

Slope protection of Da-Wa delta-plain reservoir using fabriform concrete

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ABSTRACT: The slope protection project of Da-wa delta-plain, which is in northern cold area, is the largest monomial project in area using fabriform concrete. Its area reaches to 280 thousand square meters using 35 thousand cubic meters concrete. The article introduces the design and construction techniques of fabriform, which is applied to slope protection project of plain reservoir in cold area, hoping to offer some experiences of extending and applying this technique.

1 GENERAL SITUATION OF PROJECT

Da-Wa Delta-Plain Reservoir locates in the shore beach of southwestern Da-Wa county in Liaoning province, which is built to adjust the use of water among paddy fields, persons, livestock and industrial in delta-district. Its dyke spans 14.3 kilometers, ground elevation reaches to 2.2 meters, crest elevation reaches to 8.2 meters, height of dam reaches to 6.0 meters, storage area reaches to 13.4 kilometers, total storage capacity reaches to 56 million cubic meters, design water level reaches to 6.48 meters, dead water level reaches to 3.1 meters, yardage reaches to 4.837 million cubic meters, total area of the slope protection reaches to 280 thousand kilometers, used concrete reaches to 35 thousand kilometers. The project of placement started in April 5 1992, completed in July 1995; the project of slope protection started in May 1997, completed in Sep 1998. Then the reservoir launched into water storage.

2 DESIGN OF PROJECT

2.1 *Demonstration of slope protection scheme*

In the northern area of our country, the key question of design and construction for plain reservoir is how to select and determine the project scheme of slope protection. Slope protection of plain reservoir dam generally suffers from destructions of frost heave, ice pressure and wind wave. Wind wave is the direct reason of all kinds of large area destruction; ice pressure results in partial failure by processing the

slope protection, which is the forerunner of destruction caused by wind wave; asymmetry of the dam body intensifies the destruction effect caused by ice pressure and wind wave. At the same time, after the material analysis of engineering practice, slope protection project accounts for above 50% of the total investment invested in plain reservoir.

Main forms of the slope protection for plain reservoir in the northern area of our country are (1) dry-laid stone; (2) cement-rubble; (3) premixed concrete sheet or cast-in-place concrete sheet; (4) residual oil asphalt concrete; (5) ashlar; (6) laid stone mixed with concrete sheet; (7) reinforcing bar concrete sheet; (8) simple mold bag concrete; (9) fabriform concrete and so on. After several times of investigation and systemic analysis of the pertinent data, yet combined with domestic slope protection project, the newest achievement of technological development and the actual condition of slope protection project of delta reservoir, we proposed the slope protection scheme of fabriform concrete in 1996. It is a new pattern of protective facing technology, with the good characters of strong integrity; simple construction, resisting frost heave, ice push and wind wave.

2.2 *Slope protection design of fabriform concrete*

- (1) Gradient: ratio of slope is 1:3, river side of the dam undergoes scaling disposal according to proportion of 1:3.
- (2) Thickness: according to the rule of frost heave destruction in northern cold area, we adopt the mold bags with different thickness for the first

time. By calculating, we adopt two kinds of specifications of 12 centimeters and 15 centimeters. Namely, at the range of winter variation region in operation level, the thickness is 15 centimeters, above and nether it adopt 12 centimeters.

- (3) Cutoff wall: the base of mold bag is situated in dry-laid block stone with 1 meter depth.
- (4) Pattern of mold bag: rectangular fabriform.
- (5) Request of concrete to be filled up.

The mold bag is filled up with concrete. The 32.5th-class of slag Portland cement were used; the median sand were applied, which sediment percentage were less than 3% and mica percentage less than 1%. The sand does not contain grain of porously, easily cracked by decomposition, the grain diameters of gravel is between 5 millimeters and 20 millimeters. The adscititious materials select the ZL() pumping material and the DH9 gassing material. The intensity rank of concrete is C20; the frock resistance grade of concrete is F100.

- (6) Parting processing.
Each time, the breadth of the filling mold bag is 4 meters; we set a settlement joint between every 12 meters. The connection ways of butt joint with bight are used for adjoining cloth block. At the bottom of mold bag locates in joint, we select geotechnical cloth of 400 gram per square meters for filtering. The width of filter cloth is 1 meter, in order to prevent the tiny grain from washing from settlement joint, which results in destruction by hanging the fabriform concrete. The settlement

joint maintains suitable straight, the minimal width and rich remainder of filling constriction to ensure the fully close, close-grained and smooth straight joint between mold bag after filling inflated and formed mold bag concrete.

- (7) Frost heave prevention measures.
At the slope face destructed easily by frost heave, except for enhancing the depth from 12 meters to 15 meters, yet we lay 30 centimeters depth sand blanket below the mold bag cloth in the area of frost heave to prevent from frost heave.

The standard cross section of slope protection of Da-Wa delta–plain reservoir using fabriform concrete is showed in Figure 1.

