is observed in all three types of cementitious materials. Also, the results of the L-Box test show that by increasing the replacement percentage of sand with limestone dust, its ratio has increased, and this suggests improving the passing ability of SCC due to the use of limestone.

Based on the results of the compressive strength test, it can be seen that the increase of limestone dust in all three types of cementitious materials, up to a certain percentage, has improved the compressive strength at all ages. According to the results of the splitting tensile strength test, the tensile strength increased with increasing the amount of limestone dust by about 10% of sand. By exceeding more than this amount, the tensile strength is reduced. It is therefore concluded that there is an optimal percentage.

Based on the results of open porosity test, concrete mixes containing 10% limestone dust instead of sand and 8% silica fume instead of cement have the lowest water absorption in all concrete mixtures. The results of the RCPT test show that the use of silica fume is much higher than that of limestone dust, reducing the passing charge and it can be concluded that the use of limestone has no significant effect on the results of this experiment.

4. CONCLUSIONS

With the increase in the amount of limestone dust replacing sand in SCC mixtures, the slump-flow, as well as the test ratio of the L-box, increased significantly. Therefore, it can be concluded that, respectively, the filling ability and passing ability have been improved in SCC.

According to the results of this study, the replacement of fine-grained aggregates with limestone dust has a positive effect on the mechanical and durability properties of concrete, and its optimum value is about 10%.

REFERENCES

[1] D. W. S. Ho, A. M. M. Sheinn, C. C. Ng, and C. T. Tam, "The use of quarry dust for SCC applications," *Cem. Concr. Res.*, vol. 32, no. 4, pp. 505–511, 2002.

[2] V. . Malhotra and G. . Carette, "Performance of Concrete Incorporating Limestone Dust as Partial Replacement for Sand," *ACI Mater. J.*, vol. 82, no. 3, pp. 363–371, 1985.

[3] P. Turgut and H. Murat Algin, "Limestone dust and wood sawdust as brick material," *Build. Environ.*, vol. 42, no. 9, pp. 3399–3403, 2007.

[4] P. Turgut, "Cement composites with limestone dust and different grades of wood sawdust," *Build. Environ.*, vol. 42, no. 11, pp. 3801–3807, 2007.

[5] M. Karaşahin and S. Terzi, "Evaluation of marble waste dust in the mixture of asphaltic concrete," *Constr. Build. Mater.*, vol. 21, no. 3, pp. 616–620, 2007.

[6] H. Binici, H. Kaplan, and S. Yilmaz, "Influence of marble and limestone dusts as additives on some mechanical properties of concrete," *Acad. Journals*, vol. 2 (9), no. September, pp. 372–379, 2007.

[7] A. Gorokhovsky, J. I. Escalante-Garcia, V. Gorokhovsky, and D. Mescheryakov, "Inorganic wastes in the manufacture of glass and glass-ceramics: Quartz-feldspar waste of ore refining, metallurgical slag, limestone dust, and phosphorus slurry," *J. Am. Ceram. Soc.*, vol. 85, no. 1, pp. 285–287, 2002.

[8] Y. W. C. Shi and C. Riefler, "The Use of Crushed Limestone Dust in Production of Self-Consolidating Concrete (SCC)," *Spec. Publ.*, vol. 219.

[9] Ö. Eren and K. Marar, "Effects of limestone crusher dust and steel fibers on concrete," *Constr. Build. Mater.*, vol. 23, no. 2, pp. 981–988, 2009.

[10] N. Almeida, F. Branco, J. de Brito, and J. R. Santos, "High-performance concrete with recycled stone slurry," *Cem. Concr. Res.*, vol. 37, no. 2, pp. 210–220, 2007.

[11] A. Bishnoi and M. Bala, "Effect of Quarry Dust as Partial Replacement of Sand in Concrete," *Int. J. All Res. Educ. Sci. Methods*, vol. 3, no. 6, pp. 2455–6211, 2015.

[12] M. Galetakis, G. Alevizos, and K. Leventakis, "Evaluation of fine limestone quarry by-products, for the production of building elements - An experimental approach," *Constr. Build. Mater.*, vol.

26, no. 1, pp. 122–130, 2012.
[13] B. Demirel, "The effect of the using waste marble dust as fine sand on the mechanical properties of the concrete," *Int. J. Phys. Sci.*, vol. 5, no. 9, pp. 1372–1380, 2010.
[14] EFNARC, "Specification and Guidelines for Self-Compacting Concrete," *Rep. from EFNARC*, vol. 44, no. February, p. 32, 2005.
[15] ASTM C1611, "Standard Test Method for Slump Flow of Self-Consolidating Concrete," *Annu. B. ASTM Stand. Vol. 04.02*, pp. 1–6, 2009.
[16] BSI, "BS EN 12390-3:2002 Testing hardened concrete. Compressive strength of test specimens." 2002.
[17] ASTM International, "ASTM C496 Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens," *ASTM Int.*, p. 5, 2011.
[18] ASTM C 642-06, "Standard Test Method for Density , Absorption , and Voids in Hardened Concrete," *United States Am. Soc. Test. Mater.*, pp. 11–13, 2008.
[19] ASTM C 1202-12, "Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration 1," *Am. Soc. Test. Mater.*, 2012.

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