doi: 10. 3969/j. issn. 1673-9736. 2010. 02. 05 Article D: 1673-9736 (2010) 02-0085-05

Drillhole high-pressure packer permeability test for underground powerhouse in Pushihe pumped storage hydro-plant

TAN Zuoyin¹, CHEN L 1^2 , REN Xiangyu¹ and LI Zhanjun¹

1. Institute of Northeast Hydroelectric Investigation Design, Changchun 130000, China;

2 College of Construction Engineering, Jilin University, Changchun 130026, China

Abstract: Usually the water head of the pumped storage hydro-plant is high, generally up to 400-500 m, therefore the rock mass under the high-pressure bifurcation pipe have to bear as high as millions Pascal water pressure, in according with the requirements of high water head pumped storage hydro-plant should be 1.2 times of the water head special high-pressure packer permeability test compared with normal to test the permeability of rock and rock cleavage pressure value. The test results on the choice of design options often play a decisive role. Based on the engineering practice, the authors studied the drillhole high-pressure packer permeability test in the pumped storage hydro-plant's underground powerhouse, by the analysis of test results, this article offers a demonstration of the deformation of rock fracture witch under building in the condition of high-pressure water head, it provides a more detailed engineering geological background

Key words: pumped storage; high-pressure packer permeability test; rock mass; deformation; permeability; rock cleavage

1 Introduction

Pushihe pumped storage hydro-plant is located in Dongyanghe village of Kuandian County in Liaoning Province, which is 57 km from Dandong City. As a large (1)-type power station, its power capacity is 1200 MW.

According to the Pumped Storage Hydro-Plant Design Guidelines (DL/T5208-2005), high water head pumped storage hydro-plant should be 1.2 times of the water head special high-pressure packer permeability test, we take on the high-pressure packer permeability test in the underground of the plant in October 2007. Lacking of formal industry standards on the drillhole high-pressure packer permeability test in domestic, the test we refer Appendix A of "Code for Hydropower Projects Drillhole Packer Permeability Test " (DL/T5331-2005).

2 Geological introduction for test zone

The outcropped rock is Early Protenzoic era (M $_2$) and insert diorite pophyrite vein ($_2$). Geological structure in the test zone is developed Near the test drillhole we can see shattered fault zones of f3-2, fC20, f24.

Rock fissures are developed, joint frequency of the test zone (1 to 3) is 3.3-5.6/m and the joint frequency of test zone (4 to 6) is 1.2-1.9/m.

3 Test and record equipments

The 3SNS high pressure pump and TS intelligent

Received 16 April 2010, accepted 28 May 2010

automatic recording devices were used The maximum pressure of the pump ups to 10 MPa and the maximum discharge is 100 L/m in The advantages of the equipment are high pressure, stable discharge, reasonable structure, easy to operate and with the regulator equipment to ensure the stability of the test pressure A notebook computer as the host of intelligent automatic recording devices determines the characters are stable performance, strong anti-interference capabilities, byreal-time display screen with the test data and the power-time curves that the accuracy is 1 L/m in The XTF-2 hydraulic rubber double embolization which can bear the pressure of 30 MPa is used, which expansive rate is 200%.

4 High-pressure packer permeability test

4.1 D ivision of the test zone

The zones of packer permeability test are controlled within 15 m and a total of 6 in the center line of the high-pressure bifurcation pipe. In order to arrange the embolization in a more completely rock mass, we use a digital imaging drillhole test before the packer permeability test to know the development of rock structure. According to the drill core logging and in combination with digital imaging results, we arrange the pressure water test zones

4.2 Determination of test parameters

According to the design of the bifurcation the water pressure head is 470 m, and the coefficient is 1.2, the maximum pressure is determined as 6 MPa in the test In principle, 6 pressure values and 11 pressure stages are selected And third segment which is the double cycle and each cycle of pressure is as follows: 1 MPa 2 MPa 3 MPa 4 MPa 5 MPa 6 MPa 5 MPa 4 MPa 3 MPa 2 MPa 1 MPa 0 is the most representative one in the pilot test in those 6 segments

