Study on the Selection Principles of Building Sealant in AAC External Wall

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Abstract. With the vigorous development of prefabricated buildings in China, the maturity of assembly technology, the matching of materials and the professionalism of construction have become the focus of attention. As the most important lightweight wall enclosure material, the sealant for autoclaved aerated concrete (AAC) wall plays a major role in the joint sealing of the wall. In this paper, on the analysis of related standards and the application characteristics of sealants, the requirements of sealant for AAC external wall are discussed and summarized. The requirements include good compatibility and adhesion with the substrate, low modulus and high displacement ability, environmental protection, good weather resistance and paint ability (when there is painting demand for the joints).

1. Introduction
With the vigorous development of prefabricated buildings in China, the maturity of assembly technology and the matching of materials have become the focus of attention. Autoclaved aerated concrete (AAC) board is the most important lightweight wallboard of prefabricated buildings, and the treatment of board joints is the quality concern of building walls [1-2]. After the external wall components of prefabricated building are spliced, there will be a large number of joints, which will inevitably encounter the combined effect of structure vibration and thermal expansion and contraction of material caused by temperature change. The sealant for AAC wall plays a major role in the joint sealing of the wall, which integrates the two functions of bonding and sealing [3-4]. In this paper, on the basis of the application characteristics of sealants and the analysis of related standards, the requirements of sealant for AAC external wall are discussed and summarized.

2. Characteristics of different building sealants and related standards

2.1. Characteristics of different building sealants
In the initial development of domestic prefabricated buildings, low-modulus silicone sealants were used in many places to seal the joints of the external walls [2]. Silicone sealant has excellent weather resistance, but it also has some application defects, such as poor adhesion to concrete, poor stain resistance, and non-painting of the surface, which is not conducive to its application on concrete substrates; Polyurethane sealant is also a common sealant for prefabricated construction. It has good adhesion to concrete substrates and excellent paintability of surface, but its weather resistance is relatively poor. The modified silicone sealant was first introduced from abroad, which combines the excellent performance of silicone sealant and polyurethane sealant. Table 1 lists the characteristics of
different sealants in engineering use. The characteristics of sealants are closely related to their molecular structure and production process.

| Species                  | Cohesiveness | Displacement ability | Weather resistance | Environmental protection | Paintability |
|--------------------------|--------------|----------------------|--------------------|--------------------------|--------------|
| Silicone sealant         | good         | Very good            | Excellent          | Excellent                | -            |
| Silane modified polyether sealant | Excellent | good | good | Excellent | Very good |
| Polyurethane sealant     | good         | good                 | -                  | -                        | good         |
| Polythiourea sealant     | good         | good                 | -                  | good                     | good         |

2.2. Related standards

Table 2 lists the requirements for construction sealants proposed in the construction sealant standards and related technical regulations for prefabricated buildings. In terms of the scope of application of the GB/T 14683 standard, the most prominent feature of the 2017 version compared to the 2003 version is the definition of "modified silicone building sealant": "Silane-terminated polyether as the main component, room temperature cured one-component and multi-component sealants.” At the same time, the requirements for alkane plasticizers have been increased, and requirements for ensuring the quality of silicone sealants and preventing the addition of "white oil" are put forward. According to the development of existing prefabricated buildings, the standard adds the R type in the modified silicone sealant, and points out that it has stress relaxation properties. The mass loss rate of modified silicone sealant is ≤5%, which is different from that of silicone rubber, which is ≤8%, and its elastic recovery rate is different from that of silicone rubber.

In the relevant standards of prefabricated buildings, the requirements for sealants of construction are also put forward. The common point is that the sealants should have compatibility with the substrate, and the specified resistance to shear and expansion; they should also be mold-proof, fireproof, waterproof, weather resistance and other properties. In DB11/T 1477, it is proposed that the joint sealant for prefabricated buildings should adopt a low-modulus weather-resistant building sealant with a displacement capacity of not less than 25%.

| Standard                      | Scope of application                                                                 | Comments                                                                 |
|-------------------------------|--------------------------------------------------------------------------------------|--------------------------------------------------------------------------|
| GB/T 14683 Silicone and modified silicone sealants for building | Silicone construction sealant for general decoration, non-structural assembly of building curtain walls, and modified silicone sealant for construction joints and shrinkage displacement joints. | Modified silicone sealant refers to silane modified polyether sealant. The standard was revised in 2017, adding performance requirements for modified silicone sealant. |
| GB/T 16776 Structural silicon sealants for building | Suitable for curtain wall and structural bonding assembly | Requirements for structural silicone sealants |
| GB/T22083 Classification and requirements for building sealants | Classification of sealants according to performance and use | For the first time, the levels and requirements of sealants with high displacement capabilities are included in an informative appendix. |
| GB/T24267 Requirements for flame retardant | | Functional sealants |
3. Principles for AAC matching sealant and the key points of construction

