

# A Review of Exterior Waterproofing Technologies in Prefabricated Buildings

Baiheng Liao<sup>1</sup>, Meng Zhou<sup>2\*</sup>, Yutong Wang<sup>3</sup>, and Zhiduo Wu<sup>4</sup>

<sup>1</sup>Civil Engineering, Hubei University of Technology Engineering and Technology College, Wuhan, China, 430068

<sup>2</sup>Civil Engineering, Tianjin Chengjian University, Tianjin, China, 300192

<sup>3</sup>Port, Waterway and Coastal Engineering, Harbin Engineering University, Heilongjiang Province, China, 150006

<sup>4</sup>Civil Engineering, Southwest Jiaotong University, Sichuan Province, China, 611756

**Abstract.** This paper analyses the status quo of exterior wall waterproofing technology of prefabricated building, introduces the application of waterproofing coil laying, sealant waterproofing, grouting method, exterior wall waterproofing coating, waterproof concrete and the integration technology of heat preservation and drainage, and analyses their advantages and disadvantages. In the future, the research and application of new materials should be strengthened, and the effects of different waterproof technologies should be quantitatively compared through experiments to further improve the waterproof performance of prefabricated building external walls.

## 1 Introduction

With the development of society, prefabricated buildings, as a representative of modern industrial production, have made great progress in the field of construction, and have gradually become one of the important ways of modern building construction. The waterproofing technology of prefabricated building exterior wall is a special technology to ensure that the construction structure is not corroded, and it is indispensable.

As an important part of the waterproofing of prefabricated buildings, exterior wall waterproofing technology is an important means to ensure the performance of the building throughout its life cycle. Among them, there are physical shielding waterproofing technologies such as waterproofing membranes, chemical reaction waterproofing such as waterproof coatings, and composite waterproofing such as thermal insulation and drainage integrated systems [1]. Since prefabricated buildings often have joint leaks and hidden dangers, effective exterior wall waterproofing can prevent a series of problems caused by moisture penetrating into the interior of the building, thus significantly extend the life of buildings [2]. Effectively improve economic, social, environmental protection, safety and other benefits [3].

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\* Corresponding author: 85849@student.pb.edu.pl

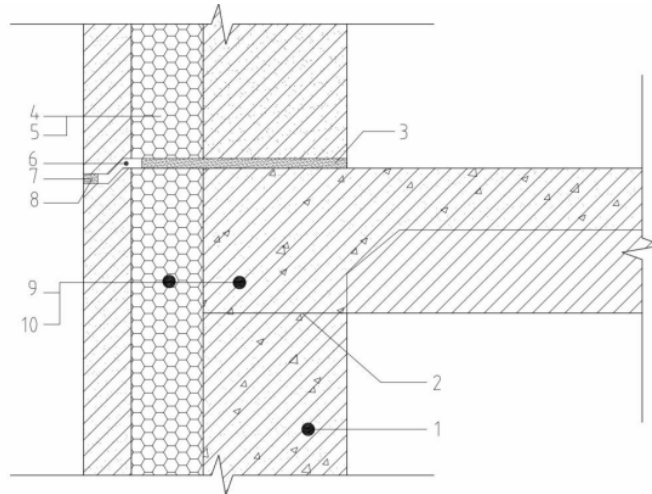
Since the development in the middle of the last century, the prefabricated building waterproofing technology has experienced a transformation from manual to modern assembly, and has gradually developed into waterproofing membrane technology, joint waterproofing technology, etc. In recent years, with the development of science and technology, new building waterproofing materials and supporting construction methods have shown a blowout, which has promoted the development of building waterproofing.

This paper analyzes the current research status of prefabricated building exterior wall waterproofing technology, focusing on the laying of waterproof membranes, sealant waterproofing, grouting, exterior wall waterproofing coatings, exterior wall waterproofing concrete, and integrated insulation and drainage technologies, and explores future research directions to provide ideas for the future development of prefabricated building exterior wall waterproofing technology.

## 2 Overview of prefabricated building facades

### 2.1 Prefabricated building craft

The wallboard edge at the horizontal joint of the upper and lower edges of the component is designed as the shape of outer low and inner high. In the joint, the outdoor side of the lower end of the weather-resistant sealant for sealing, indoor side of the higher end of the waterproof adhesive for sealing. Thus, a cavity is formed in the middle and a gradient for water conduction is arranged in the length direction as shown in Figure 1.



