Joints of Coal Gangue Wallboards in Steel Structure Housing

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Abstract. In this paper, according to some relevant requirements on construction and normal use of wallboards in steel structure housing, the coal gangue wallboard is taken as a research subject and a new joint idea is presented. Floor slab bears the wallboards’ dead load directly, meanwhile, components at the wall opening edge and wall studs are not to be needed. A series of problems on external wallboards—lifting, installing and adjusting, fixing, splicing and joint seams have been studied. Through these studies, the method of coal gangue wallboards’ joints was obtained and this method is fit to fabricating of the steel structure housing. In addition, the research results of this paper can be used in the application of other prefabricated wallboards in the steel structure housing.

Introduction

Steel structure housing has decades of history in Europe and the United States, its factory processing is fast, steel can be recycled, construction speed, in line with the requirements of sustainable development and to meet the requirements of the times\cite{1}. At present in our country, the problem of structural system has been basically solved, the wallboard and its connection structure is the biggest problem \cite{2}. Assembly type external wallboard system in the steel structure represents the development trend of the current assembly building, its popularization and application has important significance to the development of the construction industry \cite{3}. Seeking and developing the external wallboard suitable for the current building system is a problem that needs to be solved in the development of the construction industry \cite{4}. With the vigorous promotion of the assembly structure, the external wallboards are in the form of prefabricated external stores and have hinge joint with the beams and columns which is very common \cite{5}. The connection structure of the wallboard is the key to whether the panel and the whole structure are consistent with the theoretical calculation model, and whether the safety and reliability of the house is guaranteed \cite{6}. Based on the study on mixing ratio of coal gangue concrete, wallboard weight is too large, if use the traditional connection construction method, the installation and adjustment will be very difficult, the speed of construction will be reduced and installation quality cannot be guaranteed, in the use of the process will be a problem for water seepage, poor effect of sound insulation. In order to make the coal gangue wallboard installation simple and convenient while reducing the demand of bearing capacity, a series of connection construction problems of external wallboards are studied, and the idea that the floor slab directly bears the weight of the wall plate is put forward.
Introduction of Wallboards

According to the requirements of the installation and use of the external wallboards, the length of the four cases of 3m, 4.5m, 6m, 7.5m were considered, the width of the three cases of 600mm, 1000mm, 1200mm were considered, the thickness of the three cases of 100mm, 150mm, 200mm were considered. For 150mm, 200mm thick wall, in order to further reduce the weight, the wall board is made into a hollow board, hollow diameter D is equal to or less than 50mm (150mm thick plate); equal to or less than 100mm (200mm thick plate). Plate length is not larger than 4.5m, with a double deck two-way steel wire mesh. The plate length is larger than 4.5m, the double deck and double wire mesh. The hole side wall board, no matter big and small, are double deck and double wire mesh. Based on the wall board and the connecting structure design principle, the top, bottom with right angle sides, side of the precast splice to the desired shape of panel schematic diagram is shown in Fig.1.

![Figure 1. A sketch map of external wallboards.](image)

Hoisting

The hanging position and structure of coal gangue wallboard directly affects the safety of transportation and hoisting process. In the course of the study, take the lifting point design and the wall plate fastening into consideration—the embedded parts can be as hanging point in the lifting process, and can be used as a connecting member in fastening the wall. Therefore, the need for embedded wallboard hoisting calculation consider from the construction stage and normal use stage. Also, do not consider lifting under the extreme weather conditions, the ring diameter is 10mm ~ 14mm.

In the course of construction, two points are hoisted at the time of installing a plate, and four points are hoisted at the time of transportation. For the convenience of lifting many boards, therefore, the minimum tensile bearing of the embedded parts is larger enough than the weight of the plate, embedded holes will not occur deformation and failure in hoisting.

In normal use phase, the wall weight by floor bear, embedded parts only need to bear the horizontal load, which reduces the bearing capacity requirements of embedded parts. It can be known that the plates’ number of the four points should be less than 3.

The lifting connecting piece (i.e. embedded) size is shown in Fig.2, the embedded parts embedded wall depth no less than 45mm, welded on steel wire mesh or C type steel inner side. In order to facilitate the adjustment of the board in each direction, at the same time to avoid the collision between the bolt and the steel bars in the floor, unilateral open a long round hole.
Wallboard Splicing

In order to ensure the stability of wallboards and the replacement in the process of use, combined with the principle of vertical layout, the external wall board is used in the transverse connection. The special location (such as the edges of the hole) use horizontal layout. Wallboard arrangement is shown in Fig.3. Wallboard splicing include external wall splicing, corner of wall—external angle, internal angle and hole edge wall connection.

External Wallboard Splicing—Lap Joint

In order to facilitate the replacement of the wall, but also because the thickness of the external wallboard is large, using the symmetrical overlapping method to splice, locked type is used in installation. The external wallboard assembly is preformed as shown in Fig.4, splicing is shown in Fig.5.

After the wallboard is transported to the construction site, the sealing joint strip is pasted on the lap joint equably. After lifting to the corresponding installation position, tear up the
surface protective film of sealing joint strip, and then splice directly. In order to facilitate the adjustment of the board position, at the same time considering the normal use of the process of expansion of the wall, the gap between the two plates should be reserved for 10mm in installation.

**Corner of Wall—External Angle, Internal Angle**

The stability of the whole envelope is directly influenced by the structural measures at the corner of the wall. When installing the corner of the wall plate, in order to ensure the performance of thermal insulation to meet the requirements, the connection should be pasted sealing joint strip not less than 3. Similar to the wallboards, the 10mm should be reserved for the construction joints.

The stiffness of the external wall plate can enhance the lateral stiffness and torsional rigidity of the whole structure [7]. In order to ensure the integrity of the enclosure structure, between the two in the direction of a long board three-point position increased angle (angle 75 x 45 x 4) to fix. The side is welded with the C type steel, the other side is fixed by the bolt with the wall. The wall is similar to the hole wall plate shown in Fig.8, joint of external angle is shown in Fig.6 and joint of internal angle is shown in Fig. 7.

**Hole Edge Wallboard Connection.**

In order to make the connection simple and convenient between the hole edge wallboard and the top (bottom) board, at the same time, the door and window frame is installed no longer need to add other parts or components, wallboards around the hole should be embedded C steel. When the wall openings, the wallboard at left and right sides of the hole should be vertical, the upper and lower should be horizontal. The edge wallboard is shown in Fig.8, top (bottom) wallboard is shown in Fig.9, and the connection between the side wallboard and the top (bottom) wallboard of the hole is shown in Fig.10.
**Wallboard Fixing**

Wallboard fixation is mainly used to solve the horizontal load and vertical load transfer, but also to meet the water, sound insulation, thermal insulation, etc. Because of the high weight of coal gangue wallboard, in order to reduce the load bearing capacity of the connection parts, the floor is extended to bear weight of the wallboard. Therefore, in the early stage of structural design, the floor will be hanging out, protruding column skin 210mm, used to place the external wall panels. It not only effectively reduces thermal bridge effect by wrapping up the beams and columns [2], but also increases the indoor area to use. There are three ways to fix the wallboards (Fig.11, Fig.12 and Fig.13).

As is shown in Fig.14, if the embedded part is located in outer surface of the steel column, the angle steel should be welded on both sides of the steel column to fix the wallboard.

**Conclusions**

(1) The weight of the wall plate is directly borne by the floor slab, which solves the problem of difficult installation process due to the heavy weight of the wall plate.
(2) Door (window) frame can be directly fixed with C type steel, no need to add a hole edge component.
(3) The assembly of wallboards is realized. Construction is fast and the operation is simple.
References


