Cause Analysis and Structural Measures of Seepage in Basement——Take the Basement of Student Apartment in the East Campus of XXX College as an Example

Yan Zhang1,*, Kun Zhu1, Wenjia Zhang1 and Boshi Pang1
1Changchun Institute of Technology, Jilin Province Key Laboratory for Earthquake Resistance&Hazard Mitigation of Civil Engineering, Jilin Province Research Center of Construction Technology&Engineering For Housing in Cold Regions, Changchun 130012, Changchun, China

*Corresponding author e-mail: 284664729@qq.com

Abstract. According to the problem of basement seepage, the paper analyzes the reasons of seepage synthetically, selects suitable waterproof materials according to different positions, and puts forward corresponding prevention measures and specific construction methods.

Keywords: Basement, Seepage, Combination of Preventive Infiltration and Drainage Water

1. Brief Introduction to the Project
The third apartment is located in the East Campus of XXX College, which is a brick concrete structure dormitory building with four floors above the ground and one floor underground locally. Due to the early design time and long use time, the seepage phenomenon in the basement is becoming more and more serious. Due to the fact that the building is still in the designed durability period and the lack of accommodation space in the campus, the school decided to rebuilding and improving it without affecting the normal accommodation of students, so as to facilitate its continued use.

2. Cause Analysis
After two field investigations, the designer found the following problems:

The building is located in the southeast corner of the dormitory area, as shown in Figure 1. As the outdoor site and road have been maintained and paved for many times, those site elevation has been higher than the site elevation within 1 meter around the dormitory building, and the outdoor site slope towards the dormitory building, and there are building entrances and exits within the range of the low point of the site. The entrance and exit of the dormitory are close to the entrance and exit of the basement, both located under the staircase. The height difference between indoor and outdoor is small, and the height is about 2.2m through straight single stair to the basement. The internal space layout of the basement is the same as that of the first floor, with the middle corridor; independent rooms on sides, many inner partitions, and most of the functions are storage room and equipment room. Due to the influence of accumulated water all year round, the wall peeling off is serious, as shown in Figure 2.
The ground waterlogging is about 80mm. After one-time drainage, the leakage amount can still reach 50mm in 24h. The roof rainwater pipe falls directly on the surrounding area of the building, as shown in Figure 3.

According to the above situation, the possibility of water leakage in the upper space of the dormitory is basically ruled out, and the further analysis shows that the reasons for water accumulation in the basement of the dormitory are as follows:

The elevation of the outdoor site is higher than the elevation of the surrounding area of the dormitory, and the slope is made to the dormitory building, so that the area including the entrance and exit becomes the lowest point of the site, which causes the surface water of the outdoor site to collect around the dormitory; at the same time, the roof rainwater is discharged to the vicinity of the outer wall through the rainwater pipe, which increases the surrounding rainwater collection. Rainwater infiltrates from the plinth, accumulates in the soil around the basement wall, and infiltrates from the side wall of the basement and the basement floor to the interior; due to the small height difference between the interior and the exterior, when there is a large amount of rainwater, leads to a large amount of rainwater is poured back to the interior, and enters the basement along the straight single stair leading to the basement.

Based on the above analysis, the selection of waterproof structure form mainly considers the feasibility of existing building reconstruction. The external waterproof needs to be excavated for precipitation. For the existing buildings in use, it will inevitably affect the normal life of students. At the same time, considering the feasibility of winter construction in severe cold area, the internal waterproof structure form is finally adopted.

For the selection of waterproof materials, one is to integrate with the structural form of internal waterproof, and the other is to depend on the building function after transformation. As there is no ventilation and lighting facilities in the basement, the school decided to use the basement after waterproof treatment as ordinary class E storage space.

3. Material Selection
The interior waterproof construction is convenient, and it is more suitable for repair engineering or reconstruction engineering [1]. This project belongs to the reconstruction project. In view of the reasons such as not interrupting the use of students, the form of internal waterproof is adopted in the case of Limited large excavation, and the strengthening measures are taken in the construction method. In the selection of waterproof materials, not only the waterproof performance of different materials should be considered, but also the construction feature suitable for internal waterproof should be considered.

