EAN 2017
55th conference on experimental stress analysis

Destructive Testing of Cement Paste with Micronized Waste Marble Powder as Partial Replacement for Cement – Long Time Development of Mechanical Properties

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Keywords: Cement Pastes, Compressive Strength, Flexural Strength, Micronized Marble Powder

Abstract. This article deals with using waste marble powder as partial replacement for cement. In particular, we focus on mechanical properties of the cement pastes. We used five mixtures of cement pastes containing 5, 10, 15 and 50 wt. % of micronized marble powder as partial replacement for cement. The investigated mechanical properties were flexural strength and compressive strength for the 28 and 377 days old samples. The results obtained from these materials were compared with reference material.

Introduction

Leaving the waste materials from marble industry to the environment directly can cause environmental problem [1]. Hence, many countries have been working on how to reuse the waste material so that they reduced hazards to the environment [2]. One possible utilization of this waste is used in the production of blended cement [3]. There are several works that deal with use the marble sludge as replacement for cement in creating the blended cement. The first study found that the addition of the marble sludge to the cement composite is changed CH crystals ($Ca(OH)_2$) [4]. The second study showed the morphology of the internal structures of cement pastes with and without marble sludge by using a scanning electron microscopy. The morphology was identical [5]. In all case, marble sludge in a small amount had a good influence on compressive strength [6,7]. Moreover, according to the study, which was written by Menendez et al. [8] marble and limestone dust resulted in slight decrease compressive strength after 90 days compared to the value of compressive strength 28 days old samples .Reduction of compressive strength was explained by measurement uncertainty.

New options to possibly confirm or deny the allegations about the influence of the marble sludge on long-term mechanical properties of cement pastes is using the method of micro milling by high-speed mill, because the resulting micronized marble powder has a higher specific surface area and thus possible higher reactivity [9].

Materials and Samples

The mixtures composed of Portland cement CEM I 42.5R (Radotín) and micronized marble powder with fractions 0-40 μm has been prepared for investigating the impact of micronized marble powder on long time mechanical properties. Micronized marble powder was obtained

from the processing of limestone marble and it is mixture of marble dust and sludge from Spain, Italy, Turkey, West Bank of Jordan and Egypt. Micronized marble powder was micronized by a high-speed mill from Lavaris Ltd. (Libčice – Czech Republic). The figure 1 show particle size distribution of Micronized marble powder. The mixtures were designed to maintain the same workability of the fresh mixture. Consistency of the mixtures was determined using a flow expansion test after 10 (d_{10}) and 20 (d_{20}) impulses (Tab. 1). Individual material samples differed in the quantity of micronized marble powder. The cement was replaced by the waste micronized marble powder in an amount of 5, 10, 15 and 50 weight percent (Tab. 1). The results obtained from these materials were compared with reference.

