

INFLUENCES OF LIGHT-BURNT DOLOMITE ON STRENGTH AND DEFORMATION OF BLENDED CEMENT

DENG CHEN^{1,2*}, ZHI-HAI HE³, AI-GUO WANG⁴, TAO YANG⁵

¹ College of Civil Engineering, Suzhou University of Science and Technology, Suzhou 215011, China;

² Guangxi Key Laboratory of New Energy and Building Energy Saving, Guilin 541004, China;

³ College of Civil Engineering, Shaoxing University, Shaoxing 312000, China;

⁴ Anhui Key Laboratory of Advanced Building Materials, Anhui Jianzhu University, Hefei 230022, China;

⁵ College of Materials Science and Engineering, Yancheng Institute of Technology, Yancheng 224051, China.

Shrinkage of cement-based materials may cause cracking in concrete structure under restrained conditions. In this study, light-burnt dolomite (LBD) as a mixture of periclase and calcite obtained by calcinations of dolomite at 750-850 °C was incorporated in Portland cement to compensate shrinkage of cement-based materials at early age. The results show that the water requirement for normal consistency of blended cement is increased with the increase of dosage, calcination temperature and holding time of LBD. The addition of 10% LBD calcined at 800 °C for 2.0 h can effectively enhance the compressive strengths of blended cement at all ages. This is due to that 10% LBD can improve the microstructure attributed to the filler effect and hydration reactivity of LBD. Furthermore, the hydration of periclase in LBD leads to the expansion of blended cement at early age, and increases the expansion value with the increase of dosage, calcination temperature and holding time of LBD.

Keywords: light-burnt dolomite, blended cement, strength, deformation

1. Introduction

Cement-based materials are the most widely used building materials in the world owing to their outstanding performance [1]. However, cement-based materials normally undergo various types of volumetric shrinkage, such as drying shrinkage, autogenous shrinkage, thermal shrinkage and carbonation shrinkage. When the structure was restrained, the shrinkage may cause large tensile stress to crack the cement-based materials. Cracking in cement-based materials can lead to the high permeability and low durability to cause the degradation of cement-based materials properties. Accordingly, it is very important and necessary to control and mitigate shrinkage of cement-based materials to prolong the service life. At present, many research works have been carried out to develop useful ways of mitigating the shrinkage, such as internal curing, shrinkage compensating concrete, incorporation of fibre and supplementary cementing materials (SCMs), etc [2-5].

Expansion produced by the hydration of expansive mineral components, such as MgO and calcium sulfate aluminate, was widely used to compensate of the shrinkage of cement-based materials [6-8]. In China, delayed expansive cement containing MgO was used for compensating the thermal shrinkage of mass dam concrete, in which the MgO was normally formed as dead burnt periclase at high calcination temperature of up to 1450°C [9,10]. However, hydration of the dead-burnt periclase is very slow, and has little effect on compensating the shrinkage of concrete at early age. Moreover, the content of MgO in Portland cement was limited to avoid unsoundness [11].

To control the MgO content and reactivity, the MgO was separately prepared and used as expansive additive in the cement. In recent years, the hydration and expansion properties of the MgO with relatively high reactivity formed as light burnt periclase have attracted more attention as it has important potential application in normal concrete. Some research works [12,13] have been carried out on the effects of light burnt periclase on the deformations and mechanical properties of cement-based materials, but this still needs to be investigated further.

MgO expansive agents are usually produced by calcining magnesite at 800-1200°C. But considering the depletion of magnesite, the possibility of using the other magnesium-bearing minerals as raw materials to produce MgO has been considered. Dolomite, with the chemical formula of $\text{CaMg}(\text{CO}_3)_2$, is naturally occurring mineral with abundant reserves around the world [14-17]. Dolomitic rocks can be used as aggregate, but under the alkaline environment, dolomite reacts with calcium anions to form calcite and brucite, which causes structure degradation of many concrete constructions. Therefore, the dedolomitization reaction reduces the utilization ratio of dolomite [18-21]. However, dolomite can decompose to lime and periclase at high calcining temperature. Xu et al. [22] used dolomite to produce an expansive agent based on periclase, and the silica-bearing mineral was combined with the lime released from dolomite to form dicalcium silicate. The expansive agent mainly consists of periclase, dicalcium silicate and a little amount of lime, which was used to compensate for the thermal shrinkage of mass dam concrete. However, there is little knowledge related to a mixture of periclase and calcite obtained by calcining

Table 1

Chemical compositions of PC and DP (wt %)								
	SiO ₂	Fe ₂ O ₃	Al ₂ O ₃	CaO	MgO	K ₂ O	Na ₂ O	Loss on ignition
PC	22.18	3.76	3.98	62.47	0.87	0.85	0.10	2.28
DP	2.00	0.25	0.88	29.73	21.89	0.04	0.02	44.69

dolomite at relatively low temperature which is referred as LBD, and the influences of LBD on strength and expansion of cement-based materials have not been reported.

