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A durability study of the geotextile application in a water diversion project

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ABSTRACT: The geotextile applied in Luanhe-Tianjin Water Diversion Project is mainly for filtration and seeping treatment. After more than 10 years, there is difference in the mechanical index and seeping coefficient of the geotextile comparison, but it still can satisfy the requirement of the project with good efficiency of earth protection.

1 BRIEF INTRODUCTION ON LUANHE–TIANJIN WATER DIVERSION PROJECT

Luanhe-Tianjin water diversion project is one of the biggest water projects in China, which is 234 km long. The project includes water tunnel, Lihe river treatment, the strengthening of Yuqiao Dam, Zhouhe river treatment, specialized channel, Erwangzhuang reservoir, closed culvert, Xinkaihe water plant, communication and power supply.

The water starts from the hub gate of behind Daheiting reservoir, going through the water tunnel and into Yuqiao reservoir along with Lihe river, and then running along with Zhouhe river and Jiyunhe river into specialized water channel by Jiuwangzhuang water gate, after three times high-pumping, into Haihe river and flowing into the water plant through the closed culvert.

The specialized channel is 62.4km from Jiuwangzhaung water brake to Dazhangzhuang pump station, which is located at the plain. The height difference is from 3.0m to 1.0m with tender slope. The designed bottom slope degree is 1/20000.

The cutting stratum of the channel belongs to the fourth system alluvium, lake alluvium and sea alluvium. The ground layer from the depth of zero to 10m or 12m is duality structure. It is the yellow or filemot clay of land sediment at the upper part, and the grey or deep grey silt of lake and sea at the lower part, and it is the yellow clay under the silt.

The slope of the channel suffered a lot of collapse because of the factors that include the nature of clay, which is not endurable rushing, many years of weathering, big difference of water level, and the ice alongside of the bank and so on. The consistency of the building slope of the channel is damaged by the irrigation ditch, siphon, outside reservoir and fish-pool, which lead to the 2-6m or 10m difference of water level between inside channel and the outside channel. So the seepage of the channel happens at part of the channel.

2 THE GEOTEXTILE APPLICATION IN THE LUANHE-TIANJIN WATER DIVERSION PROJECT

Since 1980s, the geotextile has been applied for the slope protection of seepage and filtration at reservoir in Tianjin area. The geotextile was applied for the slope protection of rushing and filtration of Erwangzhuang specialized channel in Luanhe-Tianjin water diversion project. The building slope is built with stone and gravel and the geotextile is applied for the rushing and filtration instead of gravel, which reduces the cost and lasts the life of the project. Fig.1 shows the cross-section of the channel.

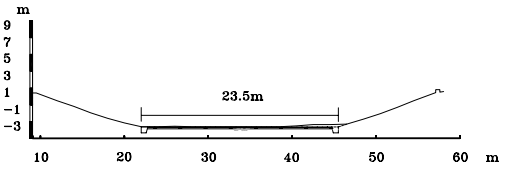

Figure1. The cross-section of the channel

3 SAMPLE TEST AND ANALYSIS

Studying the durability of geotextile by testing its mechanical index for the filtration. In order to finding out the performance of geotextile during the past more than 10 years, the geotextile samples, fetched at the slope of both banks near Erwangzhuang NO1 sluice Gate, were tested and analyzed in Oct., 1999, Nov., 2000, and Aug., 2004 respectively.

3.1 *The geotextile under the 400mm of building stone at the right bank slope near Erwangzhuang No 1 water gate.*

It is the 400mm of building stone protection slope at the right bank near Erwangzhuang No 1 water gate. The earth structure above the channel bed is consisted of two different earth layers. The upper part is yellow-grey clay and the lower part is light grey subclay, part of which is silt. The geotextile of 400g/m^2 is for the protection layer of filtration. The construction time is in 1986 and the performing time of the geotextile is 13 years.

The building stone protection slope is with concrete slurry fillings. Some of the concrete fillings have come off with dust, grass and bulrush in the stone slot. Some of the concrete fillings are glued with the geotextile.

Some part of the geotextile with mortar becomes stiffed while other part without mortar is still soft.

After years of the project, the bulrush recovered and penetrated the geotextile going through the stone slot.

Exposing 2 square meters of the slope, we found that the slope was perfect without rushing slot and the geotextile is closed with the earth.

Analysis：

(1)The geotextile sampling is under the 400mm of building stone protection and is in the water forever, the slope lining is made by mortared stone with the geotextile and slurry combined as an integration, the weight of wet geotextile is 13.8 times of the original and the weight of natural dried geotextile is 4.0 times of the original, which shows that the water absorptivity of the geotextile is 242.1%. .

(2) Because of the concrete, the thickness of wet geotextile is 1.57 times of the original and the natural dried geotextile is 1.43 times of the original.

(3)Mechanical index： the original humidity state is the correct state for performance. Because of the hardened, the mechanical index of the wet geotextile is 78.5% of the original and the mechanics of the natural dried geotextile is 59.3% of the original.

(4)The seepage coefficient of the tested geotextile is one degree lower little than the original. But it is still larger further than the seepage coefficient of the earth, which is 3.3×10^{-7}.

3.2 *The geotextile under the 100mm of building gravel at the left bank slope near Erwangzhuang No 1 water gate*

It is the 100mm of building gravel protection slope at the left bank near Erwangzhuang No 1 water gate. The geotextile of 400g/m^2 is for the protection layer of filtration, which is the same as on the right bank. The construction time is in 1987 and the performing time of the geotextile is 12 years.