Cement mortar waterproofing is divided into multi-layer ordinary cement mortar waterproof layer and admixture cement mortar waterproof layer. It belongs to rigid waterproofing, which is suitable for projects with large rigidity of main structure, small deformation and small area of buildings, and not
for projects with corrosiveness and strong vibration [2]. It is suitable for internal waterproofing in general conditions.

Polymer cement waterproof mortar is a kind of mortar which uses polymer and cement as cementitious material to bond aggregate [3]. Compared with ordinary mortar, it has the advantages of good workability, overcoming delamination, segregation and bleeding, high strength, strong bond force, good ductility, good water tightness (impermeability) and great freeze-thaw resistance stability, corrosion resistance, impact resistance and wear resistance. Therefore, it can be used as ground material, paving material, waterproof material, bonding material, antirrosive lining material, surface covering material, etc. Polymer cement waterproof mortar has remarkable waterproof and impermeability effect, and is suitable for waterproof plastering in toilet room, roof, basement and other parts [4]. In this design, polymer cement mortar is used for the prime of the floor and wall, which can give full play to the impermeability of the material.

In the basement waterproof structure, the membrane waterproof is generally made of (such as SBS modified bitumen membrane, APP transformed asphalt rolling material) or synthetic polymer waterproof rolls and corresponding cementitious materials binding to form a waterproof layer [5]. There are many kinds and classification methods of high polymer waterproof sheet, including rubber-kind, resin-like and self-adhesive class. The rubber type polymer waterproof roll is represented by EPDM [6] rubber waterproofing sheet; the self-adhesive type polymer waterproof coiled materials includes: pre-applied waterproofing membrane, polymer waterproof roll with self-adhesive layer, etc.

Polyethylene polypropylene fiber [7] belongs to resin polymer waterproof roll material, which has the advantages of high tensile strength, good low temperature flexibility, high elongation, being able to adapt to the expansion and deformation of the building structure under different climatic conditions; corrosion resistance, anti-aging, long service life; cold construction; construction safety, environmental protection and pollution-free; single-layer use, simple construction and so on [8]. It can be used stably for a long time in the range of -40 ~ 60 °C ambient temperature, and can even be laid under the condition of water [9]. Widely used at this stage.

At the same time, attention should be paid to the construction points of polyethylene polypropylene fiber. In the process of pasting the vertical composite coiled material, it must be pasted longitudinally, aligned from top to bottom, vented and compacted from bottom to top. It is required that the base course and the coiled material should be pasted at the same time, with a thickness of about 1.0mm [10].

Since the building was built earlier, the exterior wall of the basement is a brick-concrete structure rather than self-waterproofing of reinforced concrete, which can't meet the requirements only by using rigid waterproof. Therefore, flexible waterproof is added to the upper part of the rigid waterproof layer, i.e. polyethylene polypropylene fiber composite waterproofing membrane, which strengthens the waterproof and anti-permeability effect.

4. Structural Measures
Based on the above analysis, according to the waterproof grade and the applicable scope of the basement, the waterproof grade of the basement is determined to be grade III. in the design, the method of combination of preventive infiltration and drainage water is used, and appropriate and feasible structural measures are taken for different parts:

Basement ground drainage treatment: select two points at the lowest part of the basement ground (two ends of the corridor can be selected) for deep excavation to form a sump. The ground of basement room is facing the corridor for slope making. One side of the corridor is provided with a shallow drainage ditch, as shown in Figure 4, which leads to the sump. The water in the pit is extracted by water pump and discharged to the outdoor effective drainage well;
1. Waterproof treatment of basement floor: after the original floor is cleaned, a layer of concrete cushion is laid as the base course. Cement mortar is laid on the base course to make slope to the sump. The thinnest part of the mortar layer shall not be less than 30mm thick, and the strength of the mortar base course shall not be less than 80% of the design strength. Meanwhile, it shall be flat, clean, moist and free of water accumulation; two layers of polymer cement waterproofing mortar waterproofing layer will be further divided into two layers, each thickness is 6mm, and the upper layer will be mud extracting and calendering. The appearance of polymer emulsion in polymer mortar should be uniform liquid, impurity, no precipitation and no stratification. A layer of polyethylene polypropylene fiber composite waterproofing membrane is pasted on the top of polymer mortar with professional adhesive, and then protected with fine aggregate concrete layer, as shown in Figure 5.

