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Applications of Geomembrane in Masonry Structures

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ABSTRACT: Masonry structures such as dams, water ponds are very popular. For their waterproofing, the conventional method is to finish a thin layer of cement mortar or concrete on their upstream to use composite geomembrane instead, which assumes good imperviousness, and has good waterproofing function. The paper introduces the selection of geomembrane, adhesive agents, practical experiences drawn from more than 10 projects are accumulated, including a dam repaired with height up to 30m, through 3 years observation, proving its success.

1 INTRODUCTION

Masonry structures built of stones such as dams, water ponds are very economical, but they can not prevent seepage. Some of them are plastered with a layer of cement mortar or poured with a Layer of concrete upstream, yet the results are still often not ideal. This paper introduces another solution utilizing composite geomembrane on water front side of the dam for waterproof, which leads to a good effectiveness.

2 MECHANISM OF WATERPROOFING

Composite geomembrane is a kind of flexible material and being made of geomembrane and needle-punched non-woven geotextile by heat bonding. Geomembrane possessing a coefficient of permeability of 10^{-11}～10^{-14}m/s may be seen as an impervious material. Because of heat bonding, they are bonded firmly, their peel strength is rather high. The downy surface of the non-woven geotextile has good affinity for cement mortar. Tests show that if the surface of mortar on the masonry wall is coated with a layer of glue, then put on the geomombrane, the shear strength between them will be high as shown, in Tab.1.when the surface of the composite geomembrane is plastered with cement mortar as protective cover. the self weight of the mortar is only 1/140 of that of the shearing strength, So the composite geomembrane sticken the wall surface is reliable.

There are many kinds of composite geomembrane, but the lab tests point out that it is better to use the non-woven geotextile of 150～200g/㎡ to bond with geomembrane. The thicker ones are not adequate because of their compact surface.

3 CONSTRUCTION PROCEDURE

First smooth the surface of the masonry wall using cement mortar. When it is dry and gets some strength, apply a layer of special adhesive on its surface. Then quickly stick geomembrane on it and press the geomambrane to drive out the entrapped air hehind it. Next step is to spread the cement mortar on the outer surface of the composite geomembrane as a protective lager. The thickness of the mortar is 1.5 to 2.0cm. If the high pressure spreading method is used lager by lager. the result will be better. By such procedure an ideal system which prevents geomembrane from UV and also protects the composite material will be established. The system consists of the inner non-woven geotextile sticken to the wall, the middle geomembrane capable of interrupting seepage and the outer geatextile being able to safeguard the geomembrane, The system structure is shown in Fig.1

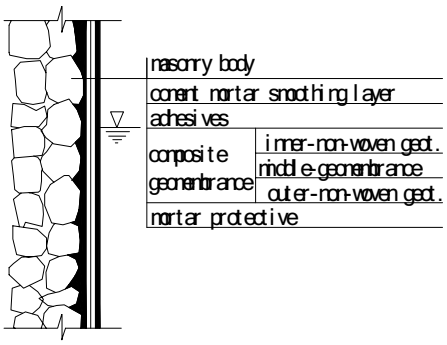

Figure 1. Waterproof structured masonry engineering

Geomembrane rolls or panels the wall surface must be joined together either by thermal fusion or adhesive method depending on the raw material and thickness of the geomembrane. The former method gives higher seam strength, the latter is more convenient in operation, but the adhesive used must be insoluble.

The thinner layer of cement mortar M10 on the wall surface if not adequately applied, is prone to cause cracking. For its prevention, it is necessary to add certain quantity of staple fibers into mortar. The fibers are helpful for lowering the deposition rate of sand and the raising of the extracted water, Thus decreasing the rate of water loss, preventing the formation of cracks owing to loss of water. The tensile strength of fibers may hinder the development of cracks and also increase the resistance to freezing and thawing damage of matter, If the plasticizer #107 is added into mortar, the consistency and toughness of mortar will be increased significantly.

For higher dams, it is advisable to install the aluminium strips(30mm wide,2-3mm thick)against the geomembrane on the wall and bolt them by nuts before the cement mortar is applied. The strips may be arranged on different elevations.

Tableau.1 The shearing strength between comment mortar and geomembrane

Type of glue	Shearing strength of inner surface	Remark
No.1	0.051Mpa	Geotextile broken, but geomembrane not broken
No.2	0.063Mpa	

Note: 1. The results are the average of six facts;
2. Specification of composite geomembrane:150g/0.3mm/150g.