In this paper, LBD is obtained by calcinations of dolomite at relatively low temperature. The deformations and mechanical properties of blended cement containing LBD cured in water are investigated. In previous works [23-26], calcite was reported that can improve the mechanical properties of cement-based materials by its filler effect, nucleation effect and chemical effect. Meanwhile, compared with dead-burnt periclase, the periclase in LBD exhibits a relatively higher reactivity, which means the hydration of LBD can generate an early expansion to compensate of the early shrinkage of concrete. Therefore, the results of this paper indicate that LBD as a new mineral additive may have an important potential application in normal concrete.

2. Experimental

2.1 Raw materials

Portland cement (PC) of grade 52.5 was provided by China Cement Company in Jiangsu, China. Dolomite powder (DP) was obtained from Yuyuan Mining Company in Hebei, China. Table 1 shows the chemical compositions of PC and DP. Figure 1 shows the appearances of PC and DP. The mineralogical composition of DP was examined by an X-ray diffractometer (XRD) (Rigaku Smartlab) with CuK α radiation at a rate of 10 °/min, and is shown in Figure 2. DP is mainly composed by dolomite and calcite. Figure 3 shows the particle size distributions of PC and DP measured with a Marlven Mastersizer 2000 particle size analyser by dispersing the particles in alcohol. The mean particle sizes (d_{50}) of PC and DP are 12 μ m and 14 μ m, respectively.

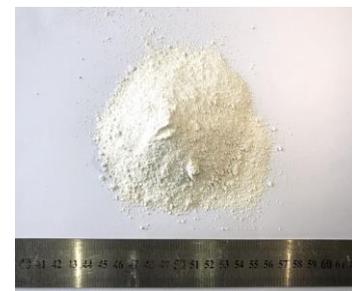
2.2 Methods

2.2.1 Preparation of LBD

Thermogravimetric analysis (TGA) was used to study the decomposition process of DP to determine the calcination temperature. Figure 4 shows the TG and DTG curves of DP. The results



(a) PC



(a) DP

Fig. 1 – Appearances of PC and DP.

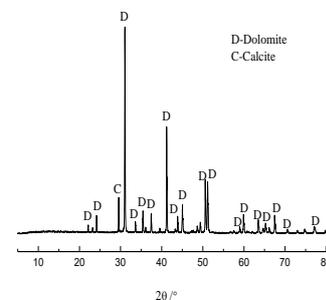


Fig. 2 - XRD pattern of DP.

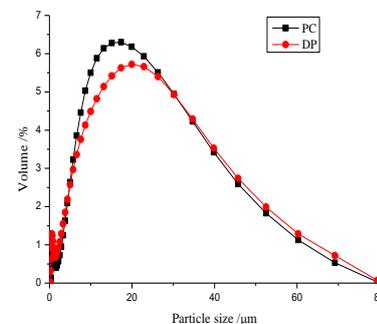


Fig.3 - Particle size distributions of PC and DP.

show that DP starts to decompose at about 620 °C and finishes its decomposing process at about 820°C. According to references [27,28], the decomposition of DP includes two stages, periclase is formed in the first stage according to the reaction:

$$\text{CaMg}(\text{CO}_3)_2 = \text{MgO} + \text{CaCO}_3 + \text{CO}_2 \uparrow$$

Then the decomposition of calcite follows when the heating temperature is increased continually:

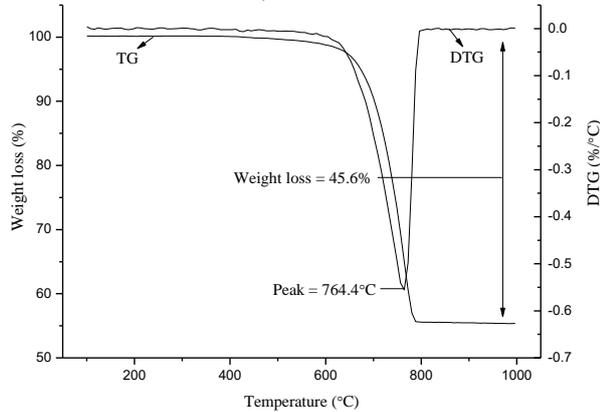


Fig. 4 - TG and DTG curves of DP.

