Study on construction technology of phosphogypsum wall

Study on construction technology of phosphogypsum wall

Yichao Zhang*, Ying Wang[a] and Jinghai Zhou[b]

School of civil engineering, Shenyang Jianzhu University, Shenyang 430070, China

*Corresponding author e-mail: lunwenww@sina.com, [a]1047803924@qq.com, [b]jinghaiz@qq.com

Abstract. In this paper, the construction technology of new cast-in-situ phosphogypsum wall is studied through pouring tests of different wall types, and the pouring operability, accuracy and efficiency of the new wall is evaluated. The results show the surface smoothness and vertical deviation of cast-in-situ phosphogypsum wall are determined to be 3-4mm. The construction efficiency of cast-in-situ phosphogypsum wall is about 6-7m^2/h, which realizes high-precision and high-efficiency construction of wall. The technology of cast-in-situ phosphogypsum wall provides an effective method for the resource utilization of industrial solid waste and the large-scale innovation of wall materials.

1. Introduction

At present, the comprehensive utilization of phosphogypsum in China is only about 10 million tons per year, and the comprehensive utilization of phosphogypsum is far less than the discharge of phosphogypsum [1]. About 70% of building materials in China are wall materials. The production of clay bricks consumes about 1 billion cubic meters of clay resources each year, equivalent to about 70 million tons of coal. In 2010, the output of new wall materials in China exceeded 400 billion standard bricks, and the application of new wall materials exceeded 350 billion standard bricks [2]. In 2015, the output of solid clay bricks in China was controlled below 300 billion standard bricks, and the output of new wall materials exceeded 65%, and the application of new wall materials exceeded 75% [3-4]. Under the background of solid waste utilization, wall material innovation and building energy saving, a new type of cast-in-situ phosphogypsum wall is proposed. The cast-in-situ phosphogypsum wall is a filling wall made for supporting mould and pouring phosphogypsum wall material. The cast-in-situ phosphogypsum wall is different from the common masonry wall. Its main characteristics are as follows: (1) Integration of the structure: the wall structure has been integrated, and the mechanical properties of the structure are better; (2) insulation of the structure: because the wall material has been lightweight, the thermal insulation performance of the structure is better; (3) high construction effectiveness: wall construction is cast-in-situ construction, which improves the efficiency and accuracy of construction. In this paper, the construction technology of new cast-in-situ phosphogypsum wall will be studied through pouring tests of different wall types, and the pouring operability, accuracy and efficiency of the new wall will be evaluated.

2. Test design and method of phosphogypsum wall

2.1. Test design

The test design of phosphogypsum wall is divided into three groups. The first group uses steel-wood formwork to pour the straight wall without opening, the second group uses steel-wood formwork to pour the straight wall with opening, and the third group uses plastic formwork to pour the corner wall with opening. The design of pouring test is shown in Table 1.

Table 1. Design of pouring test

Pouring test	Group 1	Group 2	Group 3
Wall type	straight wall without opening	traight wall with opening	corner wall with opening
Wall formwork	steel-wood formwork	steel-wood formwork	plastic formwork

The first group of cast-in-situ phosphogypsum wall is designed to be 2800mm (long) ×2800mm (high) ×200mm (thick), and waterproof cushion is designed to be 2000mm (long) ×200mm (high) ×200mm (thick). The second group of cast-in-situ phosphogypsum wall is designed to be 6000mm (long) ×2800mm (high) ×200mm (thick), and waterproof cushion is designed to be 6000mm (long) ×200mm (high) ×200mm (thick). The third group of cast-in-situ phosphogypsum walls are corner walls, with doors on the short side and windows on the long side. The longitudinal reinforcement of cast-in-situ phosphogypsum wall is 4Φ12, the hooping is Φ6@250mm, the transverse reinforcement is Φ6, and the longitudinal reinforcement is Φ6.

2.2. Test method

The construction of phosphogypsum wall is realized by laying out the wall, planting reinforcing bar, supporting waterproof cushion template, waterproof cushion pouring, waterproof cushion template removal, supporting main wall template (main wall and door and window opening template), main wall pouring and main wall template removal. The pouring methods are as follows:

(1) Wall setting-out: first pop-up the wall line, then pop-up the template control line according to the wall design width.

(2) Reinforcement planting: longitudinal reinforcement, hooping, longitudinal reinforcement and transverse reinforcement of constructional column implanted in cast-in-situ phosphogypsum wall. Longitudinal tension bars of cast-in-situ phosphogypsum wall are 500mm apart along the length direction of the wall.

(3) Supporting waterproof cushion formwork: When supporting the formwork, the waterproof cushion formwork should be set up according to the position of laying-out, and then the verticality of the waterproof cushion formwork should be checked.

(4) Waterproof cushion pouring: pouring waterproof cushion material into formwork.

(5) Mould removal of waterproof cushion formwork: two hours later, the waterproof cushion eventually solidifies and the waterproof cushion formwork is removed.