The increasing (decreasing) pressure of the third segment is by this way: each grade pressure maintains 30 m in after the first cycle recording stabling, the pressure increases to a maximum can maintains 2 h; When the second cycle reading is stable, each grade sustained pressure 10 m in, the pressure increases to a maximum sustained 1 h; every cycles at relieving pressure in each grade the stability of reading continued 10 m in

4.3 Analysis of packer permeability test results

We analyzed the results of packer permeability test taking the third trial segment as an example. The basic geological characteristics are shown in Table 1 and the test results are in Table 2; the first cycle of P-Q curve is shown in Fig 1, the second cycle of P-Q curve can be seen in Fig 2.

Rock types	ROD	Rock mass	Characteristics of Fractures												
	KQD	integrity	N.	A		A ttitude	Width	Vulnerability							
	/%	evaluation	NO.	Amount	Strike	Dip	Dip angle	/mm	degree						
Mignatite			J 4	1	N50 E	SE	85 °	1							
			J5		N4 °- 13 °E	NW	63°-66°	0.5 - 1							
	63	Medium	J6	20	N63°-76°E	NW	63°-71°	1	Highest						
			J7		N7°-14 W	SW	64°-77°	<1							
			J8	10	N11 °E	SE	35 °	0.3 - 0.5							

Table 1 Basic geological features of the test zones

From Fig 1, we can see that this segment P-Q curve is D-curve, which is convex to the P-axis In the first cycle, the rock mass in test zones is impervious in the condition of 5 MPa pressure, the largest

seepage discharge is only 0.954 L/min When the pressure reaches at 5 MPa, the curve has a clear inflection point It suggests that 5 MPa pressure is the critical pressure that rock occurs cleavage.

meable tsing /q ng)	Ratio		18.33			10.34			5.6		5.32		1.41		1.98		2.18		1.57		1.38			
Ratio of peri	Ratio of per rate (q increa decreasi	pressure /MPa	ۍ 4				m		2		-	I	ų	۶ ۶		Ŧ	ę			2		1		
	P-Q curve type						I			LI						Q		Æ						
Ratio of permeable rate /q/q							11.05	11.05				1	Z	6	11:46					36				
~	permeable rate afert splitting / q '(Lu)		9690											0.722										
	Critical pressure /MPa			v 4																				
10	Uriginal permeable rate (1MPa)	/ d (Lu)	0.063																					
	permeable rate (Lugeon value) /Lu		0.063	0.055	0.035	0.034	0.030	0.696	0.550	0.424	0.362	0.308	0.335	0.280	0.219	0.177	0.224	0.404	0.772	0.570	0.444	0.386	0.344	0.385
	Stable discharge /L·min ⁻¹		0.448	0.739	0.698	0.894	0.954	27.140	17.970	11.148	7.239	4.205	2.388	2.007	2.983	3.500	5.893	13.269	30.462	18.722	11.695	7.757	4.773	2.785
ر ا	Time of pressing water /min		41	41	41	41	41	151	21	21	20	20	20	21	20	21	20	21	71	21	20	20	20	20
ation	Total nressure of	test zone /MPa	1.127	2.101	3.117	4.075	5.033	6.135	5.134	4.133	3.146	2.144	1.121	1.128	2.139	3.116	4.134	5.170	6.207	5.164	4.138	3.158	2.184	1.137
ssure classific	Pressure of	test zone /MPa	1.012	1.986	3.002	3.960	4.918	6.020	5.019	4.018	3.031	2.029	1.006	1.013	2.024	3.001	4.019	5.055	6.092	5.049	4.023	3.043	2.069	1.022
Pre	Water	pressure /MPa											2110	c11.0										
	Len`m		۲ ٤.36 ۶.																					
	Height /m											3.54		l	-2.82									
	Depth /m											32.64		2	39.00									
	No.		3 (first cycle)									3 (second cycle)												