In this study, LBD was obtained by calcinations of DP at 750 °C, 800 °C and 850 °C in an electric furnace for 1.0 h and 2.0 h, respectively, as is shown in Figure 5. Then the samples were cooled in air. After calcination, the samples were ground in a mortar to make sure that the particle size of LBD is in the range of 0-80 μm. Table 2 shows the specific calcination regimes of LBD. The specific surface area of LBD was tested by N₂ adsorption method. Quantitative analysis of the contents of periclase and lime in LBD was performed by using the Rietveld method [29] based on powder X-ray diffraction patterns.



Fig. 5 - Preparation of LBD.

2.2.2 Water requirement for normal consistency

Blended cements containing 0% , 10% , 20% and 30% LBD by weight replacement of PC were prepared. The water requirements for normal consistency of the blended cements were measured according to Chinese national standard GB/T 1346-2011 [30].

2.2.3 Compressive strength and deformation

The compressive strengths of the blended cements were measured according to Chinese national standard GB/T 17671-1999 [31]. For each type of cement, one part of cement and three parts of standard sands by weight were mixed at a w/b ratio of 0.5 to obtain the mortars. The mortars were cast in molds measuring 40 mm × 40 mm × 160 mm. After casting, the molds were stored in a curing room with >95% relative humidity at 20 ± 2 °C for 24 h, and then the mortars were removed from the molds and cured in 20 °C water. After three different ages of curing, namely 3 d, 28 d and 90 d, the compressive strengths of cement mortars were determined.

In order to measure the deformation of cement mortars cured in water, the fresh cement mixtures were cast into molds to prepare prism cement specimens with size of 25 mm × 25 mm × 280 mm. After 1 d curing in moist room at a temperature of 20 ± 2 °C and a relative humidity of >95%, all the cement mortar specimens were demoulded, and then their initial lengths were measured. Subsequently the cement mortars were cured in water at 20 °C, and the length changes of all the cement specimens were measured at different ages. Every length changes value used was the mean value of three replicate specimens.

2.2.4 Hydration of LBD

Blended cement pastes containing different dosages of LBD were prepared at a water-to-binder ratio of 0.28. Rietveld analysis by XRD was used to determine the hydration degree of periclase of LBD in blended cement pastes. Scanning electron microscope (SEM) (JSM-6150) equipped with an energy dispersive spectrometer (EDS) was also used to analysis the hydration of LBD in blended cement pastes.

2.2.5 Pore structure

The pore structures of the blended mortar specimens were examined by using mercury intrusion porosimetry (MIP) (PoreMaster GT-60).

Table 2

The calcination regimes of LBD

Sample	Calcination condition	
	Temperature /°C	Time /h
LBD750-1.0	750	1.0
LBD750-2.0	750	2.0
LBD800-1.0	800	1.0
LBD800-2.0	800	2.0
LBD850-1.0	850	1.0
LBD850-2.0	850	2.0

Table 3

Samples	Specific surface area /m ² ·g ⁻¹	Periclase /wt%	lime /wt%
LBD750-1.0	9.03	15.1	0.0
LBD750-2.0	9.08	20.5	0.0
LBD800-1.0	9.16	24.7	0.0
LBD800-2.0	9.42	29.3	3.1
LBD850-1.0	10.97	32.3	26.8
LBD850-2.0	11.75	37.5	48.6

Table 4

Samples	Water requirement for normal consistence /%			
	0% LBD	10%LBD	20%LBD	30% LBD
LBD750-1.0	27.1	27.1	27.4	27.8
LBD750-2.0	27.1	27.3	27.8	28.0
LBD800-1.0	27.1	27.4	28.1	28.3
LBD800-2.0	27.1	27.6	28.3	28.6
LBD850-1.0	27.1	28.6	30.7	32.3
LBD850-2.0	27.1	29.4	33.2	36.4

3. Results and Discussion

3.1 Characterisation of LBD

Table 3 shows the specific surface area and contents of periclase and lime in LBD with different calcination regimes. The contents of periclase and lime increase with the increasing calcination temperature and holding time of LBD. It should be noted that there is no content of lime observed in the LBD750-1.0, LBD750-2.0 and LBD800-1.0 samples. In addition, the specific surface area of LBD increases due to the escape of CO₂ during the decomposition process of DP.

3.2 Water requirement for normal consistency

The water requirements for obtaining a normal consistency of blended cements containing LBD are shown in Table 4. It can be found that the water requirements for normal consistency are increased with the increase of dosage, calcination temperature and holding time of LBD. A slight increase in the water requirement is shown for the cement pastes containing LBD750-1.0, LBD750-2.0, LBD800-1.0 and LBD800-2.0. However, the water requirements for normal consistency of blended cements containing LBD850-1.0 and LBD850-2.0 are increased greatly. When the dosage of LBD is 30%, the water requirements for blended cement pastes containing LBD850-1.0 and LBD850-2.0 are increased by 19.2% and 34.3% compared with PC, respectively. This may be related to the higher specific surface area and contents of periclase and lime in LBD850-1.0 and LBD850-2.0.