The grass and bulrush are everywhere on the protection slope. There are insects in the grass just like cricket, centipede and so on. Getting rid of the grass and gravel, the geotextile appears which is new appearance. The earth under the geotextile is perfect as the original.

Vision check of the geotextile:

The positive face: sand granule, earth-yellow color, white color, rust color and insects on the surface.

Back: earth-brown color, fine root of the plants, soft

After years of the project, the bulrush recovered and penetrated through the geotextile going out of the 100mm gravel. Some of bulrush grew twisted and penetrated through the geotextile on the weak point.

Analysis：

(1) The geotextile sampling is under the 100mm of gravel protection and is in the water forever, the weight of wet geotextile is 9.39 times of the original and the weight of natural dried geotextile is 2.23 times of the original, which shows that the water absorptivity of geotextile is 320.6%. After many years, the geotextile has been integrated with gravel and clay.

(2) The thickness of the geotextile is not increased greatly for the clay granule and sand granule.

(3)Mechanical index: The original humidity state is the correct state for performance. The mechanical index of the wet geotextile is 61.0% of the original and the mechanical index of the natural dried geotextile is 59.3% of the original.

(4) The seepage coefficient of the tested geotextile is 51% of the original. But it is still larger further than the seepage coefficient of the earth, which is 3.3×10^{-7}.

The following table show the test result in Nov., 2000 and Aug., 2004.

Table3-1 Test result of geotextile sampling at the left bank of gravel sand near Erwangzhuang water gate comparison

Item / State	Weight (g/m^2)	Thick-ness (mm)	Seepage co-efficient ver-tically (mm/s)	Penetration strength (CBR) (kN)
Wet state in 2000	2059	2.71	11×10^{-2}	2.71
Natural dried state in 2000	1123	2.92	11×10^{-2}	2.51
Wet state in 2004	2212	2.99	24.3×10^{-2}	1.54
Natural dried state in 2004	574	3.19	24.3×10^{-2}	1.87

Item / State	Break strength (N/50mm)		Extension rate (%)		Ladder-shape avulsion strength (N)	
	Longi-tude	Lati-tude	Longi-tude	Lati-tude	Longi-tude	Lati-tude
Wet state in 2000	437	650	54	31	203	283
Natural dried state in 2000	507	757	50	34	200	343
Wet state in 2004	479	536	59	48	272	273
Natural dried state in 2004	539	659	52	45	272	273

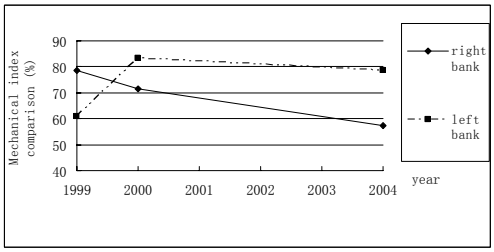

Figure2. Mechanical index comparison for wet state

The geotextile sampling in different time has the similar basic appearance and the efficient earth protection comparison. Because of different materials and different working procedure, the test variance coefficient of geotextile is large. The average variance coefficient is about 10% even in case of the test with same geotextile. The average variance coefficient is much more in case of the test with different lots of geotextile. Comparing the test results, because of different condition, the mechanical index of the geotextile has changed a little, which is not linear. The seepage coefficient of the geotextile is depressed, but it can meet the requirement of the project.

4 ANALYSIS

The same geotextile was applied at both bank of the channel near Erwangzhuang water gate. The following mechanical index table is summarized in accordance with the above tests of three times. Table4-1& Fig.2 shows mechanical index comparison.

Table 4-1 Mechanical index comparison (%)

Item / State	the right bank near No1 water gate (%)	Perform-ing time (years)	the left bank near No1 water gate	Perform-ing time (years)
Wet state in 1999	78.5	13	61.0	12
Natural dried state in 1999	59.3	13	74.6	12
Wet state in 2000	71.5	14	83.2	13
Natural dried state in 2000	60.5	14	94.3	13
Wet state in 2004	57.2	18	78.5	17
Natural dried state in 2004	61.9	18	88.1	17

5 CONCLUSION

According to the analysis of the test geotextile, we reach the following conclusion.

1. The durability of the geotextile has relationship with the sunlight. The geotextile under cover like the earth or water will be aged slowly. So we must pay attention to covering of the geotextile when construction is going on, which means trying to avoid the exposure of the geotextile. There must have the gravel sand protection on the surface of the geotextile when it is applied for the filtration.

2. After many years of application, the geotextile is integrated with the sand and clay granule. But the thickness of the geotextile is not increased greatly and the water absorptivity of the geotextile is large.

3. The wet state of the geotextile is considered as the performing state. The natural state of the geotextile is near the state of the original. The mechanical index of the geotextile with cover protection is depressed very slowly.

4. The geotextile will become stiffened when it is glued with the concrete fillings of the stone protection slope. The mechanical index is changed a little. But the seepage of the geotextile is not changed for the concrete fillings on the surface.

5. The bulrush has strong life that will penetrate the geotextile. So all of the plant must be damaged thoroughly with weedicide before construction.

6. The geotextile has perfect function for protection of the earth, which is closed with the slope without rushing slot.

7. The geotextile is mainly for the filtration. After many years, the seepage coefficient of the geotextile is lower little than the original. But it still meets the requirement of the project. The seepage coefficient of the geotextile is still larger further than the soil.

Deficit：

The aging is a long time procedure. One or two tests couldn't reflect the whole nature of the geotextile. So the sequent test must be performed continuously.

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