3.1. The tensile tests

The AAC wall has the characteristics of light weight and low heat transfer coefficient, and is usually used as the enclosure wall of steel structure buildings. For steel structure buildings, due to the large displacement between floors, both the board seams and structural seams are required to be flexible joints to maintain the integrity of the wall under structural deformation. Modified silicone sealant is the largest used sealant in Japan and it is also the sealant for AAC walls in Japan. As shown in Figure 1 and Figure 3, the damaged site is at the surface of AAC substrate after the tensile tests and it indicates the modified silicone sealant has good adhesion to AAC substrate under both normal temperature and water immersion conditions. The experimental result shows that the bonding strength between AAC and modified silicone sealant is about 0.15MPa ~ 0.2MPa, and the elongation is about 110%~120% (Figure 2). After the primer treatment of substrate, the bonding strength of AAC with the sealant is 0.2MPa and it is slightly higher than the bonding strength with untreated surface. It shows the primer improves the surface strength of AAC substrate. After immersion in water, the bonding strength is about 0.2MPa and the elastic modulus of the sealant is significantly reduced and the elongation is about 250% to 350% (Figure 3), which meets the flexible joint requirement of AAC board seams and structural seams.
Figure 1 Bonding tensile fracture morphology of AAC with modified silicone sealant

Figure 2 Tensile stress-strain curve of AAC substrate with modified silicone sealant

Figure 3 Bonding tensile fracture morphology of AAC with modified silicone sealant after immersion treatment
3.2 Principles
At present, modified silicone sealants and silicone sealants are widely used in prefabricated buildings [5-6]. Especially in the joint with the structure, the sealant with low tensile modulus and high displacement becomes the main joint material [7]. Prefabricated building is one of the main directions of future building development. As a typical material in steel structure enclosure walls, AAC's application technology has received more and more attention. From the characteristics of various types of sealants and the requirements of prefabricated buildings for sealants, aerated concrete supporting sealants must have the following performance characteristics: (1) Good compatibility and adhesion with the substrate. Aerated concrete is a porous material, and it is required that the sealant has high adhesion to the aerated concrete, and there is no oil leakage pollution around the joints of the sealant. (2) Low modulus and high displacement ability. For example, the size of the prefabricated wall panel is larger, and the accumulated deformation of the splicing joint is larger (the deformation displacement of the expansion joint and the hot and cold joint is usually within the range of ±20% to ±50%), and the sealant is required to have Super strong interface adhesion and deformation adaptability; (3) Environmental protection. (4) Weather resistance. AAC is a microporous and alkaline material. When the external wall panel is exposed to outdoor use for a long time, the sealant is required to have good acid and alkali resistance and freeze-thaw cycle resistance; (5) Paintability. When the seams need to be veneered, good paintability guarantees the compatibility of the outer veneer materials with the seam glue.

3.3 Key points of sealant construction
There are four key points of sealant construction which should be pay attention to. Firstly, appropriate width should be reserved for structural joints. The ratio of the width to the depth of the sealant is generally 2:1, and the minimum should not be less than 1:1. Secondly, the wall substrate at the seam is best to be primed. Thirdly, PE rods of appropriate size must be added to the structural joints, and the sealant filling shape must be trimmed to avoid three-sided sticking to ensure the bonding performance. Finally, construction in a clean environment with a temperature of 4°C ~ 40°C and a relative humidity of 40% ~ 80%. It is not allowed to construct when it rains or snows. In addition, within 48 hours of the sealant curing time, the sealing seam is not allowed to have a large displacement.

4. Conclusions
For prefabricated buildings, the bonding object of sealant is mainly concrete materials. The concrete materials have the properties of microporous and alkaline, which are essentially different from the sealant commonly used materials, such as glass curtain walls, stone, metal, and aluminum-plastic
materials. In addition, the role of sealants is different. In the past, the function of building sealants was mainly to seal and beautify the external wall. However, in prefabricated building components, sealants play the role of connecting the external wall components and structures. The new requirements for the technical indicators of sealants should be put forward. And these changes are also reflected in the changes of sealant related standards. In view of the current engineering practice and the performance of sealants, the sealant for AAC external wall must meet the following requirements:

1. Good compatibility and adhesion with the substrate.
2. Low modulus and high displacement ability.
3. Environmental protection.
4. Good weather resistance.
5. Paintability (if there are painting requirements for the joints).

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