**Fig. 1** Composition of waterproof concrete (Picture credit : Original)

(1- Inner panel wallboard 2- Rough surface 3- Fine aggregate concrete 4- Waterproof tape 5- Foam insulation strip or polyethylene insulation strip of the same material 6- Horizontal cavity 7- Sealant 8- Backing material 9- Cast-in-place concrete 10- Sandwich insulation layer)

### 2.2 Outline of waterproofing technology for external walls,

For waterproofing roll laying technology, the base is treated first, then the waterproofing roll

is laid. Next, the joints are sealed with bitumen paste, followed by being fixed with galvanized sheet metal and steel nails. In this way, the sealing work of the waterproof layer on the facade is completed. Finally, the steel wire mesh is hung, and the mortar is put on as the transitional zone. When laying waterproofing membrane, it should pay attention to the standard operation, including fixing and sealing, to avoid operating in an inappropriate situation.

For sealant waterproof technology, it needs to combine the building characteristics of flexible choice. Due to the performance of hot expansion and cold shrinkage, it needs to match with concrete materials in the right environment together. In the choice of sealant material should be considered when the fit with concrete.

As for the grouting method, it needs to check whether the members are clean, and then in accordance with the proportion of the deployment of slurry to ensure that the fluidity and uniformity. Next, when using professional grouting equipment, it is necessary to ensure that there is no blockage occurring in the grouting pipes. Care should be taken to ensure that the strength of the slurry is sufficient after the completion of irrigation.

### **3 Significance of prefabricated building exterior wall waterproofing technology application**

From the aspect of material selection, new waterproofing materials are based on nanotechnology, which can improve the waterproof performance and durability of the material. Furthermore, the biological waterproof material based on renewable resources can reduce the environmental pollution and the impact on human health [4].

For safety, due to the characteristics of the prefabricated building assembly, there will be some inevitable gaps between the various building parts during the assembly process. Therefore, there are certain defects in waterproof [5]. The outer wall is the first barrier to prevent water from infiltrating into the building, and the service life of the building will be greatly shortened under the condition of poor waterproof performance of the outer wall [6]. Consequently, the waterproof consideration of exterior wall is particularly important.

### **4 Exterior wall waterproofing technology of prefabricated building**

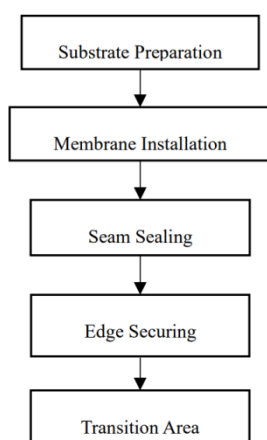
Prefabricated exterior wall waterproofing is an important part of prefabricated building waterproofing system. According to different waterproof requirements and exterior wall design, different waterproof technical measures are adopted.

#### **4.1 Waterproofing membrane laying technology**

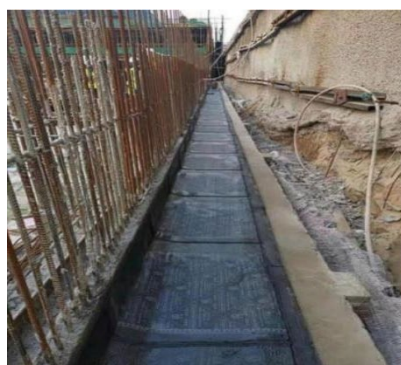
Waterproofing membrane laying is a physical waterproofing technology in building construction, which can use its physical properties to prevent water penetration building. It is mainly used for exterior walls, roofs and basements and other parts of the building. Correct waterproofing membrane laying technology for building waterproofing is essential to reduce the damage caused by moisture infiltration on the building. The construction sequence is shown in Figure 2. First, the base layer is treated, and then the waterproof coil is laid. The laying effect is shown in Figure 3. Next, the galvanized iron strip and steel nail are used to fix it. Finally, the waterproof layer of the facade is sealed with asphalt paste.