 Table 2
 Results of high-pressure packer permeability test

D www.cnki.net





Fig 2 The second cycle of P-Q curve

When the pressure rises to 6 MPa, the high-pressure infiltration results in erosion and expansion then rock cleavage, making rock seepage discharge rapidly increase to 27.14 L/m in At the same time, the P-Q curve of the second cycle clearly shows that as the influence of high water pressure, the original rock cleavages continue to come into being new expansion, extension

From Table 2, we can know that the trial of rock mass in the first cycle after the breakdown of the deformation has not fully resumed so that the discharge of the increasing pressure phase is higher than the first cycle at the same pressure c (normally 3.62-6.59 times, the maximum pressure is 5 MPa pressure that is 13.91 times), and the critical pressure reaches when the pressure is 4 MPa

On the pressure of 6 MPa, the discharge increases to 30.46 L/min, which shows that there exists time effect in this crack rock mass. That is, in the continuing role of high-pressure water, the deformation of discharge rock will continue to increase, thereby the rock critical pressure on cleavage rock further reduces (from 5 MPa in the first cycle down to 4 MPa in the second cycle). It can be seen from the P-Q curve that comparing the discharge changes in the decreasing pressure with the increasing pressure on the same pressure, the discharge is small in the first cycle of step-up to 5 MPa and discharge changes in the remaining increasing (decreasing) pressure are not big

From the Table 2 we know it is five times to eighteen times comparing the decreasing pressure discharge with the increasing pressure discharge at the same pressure in the first cycle. The low pressure (1 MPa) for the minimum is five times and the highpressure (5 MPa) for the maximum is 18 times When the pressure decreases to 5 MPa in the first cycle the discharge maintains of 17.97 L/min, while the pressure decreases to 1 MPa the discharge is 2.388 L/min Obviously it is a diametrically different result at the same pressure in the cycle test

From Fig 1 and Fig 2 we know that curve of QT is a zigzag straight line before rock mass cleavage; after rock mass cleavage Q-T rapidly rise and shows as a slash In the whole trial process, the pressure is relatively stable and curve of PT is almost a straight line

It must be pointed out that the originally impermeable rock mass on the pressure of 5 MPa in the first cycle occurred seepage that was 17.02-1.94 L/min in the decreasing pressure process A long period of high-pressure water pressure roles in rock mass cleavage then further erosion and expansion of the rock mass cleavage supply convenient water channel for the discharge. There exists permanent deformation in the rock mass

When the decreasing pressure is 5 MPa to 1MPa in the second cycle, the discharge is less, which is only 5.45-0.78 L/min (increased 1.39 times to 2.22 times) than the corresponding increase pressure. This is apparently contrasting with and five times to eighteen times in the first cycle.

5 Conclusions and recommendations

(1) To sum up, though we take on only six trial test in this high-pressure packer permeability test, comparing with the t similar projects test results at home, we believe that this trial test is successful and the test results scan reflect the characteristics of infiltration of high-voltage rock mass, which has certain representation

(2) The test depth of the rock mass is about 300 m that original permeability is weak. The test shows that the high water pressure affect integral rock to emerge cleavage while there are no significant change in permeability; joints (especial steep angle joints) than the development rock mass bring in cleavage, and permeability rate increase generally for 1.82-2.13

times furthermore the maximum is 11.46 times Its critical pressure is for 4-5 MPa The crackle can not totally recover after decreasing pressure. The critical pressure drops when the second cycle and permeability rate slightly increase

(3) Because the original permeability rate is very small, after splitting the permeability rate is about 1 Lu

(4) As the zone of high pressure bifurcation have bets of fracture zone, crack developed and complicated hydrogeological conditions, for safety reasons, we propose strengthen lining where surround the high pressure bifurcation to refrain this rock mass from spliting in the condition of high pressure water head

(5) As the number of test zones is little in this test, we can not include all of geological phenomena that the high pressure bifurcation have, suck as fault zone, joint zone and so on It needs further study about the permeability changes in high-pressure water head under effect of those geological defects

References

(Om itted)