Geosynthetics, J. Kuwano & J. Koseki (eds)

Application of geosynthetic in rainwater storage works

Su, Q. & Zuo, Y.
Henan Water Conservancy Research Institute Zhengzhou, Henan, China 450003

Keywords: geosynthetic, rainwater storage, water storage tank, water cellar

ABSTRACT: Geosynthetic is a new kind of geotechnical material made of polymer, which can be used in engineering for the purpose of seepage prevention, filter, isolation, reinforcement, protection and dewatering. In the pilot project, such geosynthetic as compound geomembrane and geomembrane were used for waterproofing of water cellars and water storage tanks of rainwater harvest project, on the basis of which the design and construction experiences have been summarized. The said new materials and technologies have been widely used in western Henan, northern Henan and other areas, creating remarkable social, economic and ecological benefits.

1 THE COMMON RAINWATER STORAGE TECHNIQUE

Both rainwater harvest and water storage are the main technique for rainwater collection and utilization, by building water storage works including water cellar, water storage tank and pond to capture and store surface runoff for future use.

1.1 *Water cellar*

Water cellar is a kind of rainwater collection and storage works most common in use, with the advantages of lower cost, long life-time and easy operation. Water cellar according to the shape could be classified into categories of bottle type, tea cup type, cave type and ball-shape concrete shell water cellar, etc., and could also be classified into clay puddle water cellar, cement mortar water cellar and concrete water cellar according to the impervious material being used. At present, the widely used cement shell water cellar with the volume of 40~60 m^3, is firstly protected with puddle, then lined with 200# concrete of 10~15 cm in thickness, and finally floated with 1:2 cement mortar (mixed with certain amount of waterproofing powder).

1.2 *Water storage tank*

Water storage tanks are mostly built in low-lying land for runoff collection, where earth condition is poor and water consumption rate is lower. The water storage tanks were typically built with bricks or brick-concrete structure in square or round shape, mostly open, underground or semi-underground, with the depth of no more than 3 m and storage capacity of 20~300 m^3.

1.3 *Pond (pool)*

In the places where there is much inflow and concentrated population, low-lying land and gully for dam construction, ponds or dikes could be built for impounding flood water with higher sediment concentration of gully, slope and road surface. The open pond or pool is typically earthen structure and could contain water of about 500~2000 m^3 for livestock drinking and low-pressure pipe irrigation, and as the water source of water cellar.

2 APPLICATION OF GEOMEMBRANE WATERTIGHT TECHNIQUE IN WATER CELLAR CONSTRUCTION

Watertight treatment is critical to water cellar and the watertight effects will influence the quality, service life and benefits of a water cellar. The common watertight technique for water cellar involves clay puddle, cement mortar and concrete. The conventional impervious layer of clay puddle has the advantage of lower cost, however, it is apt to crack and fall, resulting in poorer watertight effect and short service life. The watertight effect of cement mortar and concrete is better and service life is longer, yet the cost is higher and easily damaged because of drying cracks.

It is a new try to apply geomembrane and compound geomembrane in watertight treatment of a water cellar, providing a new method for waterproofing of water storage facilities. This technique has been tested in "the state ecological environment construction project dry cellar demonstration area" of Lingbao City in western Henan. The experimental site is located in a typical loess hilly area, with the elevation of about 1000 m and rolling topography of deep gullies and steep slope. The local average annual precipitation is 620.84 mm, where rainwater storage works could be constructed to provide water for human and livestock drinking, crops and fruit trees irrigation and development of courtyard economy.

2.1 *Structural pattern of water cellar*

The experiment was carried out in the area where loess is the primary soil and the test result showed that the soil quality was weak collapsible loess. Under natural status, loess is hard with better upright property, quite suitable for building water cellar. The local people mostly lived in loess caves for generations and started building water cellar dozens of years ago, having rich experiences. The water storage structures built in collapsible loess area are likely to collapse or be damaged because of failure of impervious layer, thus the study on watertight measures is especially important for loess area.

The structural patterns of two kinds of water cellar commonly built by local farmers are shown in Figure 1. The shaft is 5~8 m high with the diameter of 80~100 cm and width of bed and height of water cellar is about 2.3 m. Such kind of water cellar composed of a shaft and a cave-shape cellar has the advantages of better stability and less land occupation, especially suitable for local loess stratum and is an innovation based on traditional water cellar structure.