When choosing the joining technology for waterproofing membranes, adhesive fixing technology is more reliable in the repair of APP-modified membranes than thermally welded joints, due to its higher deformation capacity and superior peeling force. Besides, the

adhesive joints can be separated by sliding in shear, which enables them to cope with thermal ageing more flexibly. Although heat welded joints are strong, aging may lead to increased brittleness of the membrane and affect its overall performance. Therefore, for APP membranes, the adhesive fixation technique is a more appropriate choice [7]. When sealing the joints, asphalt putty is utilized to fill the joints, effectively preventing moisture penetration from damaging the building. The termination of the waterproofing roll-roofing closure using galvanized iron skin closure compression strip, and in the transition surface hanging steel wire mesh wiping mortar to enhance the overall effect [8]. At present, many buildings have made use of waterproofing membrane laying technology to improve the waterproof performance of the building, such as Huawei Tianjin regional headquarters in the construction of the exterior wall with a hot joint welded head of waterproofing membrane, and waterproofing coatings to strengthen its waterproofing [9].



**Fig. 2** Sequence of technical processes for laying waterproofing membranes (Picture credit : Original)

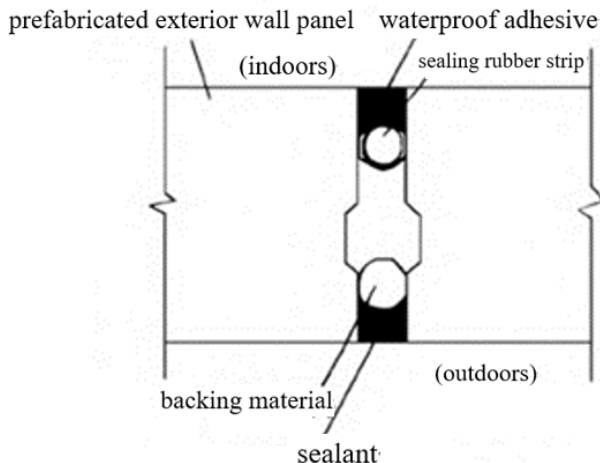


**Fig. 3** Installation of waterproof materials [10]

## 4.2 Sealant waterproofing technology

The sealant waterproofing technology uses sealant to fill the gaps between the joints of prefabricated exterior wall panels, forming an uninterrupted sealing layer to isolate moisture and achieve waterproofing [4]. The construction principle of sealant is shown in Figure 4.

Firstly, on the basis of cleaning the gaps between the prefabricated exterior wall panels, add the backing material and paste the decorative paper onto the outside of the wall, preventing the avoidable pollution during construction. Then sealant is added and smoothed on the outside of the wall. Finally, remove the decorative paper and cure the sealant to achieve the predetermined waterproof effect [11].



**Fig. 4** Principle of sealant construction technology [11].

At present, Silane Modified Polyethylene Adhesive (MS sealant) is widely used in industry, which has reliable adhesion and anti-aging properties. When Branched Polyethylene Epoxy Resin (FBEPO) and Aminosilane Coupling Agent are added into the MS sealant at the same time, the mechanical properties are optimized [12]. In 1980s, Hilton hotel in Japan had already used MS sealant during construction. After 30 years of use, it still exhibits good durability and stability, without any quality problems such as water leakage.

### 4.3 Grouting method

For grouting method, it fills the gaps between the prefabricated exterior wall panels with grouting materials including cement mortar through grouting holes set in the walls, thereby improving the waterproof performance and impermeability of the exterior wall joints [4]. In engineering, grouting methods are often used at the horizontal gap between the prefabricated exterior wall and the floor slab, which is shown in Figure 5.

During construction, it should first determine the designated location, hoist the wall panel to the location and fix it with slant support. Then use the grouting hole for grouting after the preparation is completed until the grout outlet starts to discharge grout. Finally, when inspecting the waterproof quality of the exterior wall, it is necessary to conduct a water pouring or storage test to ensure that no leakage occurs [13].



**Fig. 5** Grouting method construction [13].

When using grouting methods for construction, the following two points should be given special consideration. Firstly, the quality of grouting and compatibility of grouting materials should be ensured. Unqualified grouting quality and unsuitable grouting materials can cause cracks in the gaps of the exterior wall, thereby reducing the waterproof effect. Secondly, the cost of using grouting method to improve the waterproof performance of prefabricated exterior walls in practical engineering is relatively high, as it requires specific waterproof materials to prepare grouting aggregates and special tools and equipment for grouting operations [4].

#### **4.4 Waterproof coatings for external walls**

Exterior waterproof coating is a composite waterproofing technology for building exterior walls. It uses different physical material properties and chemical mechanisms to effectively prevent moisture penetration, not only to enhance its adhesion and durability, but also to extend the service life of the building.

