Analysis of Water-Proof Properties of Building Waterproof Materials and Concrete Components

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Abstract: Building waterproof materials are a very important part of construction projects. They can effectively prevent water penetration and protect the structure and internal facilities of buildings from water damage. Choosing suitable waterproof materials is the key to ensuring the waterproof performance of buildings. Based on the analysis of the water-proof properties of building waterproof materials and concrete components, this paper conducts experimental analysis on factors such as the selection of waterproof materials, the construction quality of waterproof layers, the compactness of concrete, and the maintenance and repair of waterproof materials. The experimental results show that the anti-seepage pressure of cement-based waterproof coatings gradually increases, but the compressive strength effect is not obvious, while polyurethane waterproof coatings have higher sealing properties. This sealing layer can form a physical isolation layer to prevent moisture from entering the building from the outside, and can effectively seal the micropores and cracks on the surface of building components to prevent moisture penetration. SBS copolymer is the main component. The coil is firmly bonded to the surface of building components through hot melt bonding technology to form a dense waterproof layer, which can effectively seal micropores and cracks and prevent moisture penetration. Therefore, whether it is cement-based waterproof coatings, polyurethane waterproof coatings, or SBS copolymers, they all have good water-proof properties, can effectively prevent moisture penetration, protect building structures, and improve the service life and living quality of buildings. However, their usage sites and functions are different, and reasonable selection and construction are needed to improve the waterproof performance of the building and ensure the safety and durability of the building structure.

Keywords: Building Waterproofing; Concrete Components; Waterproofing Analysis; Waterproof Performance

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1 Introduction

The development of building waterproofing materials has made significant progress and innovation in the past few decades. As people's awareness of environmental protection increases, the environmental protection performance of building waterproofing materials has also been valued. New waterproof materials are constantly emerging. For example, polymer modified cement waterproof coating, polymer waterproof membrane, rubber waterproof coating, etc. These materials have better waterproof performance, durability and construction performance. Many new waterproof materials are made of environmentally friendly materials, which reduce environ-

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mental pollution and meet the requirements of sustainable development. In the process, waterproof technology is also constantly innovating and improving. For example, the construction methods and technologies of waterproof coatings have been improved, improving construction efficiency and quality. At the same time, the design and construction of waterproof systems also pay more attention to integrity and reliability. With the development of digital technology, the production and construction of building waterproofing materials have also been improved in intelligence and automation. For example, by using sensors and monitoring systems, the performance and construction quality of waterproof materials can be monitored in real time, improving construction efficiency and quality control. However, how to find a long-lasting waterproof coating is also a problem at today's construction sites, so this article selected three A comparative study was conducted on various building waterproofing materials, hoping to give some feasible suggestions to the construction site.

Because waterproof materials are crucial to the safety and longevity of buildings. Currently, there are many types of waterproof materials commonly used on construction sites (including waterproof membranes, waterproof coatings, metal waterproof materials and asphalt tiles). Among them, SBS modified bitumen waterproofing membrane (SMBM) is the most widely used and occupies most of the waterproofing market [14, 15]. Then there are cement-based materials, which are one of the most commonly used materials in construction projects, and their mechanical properties and durability are directly related to the safety and reliability of the structure [13]. However, traditional cement-based materials, as a multi-phase porous material, can meet the waterproof requirements of concrete structures in terms of overall performance, but their microstructure and functions cannot meet the stringent requirements of durability. Therefore, water-based polyurethane (WPU) is gradually replacing solvent-based polyurethane and receiving more attention in the coating field. Compared with solvent-dispersed PU, WPU with water as the dispersion medium is not only green and non-toxic, but also has similar properties to traditional PU. It is considered one of the ideal "green chemical" coatings and can effectively maintain the durability of cement-based materials. properties and reliability of concrete structures [11, 12].

2 Classification of Building Waterproof Materials and Concrete Components

2.1 Classification of Building Waterproof Materials

Common building waterproofing materials include cement-based sub-contact waterproofing materials, polyurethane waterproof coatings, SBS copolymer waterproof membranes, etc. Different waterproofing materials have different application areas and locations. For example, waterproof coatings are more suitable for small-area waterproofing, while synthetic materials are more suitable for large-area waterproofing.