2. Three Waterproof treatment of basement wall: after the loose surface of the wall is removed, the cement waterproof mortar (waterproof agent is mixed in the cement mortar) is used for leveling, and polymer cement waterproof mortar waterproof layer is applied in two layers, each layer is 6mm, and the surface is calendering and surface rolling; the polymer cement waterproof mortar waterproof layer of the wall shall be extended at least 200mm along the horizontal direction of the ground at the intersection of the wall and the ground to make the longitudinal joint position on the ground, the joints of the upper and lower waterproof layers shall be staggered at least 200mm, as shown in Figure 5.

3. Strengthening treatment of local waterproof in basement: in case of founding concentrated leakage point, strengthen the treatment, such as increasing the number of waterproof layers, plugging the wall and ground in case of pipe penetration, and then applying the waterproof layer, as shown in Figure 6.
4. Waterproof and drainage treatment for outdoor surface water and entrance and exit: the retaining wall in front of the entrance and exit shall be repaired continuously without opening; 400x300 (width x depth) drainage ditch shall be set 1.5m away from the outer wall around the building, and the drainage pipe shall be set in the ditch to connect to the effective rainwater well for drainage; the rainwater within 1.5m away from the building shall be discharged by the original drainage facilities (the drainage grate is observed on site); 200x300 (width x height) fine aggregate concrete water retaining threshold is set on the indoor floor inside the entrance and exit tunnel, which is 150 mm deep under the ground and plastered with polymer cement waterproof mortar; brick steps are used at the entrance and exit and the original retaining wall where there is a height difference; roof rainwater pipe is directly led into the drainage ditch, and surface runoff is prohibited, as shown in figure 7.

5. Outdoor ground water lowering and drainage treatment: in order to prevent the underground water in the soil from converging into the building, the building is 1.5m away from the outer wall, and a blind ditch shall be added under the ground drainage ditch, the depth shall be lower than the basement ground, and the elevation of the water collecting pipe in the blind ditch shall be higher than the elevation of the surrounding effective drainage well. In this way, the first is to measure the actual elevation of surrounding rainwater wells, and the second is to detect the buried depth of the building foundation, so as to avoid affecting the building safety when excavating blind ditch, as shown in Figure 7.
To sum up, for the reconstruction project of the existing buildings, first of all, we should select the reconstruction mode suitable for the current situation, and repair or reconstruct on the premise of not affecting the work, study and life at this stage, so as to better reflect the advantages of the reconstruction compared with the new construction. Concrete analysis of the cause of the problem is the prerequisite for structural design. The construction method should give full play to the characteristics of the materials, starting from the principle, take structural measures step by step and level by level.

Reference
[1] You Hao. Professional and practical operation of construction documenter. China Building Materials Industry Press, 2015.01-53.
[2] Song Junwei. Zhang Pengfei. Housing Architecture. Wuhan University Press, 2015.01-114.
[3] Yang Bin. Dry mixed mortar and its test methods. China Building Materials Industry Press, 2013.01-311.
[4] Liu Xiangshun. National First Class Registered Architect Preparation Guide. Building Materials 2014. China Building Materials Industry Press, 2014.01-98.
[5] Han Xuan. Reading Construction Drawings of Construction Engineering with One Drawing and One Solution. Tianjin University Press, 2013.01-63.
[6] Wu Shimin. Editor in chief. Concise dictionary of fine chemical industry university. Liaoning science and Technology Press, 1999.06-125.
[7] Deng Fangyin. Manual of waterproof materials for construction engineering. 2nd Edition. China Construction Industry Press, 2001.06-204.
[8] Yang Yongqi. Building Waterproof Construction Technology. China Building Materials Industry Press, 2015.10-133.
[9] Shen Chunlin. Technical Manual of waterproof and plugging engineering. China Building Materials Industry Press, 2010.05-62.
[10] Editorial board of vocational skills. Teaching materials for vocational skills training of construction workers. Waterproof workers. China Building Materials Industry Press, 2016.09-104.