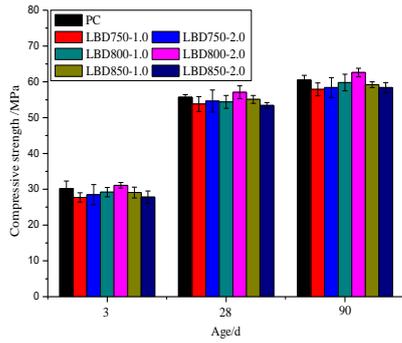
3.3 Compressive strength

Figure 6 shows the compressive strengths of PC mortar and blended cement mortars containing different dosages of LBD. PC mortar develops the

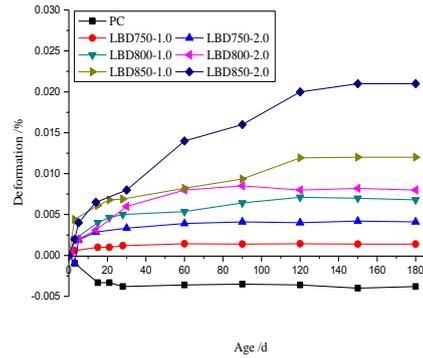
compressive strengths very quickly, the compressive strengths at 3 d, 28 d and 90 d reach 30.2 MPa, 55.7 MPa and 60.5 MPa, respectively. As is shown in Figure 4(a), when the dosage of LBD is 10%, the compressive strengths of these blended cement mortars are closely to that of PC mortar at all ages. For all of the blended cement mortars, blended cement mortar containing 10% LBD800-2.0 shows the highest compressive strength, and that the strengths even surpass that of PC mortar, with values of 31.1 MPa, 57.1 MPa and 62.6 MPa at 3 d, 28 d and 90 d, respectively. This may be due to that 10% LBD incorporated in PC mortars can improve the strength by the filler effect of LBD [23]. However, the compressive strengths of blended cement mortars containing 20% and 30% LBD decrease obviously compared to that of PC mortar. This may be due to that the higher replacement of cement clinker can lead to less formation of hydration products and thus decrease the compressive strengths. In terms of compressive strength, the optimum LBD binder type is LBD800-2.0, and the optimum cement replacement proportion is 10%.

3.4 Deformation

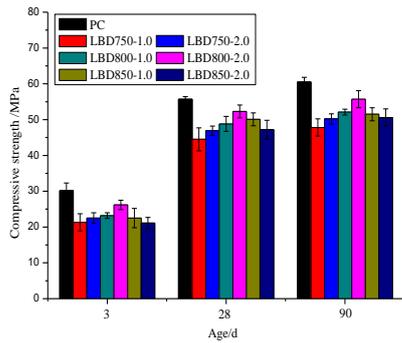
Figure 7 shows the deformations of PC mortar and blended cement mortars containing different dosages of LBD cured in water at 20 °C. The PC mortar shows a slight shrinkage, which reaches -0.0038% after 180 d of curing. The obvious expansions are observed for blended cement mortars due to the hydration of periclase in LBD compared with PC mortar. The blended cement mortars expand rapidly within 60 d, and then slow down gradually. After 120 d, the expansion curves of blended cement mortars tend to level off. At 180 d, when the dosage of LBD is



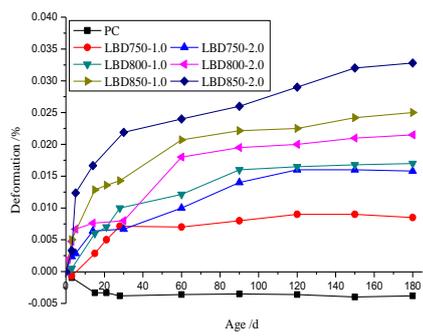
(a) 10%



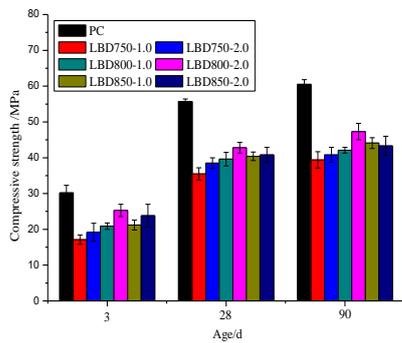
(a) 10%



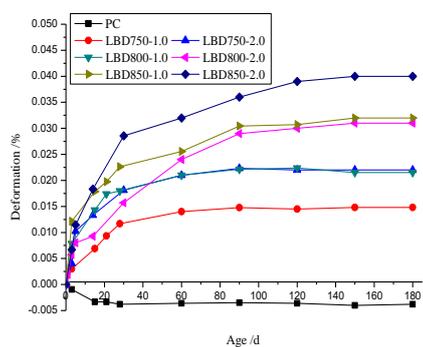
(b) 20%



(b) 20%



(c) 30%



(c) 30%

Fig. 6 - Compressive strengths of blended cement mortars containing LBD.