2.1.1 Cement -based Waterproof Material

Cement-based waterproof material is a commonly used building waterproof material, mainly used in basements, pools, water towers, tunnels and other places that require high strength and durability. Cement-based waterproof material is composed of cement, quartz sand, polymer modified materials, etc. Among them, polymer modified materials can improve the flexibility, bonding strength and durability of the material. This is also an important reason why cement-based waterproof materials have high strength, durability, good bonding and construction properties. Its construction mainly includes the following steps: Base treatment: remove debris, oil stains, etc. on the surface of the base to ensure that the base is dry and flat; Primer treatment: apply primer material to enhance the bonding force between the base and the waterproof layer; Mesh cloth laying: lay reinforced mesh cloth to increase the tensile strength and durability of the waterproof layer; Waterproof layer construction: brush or apply cement-based waterproof material evenly on the base according to the specified thickness to ensure the continuity and uniformity of the waterproof layer; Waterproof layer surface treatment: maintain and surface treat the completed waterproof layer to improve the durability and aesthetics of the waterproof layer.

Figure 1 Common cement-based waterproof coatings

Figure 2 Waterborne polyurethane waterproof coating

2.1.2 Polyurethane Waterproof Coating

Polyurethane is abbreviated as polyurethane. It is synthesized by the step-wise polymerization reaction of isocyanate with hydroxyl compounds such as polyether or polyester polyol [1]. Its molecular structure consists of a soft segment (fatty chain segment in polyether or polyester polyol) and a hard segment (polar group and rigid structure in isocyanate). The polar groups include carbamate group (-NCO), ether bond (-O-), ester group (-COO-), urea group (-NHCONH-), etc., which results in strong interaction between polyurethane molecules and high cohesive energy.

Table 1 Polyurethane waterproof coating parameter indicators

project	**index**
Tensile strength/MPa ≥	1.9
Elongation at break/% ≥	450
Tear strength/(N/mm) ≥	12
Low temperature flexure/°C≤	-35
Waterproofness: 0.3MPa 30min	impermeable
Solid content/% ≥	92
Surface drying time/ min ≤	12
Drying time/ min ≤	twenty-four

2.1.3 SBS Copolymer Waterproof Membrane

The main components of SBS copolymer waterproofing membrane include polystyrene, styrene-butadiene rubber and polyester fiber modifier. Among them, polystyrene is a thermoplastic resin with excellent dielectric properties, chemical corrosion resistance, easy processing and other characteristics, and is one of the main base materials of the membrane. Styrene-butadiene rubber is a synthetic rubber with excellent wear resistance, impact resistance, tear resistance and other characteristics, which can improve the puncture resistance and tear resistance of the membrane. Polyester fiber modifier is an additive used to enhance the tensile strength of the membrane, which can improve the toughness, impact resistance, chemical corrosion resistance and other properties of the membrane. In addition, the membrane may also contain auxiliary ingredients such as plasticizers, fillers, stabilizers, etc. to improve the processing performance and use performance of the membrane.

The production process of SBS copolymer waterproofing membrane mainly includes melt esterification cross-linking and extrusion, calendaring, compounding and other processes. In the melt esterification cross-linking process, polystyrene, styrene-butadiene rubber and polyester fiber modifier undergo melt mixing, esterification reaction and cross-linking reaction to form a polymer membrane. In the extrusion, calendaring, compounding and other processes, the membrane is processed into the required shape and size, and surface treatment and coating are performed to improve its waterproof performance and performance.

2.2 Classification of Concrete Components

Concrete is made of cement, sand, stone, water and admixtures in a certain proportion. Its compressive strength is about 6~7 MPa, with strong impermeability and good durability. However, concrete has a certain shrinkage and cracks are easy to appear on its surface.