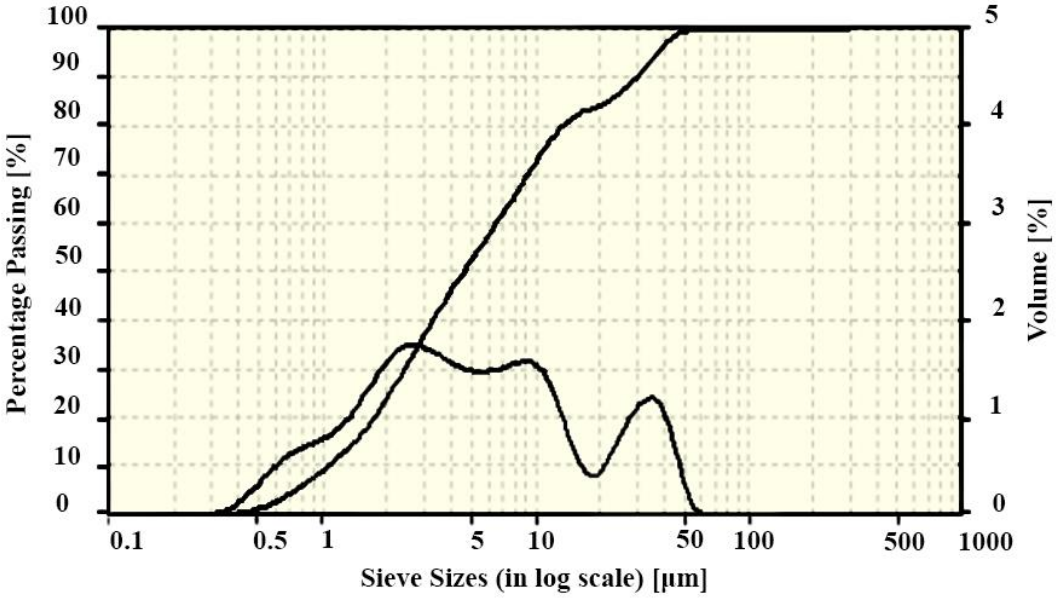

Fig. 1: Particle size distribution curve of Micronized marble powder

Mixtures prepared according to Tab. 1 were cast in the rectangular mold with dimensions equal to 40 × 40 × 160 mm. All the rectangular molds were measured their dimensions before the mixture was applied to the mold. These values were used to calculate approximate shrinkage (Tab. 1). After casting, these specimens were kept in the molds for 24 h at room temperature of 22 ° C. The six samples from each mixture. After demolding, these specimens were stored in a laboratory environment at 22 ± 1 ° C and relative humidity 50 ± 2 %.

Tab. 1: Composition of the mixtures.

Set/ Material	Cement [wt. %]	Marble powder [wt.%]	Water ratio [-]	Flow expansion test d_{10} [mm]	Flow expansion test d_{20} [mm]	Bulk density [kgm^{-3}]	Shrinkage [%]
Ref. MP0	100	0	0.35	160	190	1919 ± 5	0.19 ± 0.06
MP5	95	5	0.317	160	190	1915 ± 6	0.27 ± 0.11
MP10	90	10	0.315	160	190	1920 ± 3	0.14 ± 0.05
MP15	85	15	0.31	160	190	1879 ± 6	0.21 ± 0.07
MP50	50	50	0.305	158	190	1760 ± 8	0.45 ± 0.16

Experimental Methods and Results

The values of the compressive and the flexural strength of the samples were determined at the 28th day and 377th day. Three samples for each series and each period were used for the determination of the flexural strength on beams of dimensions equal to 40 × 40 × 160 mm and the uniaxial compressive test was performed on the broken halves of the specimens with effective dimensions of 40 × 40 × 40 mm. The load was applied at a constant rate of 0.1 mm/s in the case of the three-point bending test and 0.3 mm/s in the case of the compressive test. The distance between supports for the three-point bending test was equal to 100 mm.
Samples MP5, MP10 and MP15 had approximately same shrinkage as reference samples and value of shrinkage was about 0.20 % (Tab. 1). Samples MP50 had values of shrinkage two times higher than others, namely 0.45 ± 0.16 %. Increased shrinkage of samples was due to the addition of fine particles of micronized marble powder with high specific surface area. Also the sample MP5 and MP10 had the same bulk density as the reference sample. It is the same bulk density and marble powder is lighter than cement paste so, part of micronized marble powder must form a microfiller.
The figure 2 show results from mechanical tests. The results show the effect of long time on the mechanical properties of the cement pastes. The flexural strength was increased after 377 days for all samples. The largest flexural strength had set composed with 50 wt. % micronized marble powder, directly 5.95 ± 0.42 MPa. Compressive strength of cement pastes with micronized marble powder decreased after 377 days. The largest compressive strength after 28 days had mixture with 5 wt. % of micronized marble powder, directly 87.7 ± 6 MPa, but the value decreases after 377 days to 55.6 ± 4 MPa.

