

Application of Tracer Experiments to Predict Leakage Channel-An Example of a Power Plant in Zhen'An

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Abstract: Many water conservancy and hydropower projects are located in karst areas of which complicated structure would cause significant risks to water conservancy and hydropower projects, so identifying the presence or absence of pipeline leaks is one of important basic conditions for water conservancy and hydropower project. Determining the existence of leakage channels has important applications tracer diffusion of water tracer experiment, this paper is the experimental investigation of tracer leakage passage of a hydropower station in West China, determining the existence of leakage passage can be worked through experimental investigation on part of the left abutment of the hydropower predict leakage passage to.

Keywords: Tracer experiment, Tracer, Fluorescein, Spectrophotometer

Background

This article is a hydropower research of the leakage passage through tracer experiments conducted in West China, which through experiments to determine the left abutment of hydropower leakage passage. The subject is located in east of Mountain Taibai, the main peak of Mountains Qingling that is located in southwestern Shaanxi, hinterland of Central China. Its altitude is as high as 2,000 m above all, occupying soluble rock dam area development at a high location, large and centralized development of karst caves. Meanwhile rock mass use of the laboratory is negative, and there is a large post-karst power plant which hazards to water penetration possibilities. The existence of karst seepage channel is proposed to be a major project to investigate the significance of the reservoir the most widely-used tracer experiment and simple existence of leakage passage in the study. Through tracer experiments fluorescein, blue red

powder, experiments of this paper is conducted under stable environment with no pollution and no natural geological occurrence, using site spectrophotometer is quick and easy.

Some borehole data revealed that the dam area, which covering the lower part of the presence of karst cavity location, can see off drilling and drill digging accident in Drilling Well ZK51 ZK51-1 in the process of emergence. Dilatancy effects of black trench beam during the crustal uplift can be seen from drilling well ZK51 and ZK51-1 at the same location and large insidious erosion shaped space caused by local expansion cracks also can be observed, indicating the presence of large-scale black trench karst conduit. Internal corrosion fissures during exposing massive karst cavities is shown from east to west, with occurrence $EW/S \angle 67^{\circ} \sim 72^{\circ}$, undulating wall, rock curtain development, calcium film thickness 2-20 mm. Maximum crack open about 60 cm, partially filled blocks, yellow secondary mud can be observed.

Meanwhile, the dew of natural groundwater is included in the elevation of outside the laboratory

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database storage elevation, which is marked as Spring point 1, ditch point 1, Spring point 2, Point ZK35 ditch beside. The information communicated in each experimental point tracer experiments is selected as shown in Table 1, while the experimental points presented in three-dimensional model of the terrain response are clearly shown in Fig.1. Experimental points within the laboratory include: Spring point 1, Ditch point 1. And ditch water outside the laboratory includes: Point ZK35 ditch beside, ZK50, ZK51, ZK51-1, PD13 and Black trench springs 02.

The topographical position of each experimental point predicts whether there is leakage channel. This is very important. Experimental points may select the channel, and receive delivery of tracer to accurately analyze the connectivity of each channel.

Topographic location of each experimental point of predicting whether there is leakage channel is very important. The selected test points indicated that there may be channel, from delivery and receiving tracer of selected points, the connectivity of each channel can be accurately analyzed.

Table 1 Experimental Conditions Point Information

Experimental points	Location X	Location Y	Elevation (m)	Flow	Remark
PD13	558,376.955	3,711,110.798	1,450.123	0.7 L/s	Delivery point, Receiving point
Spring Point 1	558,493.553	3,711,064.275	1,391.613	1 L/s	Receiving point
Spring Point 2	557,919.645	3,711,182.428	1,340.000	0.5 L/s	Receiving point
Ditch Point 1	558,529.286	3,711,111.783	1,381.248	0.01 Ls/	Receiving point
ZK51	558,303.792	3,711,138.938	1,537.060	Water 0.22 L/s	Delivery point
ZK51-1	558,303.495	3,711,134.955	1,537.060	Water 0.22 L/s	Delivery point
ZK50	558,577.934	3,711,218.051	1,448.381	NO Water	Delivery point
Point ZK35 Ditch Beside	558,760.188	3,711,537.756	1,175.585	0.01 L/s	Receiving point