Fig. 7 - Deformation of blended cement mortars containing LBD.

10%, the expansion values of blended cement mortars containing LBD750-1.0, LBD750-2.0, LBD800-1.0, LBD800-2.0, LBD850-1.0 and LBD850-2.0 reach 0.0014%, 0.0041%, 0.0068%, 0.008%, 0.012% and 0.021%, respectively. This may be due to that the reactivity of periclase in LBD is higher than dead-burnt periclase [9,21], thus both of the rapid expansion behavior at early age and the stable expansion behavior at later age are observed. With the increase of dosage, calcination temperature and holding time of LBD, the expansions of the blended cement mortars are higher and higher. This may be due to the augment of the contents of periclase and lime contained in LBD according to the results of Table 3. Thus, in

comparison with PC mortar, an appropriate addition, calcination temperature and holding time of LBD can produce the early expansion, and compensate the shrinkage of concrete at early age.

3.5 Hydration of LBD

Figure 8 shows the contents of periclase in blended cement pastes containing 10-30% LBD800-2.0 at different curing ages. The initial contents of periclase in 10%, 20% and 30% LBD800-2.0 blended cements are 2.93%, 5.86% and 8.79%, respectively. At 60 d, more than 50% periclase has been consumed. At 180 d, the hydration degree of periclase reaches approximately 80%. The obvious conclusion can be

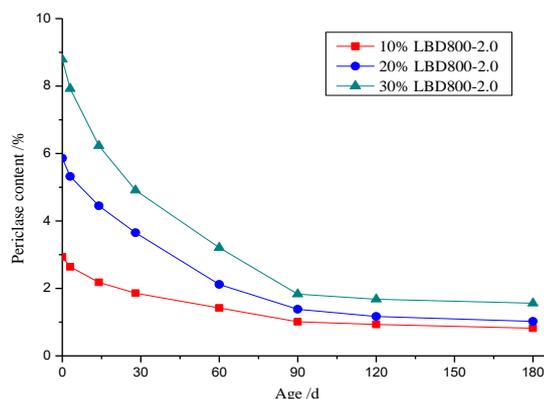


Fig. 8 - The contents of periclase in blended cement pastes.

drawn that the periclase of LBD exhibits a rapid hydration process at early age, and the hydration rate of periclase decreases gradually with the extension of curing ages. This result is partly attributed to LBD obtained at the relatively low temperature, in which the periclase has high reactivity. In addition, the decrease of the hydration rate may be due to the incomplete hydration of the most interior layer of single magnesia grains [32]. The limitation of the hydration degree has also been reported in other studies [33,34]. In comparison with Figure 7, it can be found that the hydration degree of periclase exhibits a similar tendency with the expansion of blended cement mortars, indicating the hydration of periclase promotes the expansion.

Figure 9 shows the typical SEM morphology and EDS pattern of blended cement paste containing LBD 800-2.0 cured for 90 d. As is shown in Figure 9(a), the formation of a large amounts of hydration products indicates the relatively high hydration degree of blended cement. According to Figure 9(b), closer investigation shows that zone A is covered with the dense hydration products richened in Mg, which indicates the hydration products may contain brucite owing to the hydration of LBD in cement paste, but it is quite difficult to identify very clearly the individual brucite crystals.

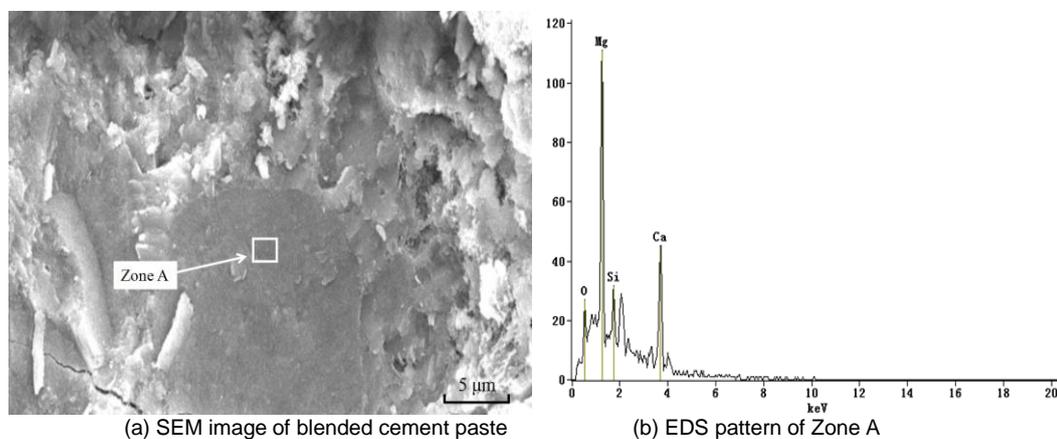


Fig. 9 - SEM image and EDS pattern of blended cement paste containing LBD 800-2.0 cured for 90 d