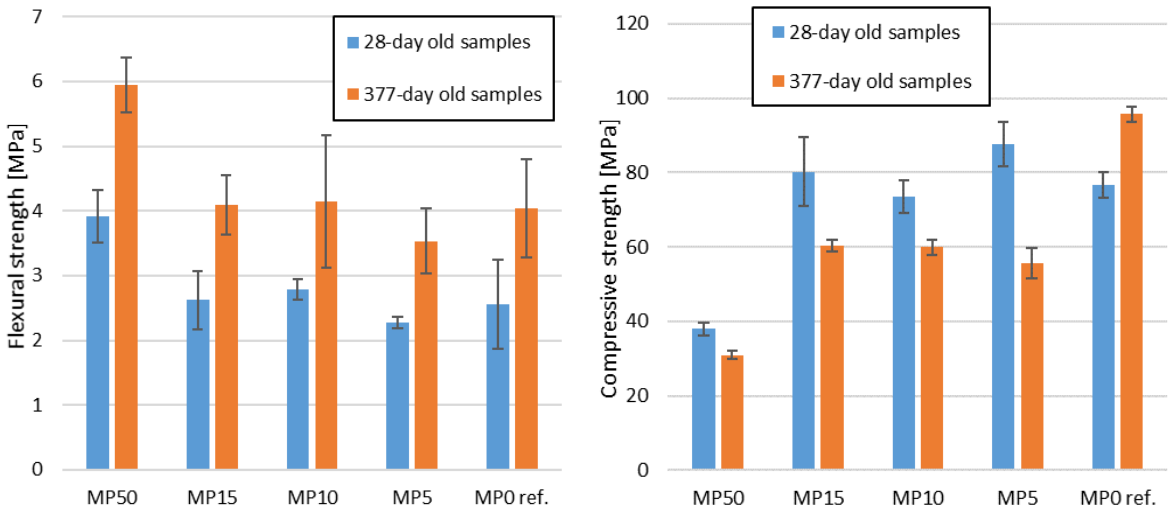

Fig. 2: Comparison of mechanical properties of cement pastes, flexural strength – left, compressive strength – right

Conclusions

Using micronized marble powder was in initial stage enhances compressive strength of cement pastes, but after 377 days impairment compressive strength by about 20%. The results show that micronized marble powder may effect on hydration process of cement. In the future, we will focus on determining of effect of micronized marble powder in the hydration process by using chemical analysis and for final confirmation or refutation of the possibility of the involvement of the micronized marble powder in hydration of Portland cement.

Acknowledgement

This outcome was supported by the Czech Technical University in Prague under No. SGS16/201/OHK1/3T/11 and by the Ministry of Education, Youth and Sports within National Sustainability Programme I, project No. LO1605. The authors also thank the Center for Nanotechnology in Civil Engineering at the Faculty of Civil Engineering, Czech Technical University in Prague.

References

[1] H. Yilmaz, M. Guru, M. Dayi, I. Tekin, Utilization of waste marble dust as an additive in cement production, Materials and Design 31 (2010) 4039-4042.

[2] M.S. Ibrahim, et al., Health Risk Assessment of Marble Dust at Marble Workshops, Nature and Science, 9 (2011) 144-154.

[3] H. Binici, H. Kaplan, S. Yilmaz, Influence of marble and limestone dusts as additives on some mechanical properties of concrete, Scientific Research and Essay, 2 (2007) 372-379.

[4] B. Demirel, The effect of the using waste marble dust as fine sand on the mechanical properties of the concrete, International journal of physical sciences 5 (2010) 1372-1380.

[5] A. A. Aliabdo, A. E. M. Abd Elmoaty, E. M. Auda, Re-use of waste marble dust in the production of cement and concrete, Construction and Building Materials 50 (2014) 28-41.

[6] A. Ergün, Effects of the usage of diatomite and waste marble powder as partial replacement of cement on the mechanical properties of concrete, Construction and Building Materials 25 (2011) 806-812.

[7] V. M. Shelke, P. Pawde, R. Shrivastava, Effect of marble powder with and without silica fume on mechanical properties of concrete, J Mech Civ Eng 1 (2012) 40-45.

[8] G. Menéndez, V. Bonavetti, E.F. Irassar, Strength development of ternary blended cement with limestone filler and blast-furnace slag, Cement and Concrete Composites 25 (2003) 61-67.

[9] Z. Prošek, J. Topič, K. Šeps, P. Tesárek, Influence of Waste Crushed Limestone and Waste Micronized Marble Powder on Mechanical Properties of Cement Composite, Key Engineering Materials 722 (2017) 222-227.

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