Study on the effect of light burned magnesia on the properties of sleeve grouting materials

Pan Zhang
KZJ New Materials Group Fujian Co., Ltd. Xiamen 361101, Fujian, China
E-mail:457586631@qq.com

Abstract. The effect of light burned magnesia on the performance of sleeve grouting under different content gradients was studied. The results show that the light burnt magnesia content has no significant effect on the fluidity of the grout when it is less than 5%. The incorporation of light burned magnesia improves the compressive strength of the sleeve grout and the expansion rate of 14d~56d in restrict condition. The incorporation of light burned magnesia can effectively solve the problem of shrinkage of the grouted slurry volume in the later stage and improve the compressive strength of the sleeve grout.

1. Introduction
The sleeve grouting joint was first used in the 38-story Ala Moana Hotel in Honolulu, USA, which was completed in 1996, pioneering a rigid joint for column extension. Sleeve grouting joints are widely used in prefabricated high-rise buildings in the United States, such as the Washington Square Hotel in New York, Paramount Tower and dwellings. In addition, in industrial plants, airport control towers (such as Orlando Airport Control Tower), stadiums (such as Eugene Autzen Stadium), precast bridges and other structures, sleeve grouting joints also are adopted[1].

Prefabricated buildings can achieve construction goals such as safety, durability, convenient construction, and low-carbon environmental protection, which can greatly reduce construction waste and construction sewage, reduce construction noise, and improve project quality, and has become a green and environmentally-friendly building strongly advocated by the country and a future development trend [2]. For prefabricated buildings, the “reliable connection method” is extremely important and is the most basic guarantee for structural safety. Reinforced sleeve grouting connection is one of the main connection methods for prefabricated buildings. Properties of sleeve grouting materials such as strength, high fluidity, and micro-expansion are important factors affecting connection reliability [3].

At present, the expansion sources used in this type of products on the market are mainly AEA expansion agents, CSA expansion agents, etc. Such expansion agents have higher hydration rates and higher expansion rates in 7 days, and occur defects such as shrinkage of the slurry volume after 7 days [4]. After years of research, Professor Deng Min, Professor Cui Xuehua, Academician Tang Mingshu, and others from Nanjing University of Technology believe that calcite (MgO crystals) calcined at a high temperature has a slow hydration effect. In the process of hydration to form Mg(OH)₂, its self volume expansion occurred later [5]. In this paper, the characteristics of delayed micro-expansion and stable hydration products of light burned magnesia were used to study its application in the grouting system. By blending light burned magnesia with different content gradients in the sleeve grout ratio system, the sleeve grout's fluidity, compressive strength, and limit expansion rate were tested, and a comprehensive
and systematic evaluation of the effect of light burned magnesia on the performance of the sleeve grout was made.

2. Test materials and methods

2.1. Test materials

2.1.1. Sleeve grout. This test uses a sleeve grout produced by a Fujian company. The grout has a sand-to-gum ratio of 0.8 and a water-to-material ratio of 0.116. The performance indicators are shown in Table 1.

| Project                        | Performance | Test results |
|--------------------------------|-------------|--------------|
| Fluidity/mm                    | Initial value | ≥300 | 335          |
|                                | 30min retaining value | ≥260 | 280          |
| Compressive strength/MPa       | 1d          | ≥35 | 42.5         |
|                                | 3d          | ≥60 | 65.8         |
|                                | 28d         | ≥85 | 99.5         |
| The rate of upright direction expansion/% | 3h          | ≥0.02 | 0.15       |
|                                | 24h and 3h difference | 0.02–0.5 | 0.11       |

2.1.2. Light burned magnesia. This test uses light burned magnesia produced by a chemical company with a MgO content ≥ 90% and a fineness of 325 mesh.

2.2. Test methods

2.2.1. Grouting materials fluidity and compressive strength. In accordance with the provisions of JG/T 408-2013 “Sleeve Grouting for Rebar Connections”, the grouting fluidity and compressive strength were tested.

2.2.2. Rubber sand limited expansion rate. The test in this paper is based on the GB/T 23439-2017 "Concrete Expansion Agent" standard. The test specimens were made by mixing the grout. The extended expansion rate of the grout was tested to understand the expansion performance of the grout in a restricted space.