3.6 Pore structure

Figure 10 shows the pore structures of PC mortar and mortars containing LBD800-2.0 cured for 90 d. The pore diameters of all the mortars are in the range of 0.02-2.0 μm . Generally speaking, according to the different effect of the pore size on the properties of concrete, the pore with the diameter more than 0.1 μm is commonly considered as the harmful pore in concrete [35]. The addition of 10% LBD800-2.0 reduces the porosity of the pore with the diameter more than 0.1 μm and increases the proportions of the diameter less than 0.1 μm in the total pore respectively, which indicates the pore structure of the mortar specimens is improved. However, blended cement mortars containing 20% and 30% LBD800-2.0 have higher volumes of harmful pores compared with that of PC mortars, indicating that the additions of 20% and 30% LBD800-2.0 degrade the pore structure. According to Figure 10(b), the total porosities of PC mortar and blended mortars with 10%, 20%, 30% LBD800-2.0 are 11.62%, 9.88%, 12.47% and 13.75%, respectively. It can be found that 10% LBD800-2.0 also decreases the total porosity of cement mortar. In contrast, the additions of 20% and 30% LBD800-2.0 increase the total porosity. This would partly account for the higher compressive strength and durability of blended cement mortar containing 10% LBD800-2.0 compared with that of PC mortar.

3.7 Discussion

For all the blended cement mortars, the compressive strengths of blended cement mortars containing 10% LBD are close to that of PC mortars at all ages. Moreover, blended cement mortar containing 10% LBD800-2.0 shows the highest compressive strength, and that the strengths even surpass that of PC mortars. This may be attributed to the filler effect of LBD. The appropriate addition of LBD may increase the water to cement ratio and facilitate cement hydration, and then provide nucleation sites for the formation of hydration products [36]. In addition, the hydration of LBD can

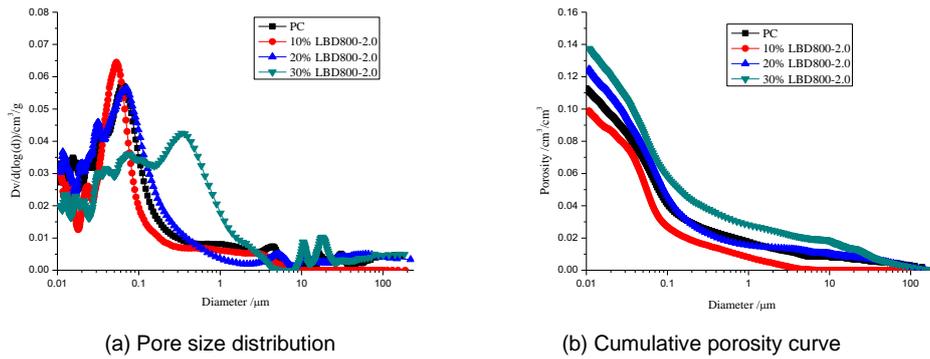


Fig. 10 - Pore structures of blended mortars containing LBD 800-2.0 cured for 90 d

generate an appropriate amount of hydration products, which may fill the pore and improve the microstructure. As is shown in Figure 10, the addition of 10% LBD800-2.0 improves the pore structure obviously, which is reflected by an increase in the finer pores and decrease in the total porosity. However, the addition of LBD also results in the dilution of hydrated cement particles in the mortar. Above a critical amount, LBD will enhance the dilution effect, leading to a reduction in hydration products, and then resulting in hardened mortars with lower strength [37,38]. In this study, when the content of LBD is more than 10%, the compressive strengths of blended cement mortars are decreased largely with increasing LBD contents.

On the other hand, blended cement mortars containing LBD show obvious expansions at early age. This is attributed to the hydration of periclase in LBD. The periclase exhibits a high reactivity due to LBD obtained at a relatively low calcination temperature, and thereby the rapid hydration at early age [9], as is shown in Figure 8. In addition, the expansions of cement mortars are increased with the increase of dosages, calcination temperature and holding time of LBD. This is due to the augment of the contents of periclase and lime in LBD, as is shown in Table 3. Accordingly, the appropriate addition of LBD as well as the optimum calcination regime of LBD can produce blended cements with low shrinkage and high strength that may have an potential application in normal concrete.