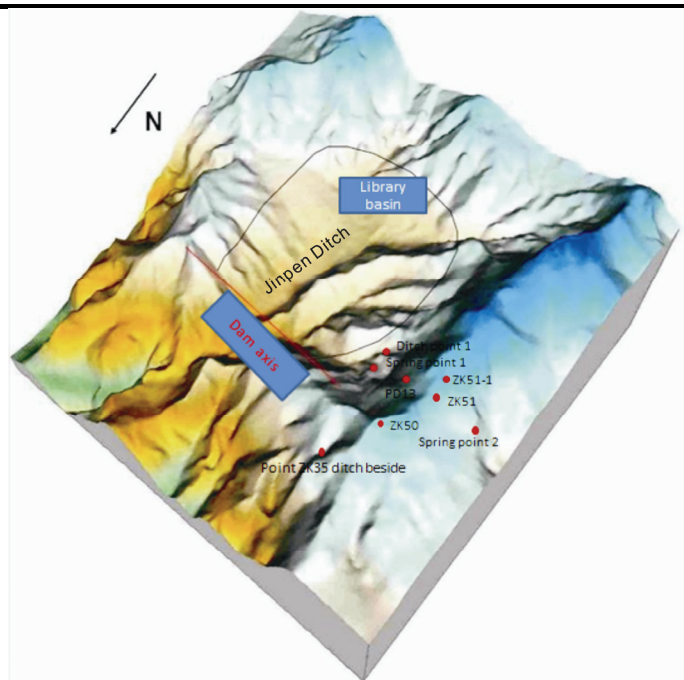


Fig.1 Three-dimensional Model of the Reservoir Area and the Terrain Experimental Points

Experimental Purposes and Provisions

After impoundment, water will go through the underground passage to the laboratory extravasation leaks in the appropriate terrain, geological conditions, which could endanger the safety or effectiveness of engineering. The main purpose of groundwater tracer test is to identify internal and external groundwater reservoir hydraulic connection, especially with the laboratory near the left bank of the reservoir's water hydraulic connection, determine the dominant groundwater flow, groundwater flow rate calculation (Dao-xian YUAN et al., 1996; Yao-ru LU, 1982; Engineering Geology Handbooks Committee, 1992).

In these leakage channels, karst seepage is worthy to be paid special attention. Because karst leakage problem is more complex than other issues with stronger water conductivity, is also more prominent hydrogeological problems in sinohydro, Massive karst wide slit in the laboratory on the left bank of the dam foundation rock adverse use, and there is a big risk to plants after karst water penetration. Through this test, the main purpose and contents are:

- (1) Detection to identify hydraulic connection of ZK51, ZK50 and dew point of natural groundwater inside the laboratory or outside the laboratory, qualitative judgment whether there is connectivity relations;
- (2) Determine groundwater flow;
- (3) Quantitative calculation of groundwater flow ratio of the laboratory and laboratory outside;

The conservation of mass is the basic principle of tracer detection which calculates flow field parameters that obtained according to the law of the tracer diffusion face recognition and the understanding of different groundwater flow field types in various structures through various techniques. Tracer experiments described in this paper are based on these principles.

Since fluorescence spectroscopy analysis method
<http://gwse.iheg.org.cn>

detection limits than other low 1-2 orders of magnitude (Shu-gui DAI, 1984), so to detect large karst flow field, corresponding tracer is required to be with high reliability and economic advantage (Jing-lan LI, Yi-min LI, 2004; Jian-guo PEI et al., 2000; Bao-jian HUANG et al., 1995). The tracer experiment was purchased by four iodine tetrachloride fluorescein disodium, of which formula is $C_{20}H_2Cl_4I_4Na_2O_5$; MW: 1,017.64; blue red powder shows blue and red with no fluorescence in water; shows brown in concentrated sulfuric acid; diluted with red meat precipitation; its maximum absorption wavelength in the indoor laboratory derived by spectral scanning of 548 nm. The pumped storage power station on the left bank predicted path tracer experiments using domestic connectivity precision instruments 722S spectrophotometer as instrumentation (Ying MEI, 2008; Yun LUO, Guang LIU, 2008; Zhen LIU et al., 2012).