3 CONSTRUCTION OF PROJECT

This is a slope protection project for dam body. The construction procedure contains slope trimming, excavation and bond of cutoff wall in the base of dam, filling fabriform concrete and so on. The project started testing construction from Oct 1996, formally started construction in May 1997 and completed in Sep 1998. The area of slope protection reaches to 280 thousand square meters, and concrete used reaches to 35 thousand square meters. The construction procedure flow is showed in Fig. 2.

3.1 Construction plan

The construction is reasonable planned according to the transport capacity of concrete delivery pump. The

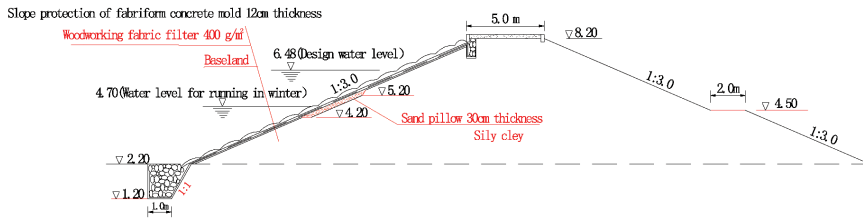


Figure 1. The standard cross section of slope protection of Da-Wa Delta-Plain reservoir using fabriform concrete.

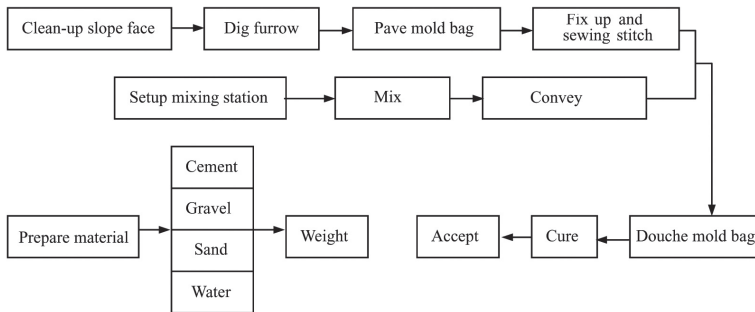


Figure 2. The construction procedure flow chart for mold bag slope protection.

maximum delivery distance of concrete delivery pump can reach to further than 400 meters, so we set a workstation along with bulkhead line every 800 meters. Every work station is used as a construction section, sand and stone are piled in downstream slope bottomland of the dyke, cement storage is at the near of concrete mixing station.

3.2 Dam slope disposals

Firstly, we go along layout of construction, then do scaling with dam water face according to the show line, mainly use the way of mechanic scaling, assistant with artificial scaling. Construction was operated according to the design side slope, and kept the dam slope face even, neatness and close. It can not contain incompact soil layer. The dry density of slope face is controlled above 1.5 gram per cubic meters. The slope face should be maintained neatness. The slope face is forbidden to containing of sharp-angled sundries, such as humus, block and so on.

3.3 Foundation trench excavation and cutoff wall bonding

The counter-shovel excavator cooperates with human labor to excavate the bottom foundation trench of the slope mold bag. Dry block stone cutoff wall were artificially bonded.

3.4 Mold bag lying

Before mold bag lying, we inspect the situation such as surface quality, design size of mold bag cloth and so on at first, and prevent from using incompetent product. Then carry on the contraposition inspection of mold bag size according to the different position of the dam section, including inspecting whether the work of joint cloth, filling mouth and perforation reliable and whether there is hole on mold bag.

Before mold bag lying, we set non-slip cutoff trench at the abutment of the water face to fix the mold bag cloth. The lying placement of mold bag cloth must be precious, all elevations accord with design request. Do keep the cloth undraped and elasticity fit when anchoring the mold bag cloth, for carrying on filling concrete easily.

3.5 Filling concrete

The filling of concrete is the most key and complicated procedure of slope protection construction using mold bag. It affects the entire quality of slope protection, so we should plan filling concrete as a whole, and carry on general and painstaking inspection on it.

(1) The project applies the HBT concrete delivery pump to fill up. Its filling pressure is 0.2-0.3 MPa. The proportioning of concrete should consider its workability, fluidity and the pump request. The slump is 23 ± 2 centimeters. The

construction mixture ratio adopted is: Cement:

- Sand: Crushed stone: Water = 1: 2.82: 2.48: 0.58
- (2) Insert the pump pipe into bond mouth of the mold bag with the mouth tied with belt. The order of filling is from bottom to top and two laterals to middle, which start from the filled mold bag. In the course of filling, we should keep the work continuously. When the mold bag concrete filled near to its capacity, we should suspend the process for 5 minutes; when the mold bag water filter out, we go on filling till reach to the capacity of the bag.
- (3) After the mold bag block concrete fills the bag full, we grip the mouth tightly, and carry on the cleaning of the slope face, to keep the slope face of the mold bag concrete cleanly and undraped. After filling concrete for 12 hours, in order to keep moist, the timely water spray maintained for 14 days is needed.
- (4) The joint of the adjoining mold should be close as far as possible. When lying down the next bag, we should obligate some allowances, which used to build on the previous bag, in order to have the effect of close-grained extrusion by manpower lying when filling.