4 CONNECTION OF VERTICAL WALL AND HORIZONTAL IMPERVIOUS LAYER

The waterproof of foundation of masonry structure is also very important. If the foundation is rigid(bedrock or stone work)the mortar may be directly applied on its surface, then the composite geomembrane is covered on it and pressed. When the mortar obtains a definite strength, 2～3cm thick protective mortar lager is applied. If the foundation is flexible (Sand and gravel, or soil), after the ground is cleared. The composite geomembrane may be directly put on if. Then upon geomembrane, a protective layer of fine sand and gravel with thickness not less than 30cm may be spread on. For borh cases above, vertical wall of structure and the horizontal imperious Lager must be joined up to stop water Leakage.

Upon filling, the imperious geomembrane on base of reservoir may be exerted by the water and gas pressure from underneath. Causing it to float upward even to be broken. For its prevention, it is necessary to take some preventive measures. The first method is to install irreversible valves on geomembrane at intervals. Then, when the pressure beneath is higher the valve will open and release the pressure, conversely, when the outer pressure is larger, the valve will be closed. The second is to cover sand and gravel on the geomembrane to balance the upward pressure which may be determined by hydraulic calculation.

5 THE PROBLEM RELATED TO WALL CRACK

The geomembrane has good behavior to conform with deformation. Tests show that its ultimate elongation may reach 74%. When the wall deforms due to some causes, the attached geomembrane can restrict it to certain degree. When the deformation exceeds the restrictive force, the wall begins to crack, but the geomembrane will only be strectched, becoming thinner, and not broken, the masonry dam can still resist water leakage, which is already well proven by many projects.

6 ANALYSIS OF LIFETIME

The durability of geomembrane means its ability to keep its original properties under various environmental conditions. It may be reflected by the time duration within which the mechanical properties of geomembrane degenerate to the values below specified ones, such that the geomembrane can no longer stop water, According to the accumulated experiences, it may be seen: (1) the polymer HDPE of crystal type is not easy to be , but the PVC of non-crystal type is easy to be; (2)the ageing rate is quicker, when the geomembrane is directly exposed to sunlight or natural atmosphere, but is slower when buried in soil or under water; (3) the thicker the geomembrane, the stronger its resistance to ageing, Artificial ageing tests show, the lifetime of HDPE buried in dam may reach 60～100 years. Similarly, geomembrane in masonry dam is protected by outer mortar layer and not exposed to UV radiation, its lifetime of course will be longer. It is believed that geomembrane may work normally at least 20 years. Provided the choice, design and construction of geomembrane are proper.

7 CASE RECORDS

Several projects were carried out since 1996.

1. Incubation pand on Biliuhe Reservoir, Liaoning. A gravitational masonry wall structure with diameter of 50m, height 7m. Originally lined with cement mortar, cracked not long after its being put into work due to unequal settlement. Many measures had been taken to repair. But all were in vain. until 1996 the composite geomembrane was adopted to reconstruct, the leakage disappeared immediately, Up to now, it has been working normally for five years.
2. Masonry Dam of Longtan Roservoir, Liaoning. The dam has a height of 12m and crest length of 80m, its upstream face was lined with cement mortar and completed in 1986. Since completion, it is fell to restore water, later, the lining mortar were thickened two times, but leakage still existed. In the spring of 1997 the dam surface was reconstructed using composite geomembrane, during following full filling in flood period, no leakage is occurred.
3. Masonry Dam of Diaoda Reservoir, Jilin. The Dam height is 33m and was completed in 1982. Its downstream face leaked very seriously. During high water level hundreds of water Leakage appeared even in the form of jet. In spring of 2000,the reservoir had been emptied and the upstream face was covered with composite geomembrane for repair. Then the leakage is stopped. In July 2001, the reservoir water reached the check-level, the dam still worked well.

8 CONCLUSION

Waterproofing technique using composite geomembrane for masonry structures is an effective measure, which has advantages of easy construction, cost saving, etc.

The technique may be extended to be used in the concrete hydraulic structures for repair or improvement. It is also may be applied the environmental engineering such as land fill, liquid waste disposal lagoon and building basement damp-proof course.