Study on the preparation of high content non-sintered brick with sludge

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Abstract. The aim of this study is to prepare non-sintered bricks using the chemical sludge as raw materials, so as to realize the recycling disposal of the sludge. Through the orthogonal experiment of five factors and four levels, the influence of five different factors and their levels on the compressive strength of non-sintered sludge test blocks was investigated. The results showed that the optimal combination of orthogonal experiment is A_4B_1C_4D_2E_3, the compressive strength reaches the maximum value of 24.29MPa; Through the analysis of the range, it was found that factor C had the greatest effect on the compressive strength, followed by the cement (P.O 32.5), hydrophobic agents and re-dispersible emulsion powder, the crack resistant fibre had the least effect.

Considering the cost and R analysis, the combination of factors was adjusted as A_3B_1C_4D_2E_1, and three verification experiments were conducted, the average compressive strength was 23.57MPa.

1. Introduction

With the development of society, sewage discharge is increasing day by day. Under the background of national energy conservation and emission reduction, sewage disposal has achieved remarkable results. However, A large amount of sludge is generated during sewage treatment, if not be treated, will be harmful to human health and ecological environment [1]. As a result, sludge treatment has become a problem that must be solved.

Traditional disposal methods of sludge mainly include incineration, recycling to agricultural land and so on [2-6]. New technologies include preparation of building materials, adsorption materials and synthetic fuels [7-11]. Using sludge to prepare building materials is a new way to develop new materials, sludge brick technology has aroused the interest of the majority of scholars, but mainly to prepare sintered bricks [12-14]. Lingzhi Yu et al. of Shanghai university of science and technology found that the compressive strength of sintered test blocks with no more than 15% sludge content could meet the requirements of GB 26538-2011[15]. Deming Gao of Northwest Agriculture & Forestry University studied the technology of preparing bricks with wet sludge, the results showed that when the sludge content was 25%, the sintered brick prepared could meet the national third-level brick standard [16]. Jiaqi Liang and Guangkun Chen found in the production practice of sludge sintered bricks that the sludge sintered bricks could meet the requirements of MU10 grade (GB/ T5101-2003) [17].
An chemical enterprise in Taiyuan produce a large amount of neutralizing sludge in the process of acidic wastewater treatment. With the increasingly strict requirements on sludge disposal, the treatment of this sludge has become an urgent problem for the enterprise to solve. In the process of project negotiation, the enterprise proposed to use the sludge to prepare wall building materials, and put forward two requirements: firstly, increasing the amount of sludge in bricks as much as possible to improve the treatment efficiency; secondly, in order to save investment and reduce energy consumption, preparing non-sintered bricks. In this paper, the influence of different factors on the compressive strength of test blocks was studied, the best preparation parameters are determined, the results can use for reference in industrial production.

2. Materials and methods

2.1. Materials

The dehydrated sludge is obtained from the chemical enterprise in Taiyuan. The sludge is spread out and dried for a week under natural condition. After drying, The moisture content is determined and the value is 20.36%. The main components of sludge after analysis are shown in table 1.

| Item   | LOSS | SiO₂  | Al₂O₃ | Fe₂O₃ | CaO  | MgO  |
|--------|------|-------|-------|-------|------|------|
| %      | 46.27| 14.28 | 15.35 | 3.23  | 13.43| 3.45 |

| Item   | SO₃  | K₂O  | Na₂O | Insolubles | Cl | Σ    |
|--------|------|------|------|------------|----|------|
| %      | 1.76 | 0.29 | 0.05 | 0.241      | 0.07| 98.11|

Additive: the cement (P.O 32.5), hydrophobic agent, crack resistant fibre (polypropylene 6mm) and re-dispersible emulsion powder.

2.2. Methods

According to the orthogonal experiment of five factors and four levels, weighing out each of raw materials, after mixing them thoroughly, compressing the mixture into block of 70*70*40mm with YP-20TB oil-pressure powder tablet press in the special mould. After natural curing for a week, the compressive strength of blocks were tested by WHY-10 microcomputer controlled full automatic pressure tester.