3. Results

3.1. Effect of light burned magnesia on grout fluidity

The water-material ratio is fixed to 0.116, and the sand-rubber ratio is 0.8. The light burned magnesia is mixed with the different contents of 0%, 1%, 2%, 3%, 4%, and 5% based on the total amount of the cementitious material. The retention value measured data of initial fluidity and fluidity tested at 30min were shown in Figure 1.
Figure 1. Effect of lightly burned magnesia on fluidity of sleeve grouting material

It can be seen from Figure 1 that the addition content of light burned magnesia less than 5% has no significant effect on the initial fluidity and 30-minute fluidity of the mortar. Compared with the mean value, the initial and 30-minute fluidity retention value fluctuations are within ± 5 mm. This may be due to the slower hydration reaction of light burned magnesia, and its particle size is equivalent to that of cement particles, and has no significant effect on grout fluidity.

3.2. Effect of light burned magnesia on grout compressive strength

The fixed water-to-material ratio is 0.116, the sand-rubber ratio is 0.8, and the light burned magnesia is mixed with the different contents of 0%, 1%, 2%, 3%, 4%, and 5% based on the total amount of the cementitious material. The compressive strength test is performed for 1 days, 3 days, 28 days, and test data are shown in Figure 2.

Figure 2. Effect of light burned magnesia content on compressive strength
It can be seen from Figure 2 that the addition of light burned magnesia has no significant effect on the 1-day and 3-day compressive strength of the grout, while the 28-day compressive strength of the grout has a trend of first increase and then decrease. When the added amount of magnesia is 3%, the 28-day compressive strength is increased by 5.5% compared with the unblended group. The reason is that with the continuous hydration, the mixture of light burned magnesia makes the slurry more compact and thus improves the compressive strength of the grouting material. When the added amount of magnesia is $\geq 4\%$, compared with 3%, the compressive strength decreases. This may be because the content of lightly burned magnesia is too high and the expansion becomes larger, which causes the slurry structure to be relatively loose at the later stage of hardening, then the strength decreases.

3.3. Effect of light burned magnesia on grout limiting expansion rate
The water-to-material ratio is fixed to 0.116, the sand-rubber ratio is 0.8. The light burned magnesia is mixed with the content of 0%, 1%, 2%, 3%, 4%, and 5% based on the total amount of the cementitious material, and the 14-day, 28-day, and 56-day limit expansion rate of grouting material were tested, the test data is shown in Figure 3.

![Figure 3: Effect of light burnt magnesia content on restricted expansion rate](image)

It can be seen from Figure 3 that the mix of light burned magnesia has no significant effect on the restricted expansion in the first 7-day grouting, and when the sleeve grout mixed with light burned magnesia with different contents of 0%, 1%, 2%, 3%, 4%, and 5%: the limiting expansion rates at the age of 14-day are -0.011%, -0.002%, 0.003%, 0.006%, and 0.010%; the limiting expansion rates at the age of 28-day are -0.026%, -0.005%, 0.006%, 0.015%, 0.023%, and 0.032%; the limiting swell rates at the age of 56-day are -0.028%, -0.005%, 0.007%, 0.018%, 0.025%, and 0.037%. It can be seen that with the increase of the mixing amount of light burned magnesia, the age-limited expansion rate of the grouting slurry increases, while the comparison group without light burned magnesia shrinks from 7 days to 56 days.

4. Conclusion
Adding less than 5% of light burned magnesia to the grout will not affect the flow properties of the grout. When the content of light burned magnesia is 3%, compared with the control group without light burned magnesia, the 28 days strength increase is the highest at 5.5%. The limiting expansion rates of the colloidal sand corresponding to the dosage of 14-day, 28-day, and 56-day are 0.003%, 0.015% and 0.018%. It can be seen that, when the incorporation content of light burned magnesia is less than 3% in
the grouting, the problem of slurry volume shrinkage in the later stage of sleeve grouting can be effectively solved, and the compressive strength of the grouting will be improved.

References

[1] Yu, C. (2014) Study on Preparation and Performance of Grouting Material for Reinforced Sleeve Connection. Southeast University., 1: 1-76.
[2] Qi, B.K., Zhu, Y., Ma, B. (2016) Research on Comprehensive Benefit Analysis Method of Prefabricated Building. Construction Technology., 4: 39-43.
[3] Wang, X.S., Yang, Z.L., Wu, Z.X. (2015) Experimental study on the performance of high-strength sleeve grouting for fabricated structures. Concrete and cement products., 2: 65-68.
[4] Yan, P.Y., Lian, H.Z., Qin, X. (2000) Several issues need to be paid attention to when using expansion agent to formulate compensated concrete. Journal of the Chinese Ceramic Society., s1: 45-48.
[5] Deng, M., Chui, X.H., Liu, Y.Z., Tang, M.S. (1990) Expansion mechanism of magnesium oxide in cement. Journal of Nanjing Institute of Chemical Technology., 4: 1-11.