In the construction, the first grass-roots level treatment, to ensure that the wall is clean and flat and free of debris. Then apply waterproof coating evenly.

Wang Guojian through the preparation and performance testing of silicone modified elastic emulsion exterior waterproof coating and obtained that this coating has good waterproof performance, stain resistance and aging resistance, suitable for exterior wall decoration and waterproofing applications [14]. Wu Runding et al. further illustrated through the preparation and performance study of fly ash inorganic exterior waterproof coating that the inorganic coatings using fly ash as filler can reduce the pollution of fly ash to the environment, and also meet the requirements of people for coatings and the environment, and at the same time greatly reduce the cost of coatings [15]. In addition, the use of hydrophobic protective materials can significantly improve the waterproofing performance of external wall materials, especially in the application of stone and rendering mortar, which can effectively improve the moisture resistance and contact angle, and play a role in enhancing the waterproofing effect [16].

#### **4.5 External wall waterproof concrete**

Fabricated concrete structural components waterproof including structure self-waterproofing and additional waterproofing layer waterproof. The structural self-waterproofing material is mainly waterproof concrete, but the concrete is a porous medium. Besides, the water will

gradually penetrate through the micro-pores to cause a series of physical and chemical reactions in the concrete, especially in the presence of corrosive ions, it will seriously affect the durability of concrete. Therefore, waterproof concrete must meet certain impervious grade requirements [17]. In the concrete application process, the precast concrete component shows the characteristics of good production quality and high stability. Compared with the traditional cast-in-place concrete form, the precast concrete component waterproof and stability is better.

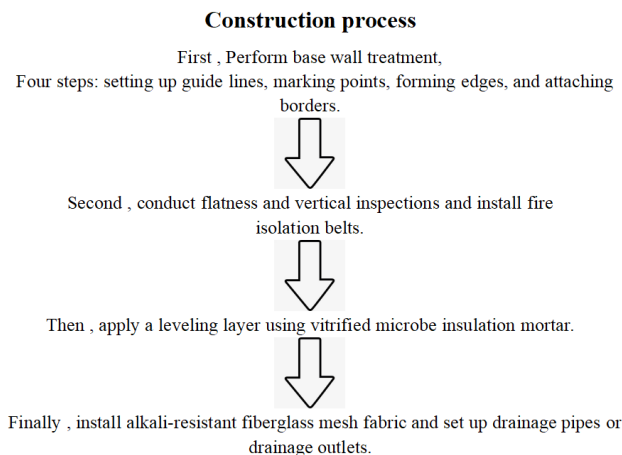
The technology of structure self-waterproofing, that is, using the impermeability of reinforced concrete to achieve the goal of waterproofing. Through controlling the concrete proportion and construction quality, the building can achieve the waterproofing effect. The self-waterproofing of the structure needs three necessary conditions, which are a complete closed structure at least, flexible sealing waterproofing at the position of displacement deformation, non-leakage of structural concrete.

The advantages of structural self-waterproofing are as follows. Firstly, the working life of structural self-waterproofing is longer. Secondly, the construction time of external waterproofing is greatly shortened. Thirdly, the maintenance after structural leakage is more convenient. Fourthly, the cost of structure self-waterproofing is lower in later maintenance [18].

To make concrete to achieve self-waterproof effect, usually need to do the following. First, it needs to strengthen the heat preservation and moisture conservation. Next, the structure design of post-cast concrete strip should be improved. Then the quality of coarse aggregate and cement is controlled. Besides, the thickness of cement should be controlled to prevent the cracking caused by hydration heat [19][ 20].

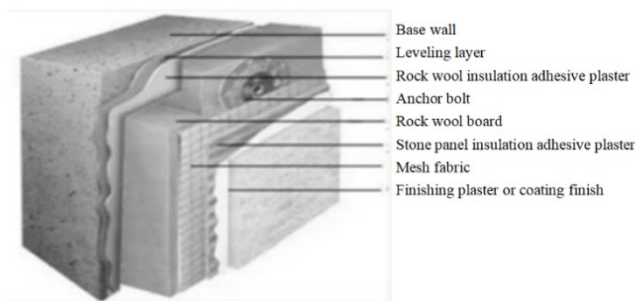
#### **4.6 External wall insulation and waterproofing integrated system`**