In construction projects, concrete structures generally include reinforced concrete components; prestressed concrete components and cast-in-place reinforced concrete components. Reinforced concrete floor slabs: The slab thickness is generally 400 mm, and the horizontal support spacing of the slab is generally 100-200 mm. Prestressed reinforced concrete beams: The beam width is generally

700-1000 mm. When the span is greater than 4m, the reinforcement can be increased by enlarging the cross section as needed, and the reinforcement ratio is generally 0.5%-1.0%. Prestressed reinforced concrete columns: The column height is generally 200-500 mm, and the column cross-section is rectangular, I-shaped and square, with a parapet on the top of the column. The column cross-section size is greatly affected by the seismic fortification intensity and construction quality.

3 Analysis of Factors Affecting the Water-Proof Properties of Building Waterproof Materials and Concrete Components

The water-proofing properties of building waterproof materials and concrete components are affected by many factors. In addition to the performance of the materials themselves, some human factors and external environmental factors during construction can also affect the water-proofing properties of building waterproof materials and concrete components.

Material selection: The type and performance of waterproof materials play a key role in water-blocking performance. Different types of waterproof materials have different properties, such as polymer coatings, cement-based waterproof materials, polymer-modified cement, etc. Selecting suitable waterproof materials can improve the water-blocking performance of concrete components.

Construction technology: Construction technology has an important impact on the waterproof effect. For example, the coating thickness, number of construction layers, and the rigor of the construction technology will affect the quality and waterproof performance of the waterproof layer. The correct construction technology can ensure the firm bonding of the waterproof material and the concrete surface and improve the waterproof performance.

Concrete quality: The density and impermeability of concrete will also affect the waterproof effect. The quality and proportion of concrete, operation control during pouring and curing, moisture content and other factors will affect the impermeability of concrete. High-quality concrete can provide better water-proof performance.

Structural design: The design of the building structure will also affect the water-proof performance of concrete components. For example, the reasonable setting of construction gaps, the location and layout of the waterproof layer, etc. will affect the waterproof effect. Structural design should take into account the waterproof requirements, reasonably set the waterproof layer, and reduce the possibility of water penetration [2].

Environmental factors: Environmental factors such as climate and groundwater level can also affect the water-proof performance of concrete components. For example, dry or rainy climates, high or low groundwater levels, etc. may increase the risk of water seepage in concrete components. Environmental factors should be fully considered when considering waterproof materials and construction techniques.

4 Experimental Materials and Methods

4.1 Analysis of Water-Proof Properties of Cement-Based Waterproof Coatings

In order to analyze the water-proofing property of cement-based waterproof coating more intuitively and effectively, 500g of cement-based coating was selected for research and analysis. First, the basic proportion of 500g of cement-based waterproof coating was carried out. Since the different contents of different components have different effects on the water-proofing property of cement-based coating, the cement-based coating was simply proportioned with reference to relevant engineering documents and the research of relevant scholars to test its water-proofing property. Two time periods were set, namely 7d and 24d, to observe its relevant indicators. The proportion contents are shown in the following table [3].

Table 2 Cement-based basic mix ratio table (%)

Cement	Ground quartz sand	$Ca(OH)_2$	Sodium silicate	Aluminum Stearate	Retarder	Water reducing agent	Silica Fume
55	25	5	3	3	0.1	0.5	9

Table 3 Cement-based index experimental statistics

Element	Impermeability pressure/ MP a		strength / MPa		Waterproof/d	
Cement-based	7d	24d	7d	24d	7d	24d
	0.7	1.3	16.89	24.25	Dry	There is water seepage