The preparation process flow chart is shown in Fig.1.

The calculation formula of compressive strength is as follows:

\[ P = \frac{F}{A} \]  \hspace{1cm} (1)

Where, P is the compressive strength of the non-sintered test block (MPa); F is the maximum pressure of the non-sintered test block(N); A is the bearing area of the test block (mm²).
3. Results and discussion
The experimental data of five-factor and four-level orthogonal experiment are shown in table 1.

Factor A is cement (5%, 10%, 15%, 20%), factor B is hydrophobic agent (2.5, 5, 7.5, 10mL), factor D is re-dispersible emulsion powder (1, 2, 3, 4%), factor E is crack resistant fibre (0.1, 0.2, 0.3, 0.4%).

| NO. | A% | B mL | C% | D% | E% | P MPa |
|-----|----|------|----|----|----|-------|
| 1   | 1(5)| 1(2.5)| 1(16)| 1(1)| 1(0.1)| 8.24  |
| 2   | 1  | 2(5) | 2(24)| 2(2)| 2(0.2)| 12.75 |
| 3   | 1  | 3(7.5)| 3(32)| 3(3)| 3(0.3)| 13.88 |
| 4   | 1  | 4(10)| 4(40)| 4(4)| 4(0.4)| 15.34 |
| 5   | 2(10)| 1 | 2 | 3 | 4 | 11.87 |
| 6   | 2  | 2   | 1 | 4 | 3 | 9.65  |
| 7   | 2  | 3   | 4 | 1 | 2 | 18.51 |
| 8   | 2  | 4   | 3 | 2 | 1 | 15.94 |
| 9   | 3(15)| 1 | 3 | 4 | 2 | 17.97 |
| 10  | 3  | 2   | 4 | 3 | 1 | 22.26 |
| 11  | 3  | 3   | 1 | 2 | 4 | 10.84 |
| 12  | 3  | 4   | 2 | 1 | 3 | 11.54 |
| 13  | 4(20)| 1 | 4 | 2 | 3 | 24.29 |
| 14  | 4  | 2   | 3 | 1 | 4 | 17.18 |
| 15  | 4  | 3   | 2 | 4 | 1 | 12.68 |
| 16  | 4  | 4   | 1 | 3 | 2 | 8.91  |
| k1  | 12.55 | 15.59 | 9.41 | 13.87 | 14.78 |
| k2  | 13.99 | 15.46 | 12.21 | 15.96 | 14.54 |
| k3  | 15.65 | 13.98 | 16.24 | 14.23 | 14.84 |
| k4  | 15.77 | 12.93 | 20.10 | 13.91 | 13.81 |
| R   | 3.21 | 2.66 | 10.69 | 2.09 | 1.03 |

According to the analysis of k value, the optimal combination of factors was A4B1C4D2E3, and the compressive strength was 24.29 MPa under this condition. According to the analysis of R value, factor C (R:10.69) had the greatest influence on compressive strength, followed by A (R:3.21), B (R:2.66) and D (R:2.09), and factor E (R:1.03) had the least influence.

In table 2, k1 (14.78 MPa) and k3 (14.84 MPa) of factor E (crack resistant fibre) were relatively close. k3 (15.65 MPa) and k4 (15.77 MPa) of factor A (cement) were relatively close. In order to reduce the cost of raw materials without greatly reducing the compressive strength as far as possible, the combination of factor levels was adjusted to A3B1C4D2E1. Three verification experiments were conducted, the average value of the compressive strengths was 23.57 MPa.

4. Conclusion
The influence of different factors such as cement, hydrophobic agent, re-dispersible emulsion powder and crack resistant fibre on the compressive strength of non-sintered test blocks with high content sludge was investigated. Through the orthogonal experiment of five factors and four levels, the optimal combination of sludge blocks with high sludge content (>70%) was determined, which provided a theoretical reference for industrial production.
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