In the experimental area, a number of water cellars were built in the past and the wall of water cellars were protected with clay and straw plaster of 3~5 cm thick for seepage prevention, however, it only worked for 3 years. The water cellar built in recent years were plastered with cement mortar for seepage control, showing a satisfactory result as a whole, occasionally part of the water cellar collapsed because of seepage as a result of mortar surface shrinkage crack.

2.2 *Construction method for impervious layer*

After water cellar is excavated to the design dimension, impervious layer should be constructed in sequence of cellar bed, side wall and arch crown. A layer of cement mortar of 5 cm thick is spread on the bed of the water cellar first and then compound geomembrane is placed. The crown of the cellar should be plastered with cement mortar and covered with compound geomembrane too. Finally, the compound geomembrane should be plastered with cement mortar of 1~2 cm thick again. Construction of the crown section is difficult.

The geomembrane is fixed on the circular arc section with nails, neither being fully stretched nor too many folds being left. The edges of compound geomembrane should be bound with special binding agent, and nonwoven fabric on both ends of the geomembrane should be properly bound with cement mortar.

The water cellar shown in Figure 1 (a) and (b) were constructed on May 18~20, 2001 and May 21~23, 2001 respectively. After completion of the water cellar construction the opening were closed and water was sprayed inside the cellar for curing. By July 15 when the water cellar was used for storing water for the first time, no shrinkage crack was found on the water cellar surface. A heavy rain occurred on July 28, 2001 in the pilot area, the water cellar was fully filled with water. By October 30, 2001, a number of observation had been made on the newly-built water cellars and no collapse or rapid declining of water level was found, indicating that the watertight effect of compound geomembrane is better. In 2001 precipitation was abundant in the area where the experiment was carried out and the 2 water cellars were filled with water for four times. The water cellar shown in figure 1 (b) was built on a higher position, therefore the farmers' apple trees and vegetables could be effectively irrigated through gravity irrigation.

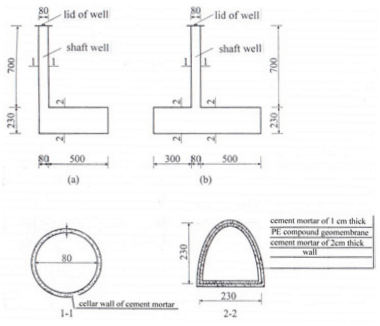

Figure 1. Structural drawing of water cellar (unit: cm).

2.3 *PE bag type water cellar*

The watertight effect and service life of joint use of compound geomembrane and cement mortar is superior to the local traditional clay and straw plaster or currently widely used cement mortar impervious layer. However, because of the higher cost, such technique is difficult to be popularized in economically underdeveloped rural area. In order to cut down the cost another kind of watertight technique that is cheaper and suitable is developed.

In the research, an impervious water bag was made with PE geomembrane of 0.3~0.5 mm thick, that was put in a bottle-type water cellar for watertight

purpose. The diameter and height of the PE bag is slightly greater and higher than that of the bottle-type water cellar. After the PE water bag was put into the water cellar, the bag was fixed onto the wall of the water cellar with ring loop of bamboo sheet, as shown in Figure 2.

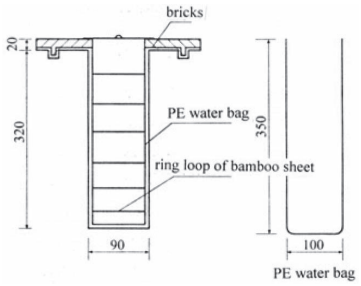

Figure 2. PE bag type water Cellar (unit: cm).

The external surface of PE water bag was not plastered with any material. When the water cellar is filled with water, the water pressure will directly act on the wall of water cellar instead of concentrating on the geomembrane because the diameter of the bag is greater than that of the water cellar, that is especially favorable for protection of geomembrane. If the diameter of the PE geomembrane bag is smaller than that of the water cellar, the bag will bear on the overall water pressure and the locally concentrated water pressure will cause spilt of geomembrane, then the impervious layer will not work. The water cellar is used for water storage all over the year, added by the lid of the cellar, therefore geomembrane inside the cellar is protected from irradiation of ultraviolet rays and ageing procession is slow.

At the experimental site, a water cellar same as that in Figure 2 was built in a farmer's courtyard on August 20, 2001. After being filled with water, no leakage or collapse was found. Such kind of water cellar has the advantages of simple structure, easily built and lower cost, only 60% of water cellar plastered with cement mortar, and are being widely used in Xinzheng and Xinmi counties.