When a monochromatic light through the solution, its energy will be absorbed and weakened, diminished concentration degree C light energy substance in solution has a proportional relationship that is consistent with Lambert-Beer (Lambert-Beer) laws. The relationship can be expressed as:

$$A=K \cdot C \cdot L = \log I/I_0$$

Formula: A - also known as optical density absorbance;

K-Absorption coefficient of the solution;

C-Concentration of the solution;

L-Optical path length of the solution;

I-Intensity of transmitted light;

I_0 - Intensity of incident light.

Through the analysis of the experimental point of direct contact leakage and seepage the presence of the four channels can be predicted. First of all, PD13 and Spring point 1 or Ditch point 1 can be predicted as from channel, and PD13 as delivery point, while Spring point 1 and Ditch point 1 can be predicted to receive water samples; PD13 and ZK51 or ZK51-1 are predicted to be leakage channel with PD13 as a receiving point that receiving day-parting tracer reagent from ZK51 and ZK51-1 and internal corrosion is predicted to crack in PD13 receiving groundwater flowing

water samples; Forecast that the leakage passage is between ZK50 and ZK35 ditch beside, the receiving point is forecasted at ZK35 ditch beside, a tracer reagent is put from ZK50, water samples is received at ZK35 to detect water in the ditch; Forecast that Spring point 2 and ZK51 or ZK51-1 is leakage channel, Spring point 2 as a receiving point; Intermittent put tracer reagents in ZK51 and ZK51-1, Spring point 2 water samples to detect.

Tracer Detection Process

In order to facilitate the progress of the experiment, water samples the ZK50 and ZK35 are divided into two batches. On the first day of the fluorescent tracer agent in ZK50 investment, pouring the first batch of samples at the receiving point ZK35 ditch, after dropping the first batch ZK50 and ZK35 in the tracer experiments on the same ZK51 ZK51-1 beginning with the water, to the lower portion inside the cavity filled with water, so that the experiment fluorescein tracer with water flow smoothly fluorescent tracer agents take water samples, the second batch of water samples in the next day. Under ZK51 and ZK51-1 water conditions are not met the conditions, the leakage path tracer experiment of PD13 and Spring point 1 or Ditch point 1. PD13 internal corrosion cracks exposed groundwater flow can be directly pairing shows agent experiments.

(1) Forecast that ZK50 and ZK35 have hydraulic connection, due to the ditch beside the outer distance ZK50 ZK35 farther away, on the detection time ZK35 is divided into two sections. After dropping fluorescein solution, five groups of

water samples were taken, next day ten groups continued to take water samples into 15 sections totally. The use of spectrophotometric analysis of water samples is to detect the concentration of fluorescein.

(2) Because ZK51 and ZK51-1 water conditions are not met, the first prediction of the existence of channel of PD13 is between Spring point 1 or Ditch point 1, and then the ZK51-1 and ZK51, and judgment of PD13 came to the conclusion that ZK51-1 ZK51 with Spring point 1 or Ditch point 1. PD13 long seepage and cracks in the flow of about 0.7 L/s, rain before the experiment had obvious effects on fracture seepage flow Spring point 1 had a large amount of water, about 1 L/s.

(3) When water conditions are met, the first ZK51-1 injection, the water flow 0.22 L/s, 8 hours on the first day of water, no water was in the ZK51-1, 40 minutes after injection on the next day, it is visible that ZK51-1 water level, water level dropped significantly after stopping. According to the crack width and pumping flow, it is can be determined that the volume of the ZK51-1 wide slit is about 7m³. Distance between ZK51 and ZK51-1 is about 5m. Since there is no water at ZK51 in the condition of water-filled ZK51-1, describing that ZK51 with ZK51-1 hydraulic connection is weak. First, put a tracer fluorescein solution in PD51-1, the receiving point did not received fluorescein. Then reinvested fluorescein solution in PD51, in the PD13 and Spring point 1 is sampled.