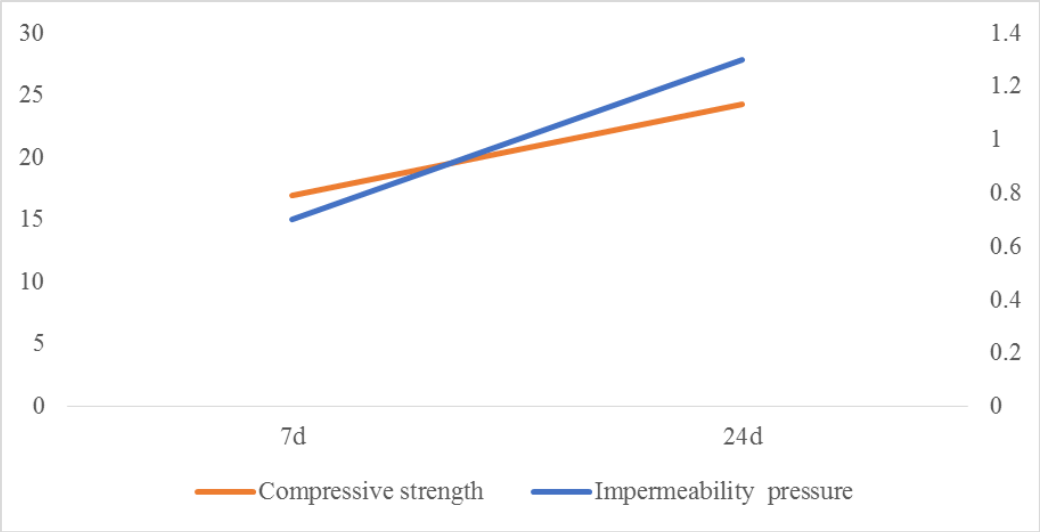

Figure 3 Cement-based index experimental data

From the figure, we can see that as time goes by, the anti-seepage pressure of the cement-based waterproof coating gradually increases. Although the compressive strength increases slowly, it is still on an upward trend. In general, cement-based waterproof coating has good water-proof performance, which can effectively prevent water penetration, protect the building structure, and improve the service life and living quality of the building. In practical applications, it is necessary to select appropriate cement-based waterproof coatings according to specific construction requirements and environmental conditions, and strictly follow the construction specifications to ensure the effectiveness and durability of its water-proof performance.

4.2 Analysis of Water-Proof Properties of Polyurethane Waterproof Coatings

The polyurethane waterproof coating uses solvent-free one-component polyurethane (PU). The selected polyurethane waterproof coating samples are coated by the manufacturer into a coating film of 1.5±0.2mm, and the surface/actual drying time is tested. The specific test results are shown in the following table:

Table 2 Testing of related indicators of polyurethane waterproof coatings

Test items	reference indicator	actual data
Solid content	>98	98.7
Surface drying time/min	≤12	7.5
Drying time/min	≤24	18
Waterproof	impermeable	impermeable

Polyurethane waterproof coating has high sealing performance. After the coating is cured, a dense film coating is formed, which can effectively seal the micropores and cracks on the surface of building components and prevent moisture from penetrating. This sealing layer can form a physical isolation layer to prevent moisture from entering the building from the outside. And it can be concluded from the table that the selected polyurethane waterproof coatings can meet the national standards. The building polyurethane waterproof coating has good water-proof performance, can effectively prevent moisture penetration, protect the building structure, and improve the service life and living quality of the building.

4.3 Analysis of Water-Barrier Properties of SBS Copolymer Waterproof Membrane

First, the SBS copolymer waterproofing membrane

needs to be processed: Processing method [4]. Remove the outermost layer of the entire membrane, and cut the remaining sample according to the size of the specimen required for each test. When testing the seam peel strength, first use hot melt to overlap the large specimen cut on the overlapped edge, and then cut it into small specimens before testing. After a simple mixing of all the specimens used in each experiment, first conduct a preliminary property test on them, and then soak the remaining specimens in the prepared solution. After the age is 90, 180, and 270 minutes, remove the specimens and place them in a constant temperature and humidity incubator for 3 days of standard curing, and then conduct the experiment again.

Table 5 SBS copolymer waterproof membrane test results

Thing	**Soaking medium**	**Pilot projects**			
SBS copolymer waterproof membrane	Water	Waterproof		Impermeability pressure/ MP a	strength / MPa
		Before soaking	After soaking	0.5	20.12
		0.3 MPa, 120min, impermeable	0.3 MPa, 120min, impermeable		

SBS copolymer waterproofing membrane has high sealing performance. It uses special SBS copolymer as the main component, and the membrane is firmly bonded to the surface of the building components through hot melt bonding technology to form a dense waterproof layer, which can effectively close micropores and cracks and prevent water penetration. SBS copolymer waterproofing membrane has good anti-seepage performance. It can withstand water pressure under a certain pressure and prevent water penetration. When the building structure is subjected to external water pressure, the SBS copolymer waterproofing membrane can withstand a certain pressure without cracking or leaking, and maintain its water-proof performance. In general, the test shows that within the limited test time, the SBS copolymer membrane has good performance and good water-proof performance and durability.