3 APPLICATION OF GEOMEMBRANE WATERTIGHT TECHNIQUE TO RAINWATER STORAGE TANK

In the past years, kinds of water storage tanks were constructed in some areas. Because of the structural defects, watertight technical imperfection and ageing effect, leakage problem was quite serious, as a result those water storage tanks are out of use now. As a newly developed impervious material, geomembrane is widely used in geotechnical engineering construction.

3.1 *Trapezoidal water storage tank*

A trapezoidal water storage tank with the volume of about 15000 m^3 was built at Xiuwu County Baijiayan Scenic Spot for impouding the water of Mingyuequan water fall and flash flood. Being sited on a higher position before the mountain, the impounded water of the tank could be used for gravity irrigation of 33.33 ha farmland. The structure of the tank is shown in Figure 3.

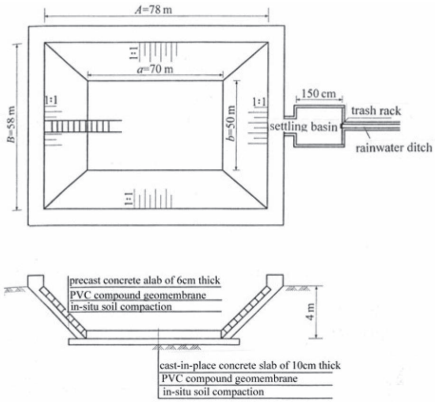

Figure 3. Trapezoidal water storage tank.

The structural stability of trapezoidal cross section is superior to round or vertical rectangular shape tank, however, the volume is less. In construction of the tank, PVC compound geomembrane was used as the impervious layer. When ground was excavated to the design level, the in-situ foundation soil was leveled and compacted first, PVC compound geomembrane was laid then and finally a layer of 150# concrete of 10 cm thick was cast over the geomembrane. The side slope was trimmed in accordance with the design and a layer of PVC compound geomembrane was placed. Precast concrete slabs of 100 cm × 50 cm × 6 cm were put on the PVC geomembrane.

In geomembrane seepage control technique construction, the underlayer and concrete cover should be constructed in accordance with construction procedure to ensure construction quality. Binding of geomembrane is of critical importance. The connection of geomembrane between the slope foot and side slope should be bound according to design strictly to guarantee the quality. Considering the deformation effect after the tank is filled with water, the geomembrane should not be pulled too tight.

3.2 *Round terrace shape water storage tank*

The water storage tank is built in Xiuwu County mountainous area for storage of rainwater and the structure of the tank is shown in Figure 4. The radius of top of the water storage tank is 45 m and the radius of the bed is 37 m. The inner side slope is 1:1

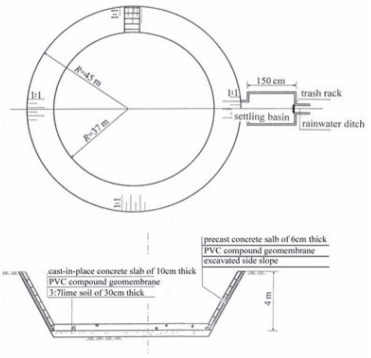

Figure 4. Round terrace shape water storage tank.

and depth of the tank is 4 m. After it was excavated to the design bed level, the in-situ soil was compacted and overlaid with PVC compound geomembrane and covered with cast-in-place concrete slab of 10 cm thick. The side slope of the tank was plastered with clay and straw of 10 cm thick, that was covered with PVC geomembrane.

This is a cheap and effective method and clay and straw could effectively ensure the binding of PVC compound geomembrane and side slope surface.

As a result of the demonstrative effect of the above-mentioned 2 water storage tanks, more than 10 large water storage tanks either in trapezoidal or round shape have been constructed by Xiuwu County WRB in Fangzhuang water saving irrigation area, allevating local drinking water shortage, supplying water for irrigation of crops and trees, creating remarkable social, economic and ecological benefits.

4 CONCLUSION

The quality of the compound geomembrane used as the impervious layer of water cellar or water storage tank should be strictly tested and connection of the geomembrane should be bound or welded. The under-layer and the protective layer of the geomembrane should be constructed in accordance with design and technical specification.

As a new geotechnical material, geosynthetic could be used in geotechnical engineering for waterproofing, filter, isolation, reinforcing, protection and dewatering, etc. Compound geomembrane could be used as impervious layer of water cellar and water storage tank and has the advantages of lower cost, easily construction and reliable impervious characteristics, therefore the geomembrane and geomembrane-based watertight technique should be popularized.

REFERENCE

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