The integrated exterior wall insulation and waterproofing system is composed of waterproof mortar and thermal insulation materials. The system can achieve the functions of waterproofing and thermal insulation at the same time. It is usually composed of a multi-layer structure including an external insulation board, anti-cracking mortar, and waterproof coating, through which the waterproofing function is achieved. It also has the advantages of saving energy, improving the durability of the external wall, and being environmentally friendly [21]. By optimizing prefabricated parts, setting waterproof measures for cast-in-place concrete, sealing gaps, and setting diversion pipes at the joints to achieve water discharge in the exterior wall. These measures are combined to achieve the purpose of waterproofing [20]. The construction technical steps of the extruded board exterior wall insulation layer are shown in the Figure 6. The above construction steps should be avoided in rainy weather [22].



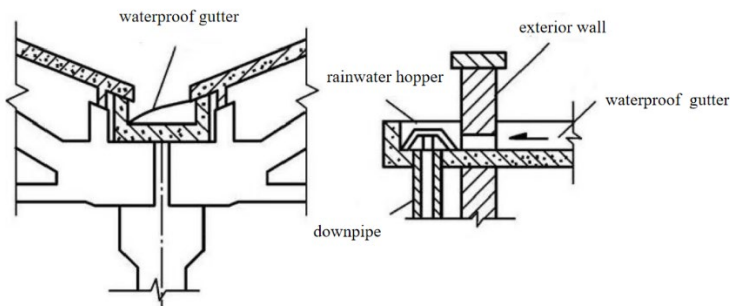
**Fig. 6** Construction technical steps of extruded board exterior wall insulation layer (Picture credit : Original)

In order to make full use of exterior wall insulation materials, expand exterior wall functions and meet demand, it is necessary to adjust the materials according to the differences in their functions. Figure 7 is a schematic diagram of the commonly used rock wool exterior insulation system.



**Fig. 7** Commonly used rock wool external insulation system components [22]

It is worth noting that the essence of the integrated external wall insulation and waterproofing system in terms of waterproofing is a combination of blocking and drainage, which is a combination of structural self-waterproofing technology and drainage technology. Drainage technology is the key to the exterior wall waterproofing system of prefabricated buildings and it can enhance the waterproofing ability of buildings. As shown in Figure 8, the gutter external wall drainage system effectively channels rainwater and prevents water accumulation at the facade. Furthermore, Figure 9 illustrates the external wall diversion pipe drainage system, which ensures that any water infiltrating the waterproof layer is promptly discharged through an integrated structure [20]. In prefabricated buildings, the application of waterproof materials and reasonable drainage design complement each other. The key lies in layered waterproofing and drainage design, water-conducting structure, and integrated drainage system. These play a role in each link of waterproofing, ensuring that even if water penetrates into the waterproof layer, it can be quickly discharged through the drainage system to avoid erosion [23].



**Fig. 8** Schematic diagram of gutter external wall drainage system (Picture credit : Original)



**Fig. 9** Schematic diagram of drainage of external wall diversion pipe [20]

## 5 Conclusion

Prefabricated building exterior wall waterproofing technology is an important part of building performance, directly affecting the durability and service life of the building. Using waterproofing membrane laying, sealant technology and grouting methods, as well as developments in construction technology and material selection, the current prefabricated building exterior wall waterproofing technology has become mature, effectively solving the pain points of prefabricated buildings and improving the overall quality and waterproofing capabilities of prefabricated buildings.

The various waterproofing technologies introduced in this article have their own characteristics. Waterproofing roll laying is suitable for large-scale waterproofing, but it has the disadvantage of complex construction. Sealant waterproofing and grouting methods are suitable for small-scale repairs. Among them, the grouting method has good effects but complex construction, and sealant waterproofing is prone to aging. Exterior wall waterproofing paint is easy to construct but has the problem of easy damage. Exterior wall waterproof concrete has a long-lasting waterproofing effect, but the subsequent maintenance is complicated. The integrated insulation and drainage system has a good comprehensive effect, but the cost is high. In general, the above technologies are suitable for different environments and conditions.

Although this paper has systematically analyzed the above waterproof technologies, there are still some shortcomings. Most of the waterproof technologies analyzed in this paper are based on physical shielding and lack chemical material related technologies. In addition, the impact of different technologies on waterproof results is often qualitative analysis and lacks experimental quantitative analysis. In future research, we should focus on breakthroughs in waterproof technology in chemical materials and achieve quantitative comparisons between different waterproof technologies through experiments.

## Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

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