4. Conclusions

In this paper, LBD as a mineral admixture is obtained from the calcinated dolomite at 750-850 °C. The deformations and mechanical properties of blended cements containing LBD are investigated. The following conclusions can be drawn:

(1) The water requirement for normal consistence of blended cements is increased with the increase of dosage, calcination temperature and holding time of LBD. This may be related to the specific surface area and content of periclase and lime in LBD.

(2) The compressive strengths of blended cement mortars containing 10%LBD are closely to that of PC mortar at all ages, and especially that of blended cement mortars containing 10% LBD800-2.0 even surpass that of PC mortars. This may be due to the microstructure densification attributed to the filler effect and hydration reactivity of LBD.

(3)The blended cement mortars containing LBD show obvious expansions compared to PC mortar at early age due to the high hydration reactivity of periclase in LBD. With the increase of dosage, calcination temperature and holding time of LBD, the expansions of blended cement mortars are increased largely.

Acknowledgments

This work is supported by the CRSRI Open Research Program (CKWV2019757/KY), National Natural Science Foundation of China (51778003), the Natural Science Foundation of the Jiangsu Higher Education Institution of China (20KJB560007), the Open Research Program of GuangXi Key Laboratory of New Energy and Building Energy Saving (19-J-22-1) and Natural Science Foundation of Suzhou University of Science and Technology (XKZ2019001).

REFERENCES

- [1] E. Aprianti, A huge number of artificial waste material can be supplementary cementitious material (SCM) for concrete production-a review part II, *Journal of Cleaner production*, 2017, **142**, 4178.
- [2] D.P. Bentz, O.M. Jensen, Mitigation strategies for autogenous shrinkage cracking, *Cement and Concrete Composites*, 2004, **26**(6), 677.
- [3] M. Sahmaran, M. Lachemi, K.M.A Hossain, C.L.Victor, Internal curing of engineered cementitious composites for prevention of early age autogenous shrinkage cracking, *Cement and Concrete Research*, 2009, **39**(10), 893.
- [4] B. Lothenbach, K.L. Scrivener, R.D. Hooton, Supplementary cementitious materials, *Cement and Concrete Research*, 2011, **41**(12), 217.
- [5] P. Zhan, Z. He, Application of shrinkage reducing admixture in concrete: A review, *Construction and Building Materials*, 2019, **201**, 676.
- [6] P. Yan, X. Qin, The effect of expansive agent and possibility of delayed ettringite formation in shrinkage-compensating massive concrete, *Cement and Concrete Research*, 2001, **31**(2),335.