(6) Supporting the main wall formwork: Firstly, the main formwork of the main wall should be set at the position of the pull bolt of the waterproof cushion, the verticality of the main formwork should be adjusted, and the pull bolt of the waterproof cushion should be tightened.

(7) Main wall casting: check the tightness of tie bolts, the verticality of the wall, and the smoothness of the middle joint. The grouting equipment is equipped with mixer, conveyor pump and conveyor pipe). The phosphogypsum wall material is poured into the formwork.

(8) Removal of main wall formwork: Remove the formwork after completion of pouring, and remove the formwork in reverse order. The supported formwork and the forming wall are shown in Figure 1-6, respectively.

Figure 1. Group 1 supported formwork

Figure 2. Group 1 forming wall

Figure 3. Group 2 supported formwork

Figure 4. Group 2 forming wall

Figure 5. Group 3 supported formwork

Figure 6. Group 3 forming wall

3. Test results and analysis of phosphogypsum wall

3.1. Test results

The pouring time, wall deviation and total construction time of phosphogypsum straight wall (without opening), phosphogypsum straight wall (with opening), phosphogypsum corner wall (with opening) were measured respectively.

Group 1: the pouring time of main wall is about 5 minutes; the axis deviation is 5mm, the surface flatness deviation is 4mm, the vertical deviation is 3mm; the total construction time is about 2.5 hours.

Group 2: the pouring time of main wall is about 20 minutes; the axis deviation is 5mm, the surface flatness deviation is 3mm, the vertical deviation of elevation is 4mm, and the deviation of doors and windows is 4mm; the total construction time is about 3 hours.

Group 3: the pouring time of the main wall is about 25 minutes; the axis deviation is 4mm, the surface flatness deviation is 3mm, the vertical deviation of the elevation is 3mm, and the deviation of the doors and windows is 3mm; the total construction time is about 3.5 hours.

3.2. Operability analysis

The results of pouring test show that the pouring time of the main wall in each group is 5 min, 20min and 25min respectively, which are less than 30min and less than the initial setting time of the material. It shows that the operability of cast-in-situ phosphogypsum wall is good, and verifies the feasibility of cast-in-situ phosphogypsum wall in construction.

3.3. Accuracy analysis

Axis deviation, surface smoothness deviation, elevation smoothness deviation and door and window opening deviation of cast-in-situ phosphogypsum wall in each group are shown in Table 2.

Table 2. Size deviation of cast-in-situ phosphogypsum wall

Size deviation	Group 1	Group 2	Group 3
Axis deviation (mm)	5	5	4
Surface smoothness deviation (mm)	4	3	3
Elevation smoothness deviation (mm)	3	4	3
Opening deviation (mm)	-	4	3

The allowable deviation of wall dimension in Technical Specification for Autoclaved Aerated Concrete Block (DB/42T 268-2012) is as follows: the allowable deviation of wall axis displacement is 5mm, the allowable deviation of surface smoothness is 8mm, the allowable deviation of vertical plane is 5mm, and the allowable deviation of doors and windows is 5mm. From Table 2, it can be seen that the surface smoothness and vertical deviation of cast-in-situ phosphogypsum wall are 3-4mm with high accuracy. Plastic formwork can reduce the deviation of wall axis and the deviation of door and window opening to a certain extent.

3.4. Efficiency analysis

After measurement, the construction efficiency of the first group is about 2.5m^2/h, and that of the second and third groups is 6m^2/h and 7m^2/h respectively. At present, the masonry efficiency of aerated concrete block wall is about 2m^2/h. Cast-in-situ phosphogypsum wall technology achieves efficient wall construction.

4. Conclusion

In this paper, the pouring test of phosphogypsum straight wall (without opening), phosphogypsum straight wall (with opening) and phosphogypsum corner wall (with opening) are carried out respectively. The main conclusions are as follows:

(1) The construction method of cast-in-situ phosphogypsum wall is analyzed through the pouring test of phosphogypsum wall.

(2) Through field measurement, the surface smoothness and vertical deviation of cast-in-situ phosphogypsum wall are determined to be 3-4mm. When large-scale construction is carried out, the construction efficiency of cast-in-situ phosphogypsum wall is about 6-7m^2/h, which realizes high-precision and high-efficiency construction of wall.

Acknowledgments

This work was supported by the National Key R&D Program of China (2016YFC0700905-04) and Science and Technology Support Program of Hubei Province (2015BCA247).

References

[1] Liao Ruobo, Xu Xiaoyan, Ji Luojun, Zhou Kaimin. Current situation and prospect of phosphogypsum resource utilization in China [J]. Sulphuric acid industry, 2012, 13 (2): 1-7.
[2] Science and technology development promotion center of the ministry of housing and urban-rural construction. China building energy conservation development report [M]. Beijing: China construction industry press, 2014: 30.
[3] General office of the state council. Notice of the general office of the state council on further promoting the innovation of wall materials and promoting energy-saving buildings.
[4] National development and reform commission. Guidelines for the innovation of wall materials in the twelfth five-year plan.