3.6 Quality control

(1) Quality control of raw material

Raw material, as the substantial base of the entire project, its quality relates directly to the project quality. Therefore, we must strictly control the material quality. The fabriform cloth, cement selected and so on must be tested eligible. The strict inspection of aggregate for sand is needed, to control the sediment percentage in aggregate, preventing the thick aggregate from pumping into delivery pump pipe.

(2) Workmanship control

The workmanship has a great effect on the project quality. To strengthen quality control and ensure project quality, we must control each construction phase well. The concrete in the mold bag request the good fluidity. According to experiments, the concrete used in this project is 1st grade concrete, with the design label of C20 and the anti-frozen label of F100

(3) Workmanship assurance under instances of not normal

Under normal instances, the filling work of single amplitude fabriform concrete should be continuous service, the pause time in midway should not surpass 20min, otherwise construction may be effected caused by construction cold joint and conglutinations between mold bag cloth and concrete. In the course of construction, when the mechanical device goes wrong, which can not be settled in the short time, we should immediately use the artificial outside forces to form hacking

effect on concrete in the fabriform, and try not to cause conglutination between fabriform and concrete. As far as possible. When restarting the machine, we should pressurize slowly, cooperated with artificial vibrating, causing the concrete to be filled up densely and forming the full and artistic outline of fabriform. When the injection pressure is too high, it is easy to cause bursting of fabriform cloth. If this occurs, we should stop pouring immediately and cork the bursting place in time. When the fabriform concrete is curdled in a way, we pour concrete slowly. After initial condensation, shear the fabriform cloth and carry through artificial repairing.

4 OPERATING CIRCUMSTANCE OF PROJECT

The slope protection project of Da-Wa delta-plain reservoir using fabriform concrete was completed in end of Sep 1998. It has been 7 years since the project was launched into water storage. The operating effect of the project is fine and achieves the design request. By analysis of site observational result, because the slope protection using fabriform has the characters of huge cubage, nice integrity, strong resistance to weathering and ice push, also it can direct the ice push from the point of force application, for many years, we have not discovered the hidden trouble influencing the normal operation of the project. We only discover 2-3 cracks with 0.5 millimeters length along the slope face, which were possibly caused by the change of the temperature. They have no effect on the normal operation of the fabriform concrete construction. The surface of slope protection using fabriform concrete is neat and artistic, without

destruction. The slope face is stable. The dam toe does not occur severe scouring. The form every two fabriform connect uses butt joint. The slope protection does not have the phenomenon of frost heave. The design scheme is reasonable, the workmanship is controlled strictly, and the concrete intensity meets the design requirement.

5 SPREADING AND APPLYING

The slope protection project of da-wa delta-plain is the largest domestic project in area using fabriform concrete. It successfully settles the problem of slope protection using fabriform concrete, with the demand of resistance to frost in northern cold area of our country, namely, frost heave, ice pressure and wind wave. In this project, different thickness fabriform is used for the first time. Through the successful application of slope protection of Da-Wa delta-plain reservoir using fabriform concrete, up to the end of 2004, this technology is applied to the shore protection of river course, dike protection and so on surpassing 20 projects in Liaoning province, with the total area of near to 700 thousand square meters, which obtained remarkable economic benefits and social benefits.

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Table1. The table of slope protection with fabriform concrete in Liaoning

No.	Name of Project	Length (Km)	Area (10 Km ²)	The end time
1	The slope protection of Liao River delta	13.7	28.0	1998
2	The slope protection of Dongfeng drainage and irrigation station in Liaoning		2.0	2002
3	The slope protection of seawall in Liao River oilfield		0.7	2000
4	The slope protection of Hunpu irrigation district of Shenyang in Liaoning		3.0	1998.10
5	The slope protection of Hunhe Lijiafanggang field in Liaoning		0.8	2004.7
6	The shore protection of Yalu river 0# Bamen, Dongkanzi and Erchaogou, etc.		10.52	2003
7	The slope protection of Hunhe Wanjia field in Shenyang	1.7	2.0	2004.11
8	The slope protection of Wusangaun development zone reservoir of Xinchengzi		6.2	2003
9	The slope protection of Shifu Mosque reservoir in Liaoning		6.0	2002
10	The slope protection of Red Flag reservoir in Liaoning	3.0	1.2	2004
11	The slope protection of Comity reservoir gate in Liaoning	0.8	1.5	2004
12	The 6 places of other projects in Liaoning		7.1	2004
	Total		69.02	