- [7] W. Sun, H. Chen, X. Luo, H. Qian, The effect of hybrid fibers and expansive agent on the shrinkage and permeability of high-performance concrete, *Cement and Concrete Research*, 2001, **31**(4), 595.
- [8] L. Mo, M. Deng, M. Tang, A.A. Tabbaa, MgO expansive cement and concrete in China: past, present and future, *Cement and Concrete Research*, 2014, **57**, 1.
- [9] L. Mo, M. Deng, M. Tang, Effects of calcination condition on expansion property of MgO-type expansive agent used in cement-based materials, *Cement and Concrete Research*, 2010, **40**(3), 437.
- [10] F. Cao, M. Miao, P. Yan, Effects of reactivity of MgO expansive agent on its performance in cement-based materials and an improvement of the evaluating method of MEA reactivity, *Construction and Building Materials*, 2018, **187**, 257.
- [11] L. Mo, M. Deng, M. Tang, Effect of calcination temperature on the microstructure, activity and expansion of MgO-type expansive additive used in cement-based materials, *Key Engineering Materials*, 2009, **400-402**, 169.
- [12] L. Mo, M. Liu, A.A. Tabbaa, M. Deng, W.Y. Lau, Deformation and mechanical properties of quaternary blended cements containing ground granulated blast furnace slag, fly ash and magnesia, *Cement and Concrete Research*, 2015, **71**, 7.
- [13] L. Mo, M. Liu, A.A. Tabbaa, M. Deng, Deformation and mechanical properties of the expansive cements produced by inter-grinding cement clinker and MgOs with various reactivities, *Construction and Building Materials*, 2015, **80**, 1.
- [14] M. Szybilski, W.N. Wczelik, The effect of dolomite additive on cement hydration, *Procedia Engineering*, 2015, **108**, 193.
- [15] M. Ning, K. Huang, X. Lang, H. Ma, H. Yuan, Y. Peng, B. Shen, Can crystal morphology indicate different generations of dolomites? Evidence from magnesium isotopes, *Chemical Geology*, 2019, **516**, 1.
- [16] M. Feng, P. Wu, Z. Qian, X. Liu, Y. Duan, M. Xia, Hydrothermal dolomite reservoir in the Precambrian Dengying formation of central Sichuan Basin, southwestern China, *Marine and Petroleum Geology*, 2017, **82**, 206.
- [17] R. Gabrovsek, T. Vuk, V. Kaucic, Evaluation of the hydration of Portland cement containing various carbonates by means of thermal of thermal analysis , *Acta Chimica Slovenia*, 2006, **53**, 159.
- [18] P. Stukovnik, V.B. Bosiljkov, M. Marinsek, Detailed investigation of ACR in concrete with silica-free dolomite aggregate, *Construction and Building Materials*, 2019, **216**, 325.
- [19] S. Krishnan, S. Bishnoi, Understanding the hydration of dolomite in cementitious systems with reactive aluminosilicates such as calcined clay, *Cement and Concrete Research*, 2018, **108**, 116.
- [20] M. Deng, M. Tang, Mechanism of dedolomitization and expansion of dolomitic rocks, *Cement and Concrete Research*, 1993, **23**(6), 1397.
- [21] T. Prinčič, P. Štukovnik, S. Pejovnik, G.D. Schutter, V.B. Bosiljkov, Observations on dedolomitization of carbonate concrete aggregates, implications for ACR and expansion, *Cement and Concrete Research*, 2013, **54**, 151.
- [22] L. Xu, M. Deng, Dolomite used as raw material to produce MgO-based expansive agent, *Cement and Concrete Research*, 2005, **35**(8), 1480.
- [23] D. Wang, C. Shi, N. Farzadnia, Z. Shi, H. Jia, Z. Ou, A review on use of limestone powder in cement-based materials: Mechanism, hydration and microstructures, *Construction and Building Materials*, 2018, **181**, 659.
- [24] M. Gheorghe, N. Saca, L. Radu, The fillers influence on the self compacted concrete properties, *Revista Romana de Materiale-Romanian Journal of Materials*, 2008, **38**(2), 212.
- [25] L. Terec, H. Szilagyi, Self-compacting concrete with limestone powder for precast elements, *Revista Romana de Materiale-Romanian Journal of Materials*, 2011, **41**(1), 15.
- [26] A. Cuibus, Z. Kiss, M. Gorea, Influence of mineral additions on the physical-mechanical properties of concretes, *Revista Romana de Materiale-Romanian Journal of Materials*, 2014, **44**(3), 225.
- [27] E.K. Mako, A.Z. Juhasz, The effect of mechanical treatment on the crystal structure and thermal decomposition of dolomite, *Thermochimica Acta*, 1999, **342**, 105.
- [28] M. Samtani, D. Dollimore, K.S. Alexander, Comparison of dolomite decomposition kinetics with related carbonates and the effect of procedural variables on its kinetics parameters, *Thermochimica Acta*, 2002, **392-393**, 135.
- [29] K.L. Scrivener, T. Füllmann, E. Gallucci, G. Walenta, E. Bermejo, Quantitative study of Portland cement hydration by x-ray diffraction/Rietveld analysis and independent methods, *Cement and Concrete Research*, 2004, **34**(9), 1541.
- [30] GB/T 1346-2011, Standards Press of China. Standard for test methods for water requirement of normal consistency, setting time and soundness of Portland cement, 2011.
- [31] GB/T 17671-1999, Standards Press of China. Standard for test methods for strength of Portland cement mortars, 1999.
- [32] B. Liu, P.S. Thomas, A.S. Ray, J.P. Guerbois, ATG analysis of the effect of calcination conditions on the properties of reactive magnesia, *Journal of Thermal Analysis and Calorimetry*, 2007, **88**(1), 145.
- [33] M.E. Aphane, E.M. van der Merwe, C.A. Strydom, Influence of hydration time on the hydration of MgO in water and in a magnesium acetate solution, *Journal of Thermal Analysis and Calorimetry*, 2009, **96**(3), 987.
- [34] F. Jin, A. Al-Tabbaa, Characterisation of different commercial reactive magnesia, *Advances in Cement Research*, 2014, **26**(2), 101.
- [35] P.K. Mehta, P.J.M. Monteiro, *Concrete: microstructure, properties, and materials*, New York: McGraw-Hill, 2006.
- [36] E. Berodier, K.L. Scrivener, Understanding the filler effect on the nucleation and growth of C-S-H, *Journal of the American Ceramic Society*, 2014, **97**, 3764.
- [37] V. Bonavetti, H. Donza, G. Menendez, O. Cabrera, E.F. Irassar, Limestone filler cement in low w/c concrete: a rational use of energy, *Cement and Concrete Research*, 2003, **33**(6), 865.
- [38] P. Lawrence, M. Cyr, E. Riggot, Mineral admixtures in mortars-effect of inert materials on short-term hydration, *Cement and Concrete Research*, 2003, **33**(12), 1939.