5 Strategies to Improve the Water-Proof Properties of Building Waterproof Materials and Concrete Components

5.1 Choose the Right Waterproof Material

Select appropriate waterproof materials according to specific project requirements and environmental conditions. Different types of waterproof materials have different performance and application ranges, such as polymer coatings, cement-based waterproof materials, polymer-modified cement, etc. Select waterproof materials suitable for the project according to specific construction conditions and requirements [5]. For example, for places such as basements and swimming pools that need to resist groundwater penetration, waterproof materials with higher anti-seepage pressure can be selected. Waterproof materials are only part of the waterproof system, and other waterproof measures can also be combined to improve the waterproof effect. For example, waterproof membranes can be combined with waterproof coatings, or waterproofing agents can be added to concrete structures [6]. In short, no matter what waterproof material is selected, the construction must be carried out in strict accordance with relevant construction specifications and requirements. Ensure that the waterproof material is firmly bonded to the concrete components to prevent leakage and seepage.

5.2 Optimizing Concrete Mix

The compactness and impermeability of concrete can be improved through reasonable concrete mix design. The selection of appropriate water-cement ratio, admixtures and additives, as well as appropriate construction technology can reduce the pores and cracks inside the concrete and improve the water-proof performance of the concrete [7]. The water-cement ratio is the ratio of water to cement in the concrete mix. Controlling the water-cement ratio can control the fluidity and compactness of the concrete, thereby affecting the impermeability of the concrete. Generally speaking, a lower water-cement ratio can improve the compactness and impermeability of concrete.

5.3 Strengthen Construction Process Control

During the concrete pouring process, it is necessary to ensure that the pouring is uniform and continuous to avoid problems such as broken bars and leakage. At the same time, attention should be paid to controlling the fluidity of the concrete to avoid excessive vibration that will increase the voids in the concrete. Vibration is to remove bubbles and voids in the concrete. When vibrating appropriately, attention should be paid to the time, frequency and choice of vibrator to ensure that the concrete can be fully vibrated and compacted. Improve the compactness of the concrete.

During the construction process, the construction process must be strictly controlled to ensure that the waterproof material is firmly bonded to the concrete surface [14]. The coating thickness, number of construction layers, and strictness of the construction process will affect the quality and waterproof performance of the waterproof layer [8]. Correct construction technology can ensure that the waterproof material is firmly bonded to the concrete surface and improve the waterproof performance.

5.4 Strictly Control the Quality of Concrete

The compactness and impermeability of concrete will also affect the waterproofing effect. The quality and proportion of concrete, operation control during pouring and curing, moisture content and other factors will affect the impermeability of concrete. High-quality concrete can provide better water-proof performance. In addition, the selection of suitable admixtures (polyurethane) for concrete can also improve the quality of concrete. Admixtures such as slag powder and fly ash can improve the working performance and impermeability of concrete [9]. Reasonable use of admixtures can reduce the amount of cement in concrete and improve the compactness and impermeability of concrete.

6 Conclusion

(1) Cement-based waterproof coating: It has good water-proof performance and can effectively prevent water penetration. However, the construction process requirements are high and the uniformity and density of the coating need to be ensured.

(2) Polyurethane waterproof coating: It has good adhesion and flexibility, and can adapt to the deformation and expansion of buildings. It has good water-proof performance and can effectively prevent water penetration.

(3) SBS copolymer waterproof membrane: It has good aging resistance and permeability resistance, and can effectively prevent water penetration. The construction process is relatively simple and is suitable for large-area waterproof construction.

The water-blocking performance of building waterproof materials and concrete components is crucial to the protection of building structures and the improvement of living quality [10]. Good water-blocking performance can prevent water penetration, extend the service life of buildings, avoid water damage and increase maintenance costs. Therefore, during the design and construction process, multiple factors such as material selection, construction technology, concrete quality, structural design and environmental factors should be fully considered, and appropriate measures should be taken to improve the water-blocking performance of building waterproof materials and concrete components.

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