Information table of each tracer experiment points and tracer recovery of each tracer experiment points are tabulated in Table 2 and Table 3 below:

Table 2 Information Table of Each Tracer Experiment Points

Experimental Points	Location X	Location Y	Elevation (m)	Flow	Remark
ZK51	558,303.792	3,711,138.938	1,537.060	inject water 0.22 L/s	Delivery point
ZK51-1	558,303.495	3,711,134.955	1,537.060	inject water 0.22 L/s	Delivery point
PD13	558,376.955	3,711,110.798	1,450.123	0.7 L/s	Delivery point, Receiving point
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Spring Point 2	557,919.645	3,711,182.428	1,340.000	0.5 L/s	Receiving point
ZK50	558,577.934	3,711,218.051	1,448.381	No injection	Delivery point
Point ZK35 Ditch Beside	558,760.188	3,711,537.756	1,175.585	0.01 L/s	Receiving point

Table 3 Tracer Recovery of Each Racer Experiment Points

Experimental Points	Dose (g)	Date	Time (min)	Collection Points	Maximum Concentration (ppb)	Recovery (%)	Flow
ZK50	7	July 11	760	Point ZK35 ditch beside	210	3.55	0.01L/s
PD13	2	July 12	340	Spring point 1	150	78.6	0.78L/s
			340	Ditch point 1	/	/	/
ZK51-1	4	July 14	270	Spring point 1	/	/	/
ZK51	10	July 15	385	PD13	190	21.42	0.14L/s
			270	Spring point 2	290	20.56	0.1L/s

Results

ZK50 ZK35 farther away, according to the calculation floor plan, the distance between delivery point and the receiving point is 1,000 m, which has long and fractured leakage pathways. So the receiving point ZK35 sample detection time should be longer, immediately ZK35 sampling after putting 7 g fluorescein solution into ZK50. The first stage in each sampling time was 20 min, with five groups of samples, after an interval of more than nine hours sampling carried out the second paragraph, the result is the same as 20 minutes a group of 10 sets of samples taken total of 15 sets of samples. ZK35 achieved significant water samples containing Lucifer in reaction, fluorescein concentration are more obvious, the receiving point developed a small crack in the gully, the flow is as slow as about 0.01 L/s, depending on which receiving rate is calculated at 3.55% at this point after sampling; considering gullies ditch water of traffic, the rate is estimated at about 0.2L / s; the receiver can get the entire ditch water as much as 71%, which can prove that the leakage channels is existed between ZK50 and Point ZK35 ditch beside.

The tracer slowly goes along the fissure water in PD13 and immediately puts sampling to detect in Spring point 1. Sampling time was 340mins, sampling and analysis curves derived from spring water samples fluorescein concentration versus time is shown in Fig.2. The maximum concentration is within 90mins, and there are obvious multiple peaks formation, and after 340

mins, springs gradually reduce the concentration of fluorescein and close to 0. After this test calculated fluorescein recovery was 78.6%, which indicates that leak path is between PD13 and Spring point 1 and relatively smooth (Zhen-wu ZHANG, 1990; Li-zheng YANG et al., 1979).

Pour water into the ZK51 before putting fluorescein solution. Two hours after injection into the ZK51, fluorescein solution was started to be ran, with the amount of 10g, the target was received in PD13 and at Spring point 2. PD13 sampling is real-time sampling, and sampling Spring point 2 began after 90mins later. Higher initial concentration of the sample can be seen from PD13, and the receiving point and ZK51 was related from the past with a large hydraulic gradient. In this state the two receiving (PD13, Spring point 2) points to start receiving water samples containing high concentrations of fluorescein; and in the long detection, the PD13 changes in water samples obtaining fluorescein concentration is more obvious than those of Spring point 2, as the performance of multi-peak. The effective rate of PD13 receiving point is 21.42% receiving time is acceptable. Due to limitations of terrain conditions, the first water sample was began after 90 mins later that the time in Spring point 2, the total sampling time was 270mins, which is slightly shorter compared with PD13. The calculation shows that the receiver receives point fluorescein at 20.56%. In all, leakage channels with PD13, Spring point 2, ZK51 can be determined.

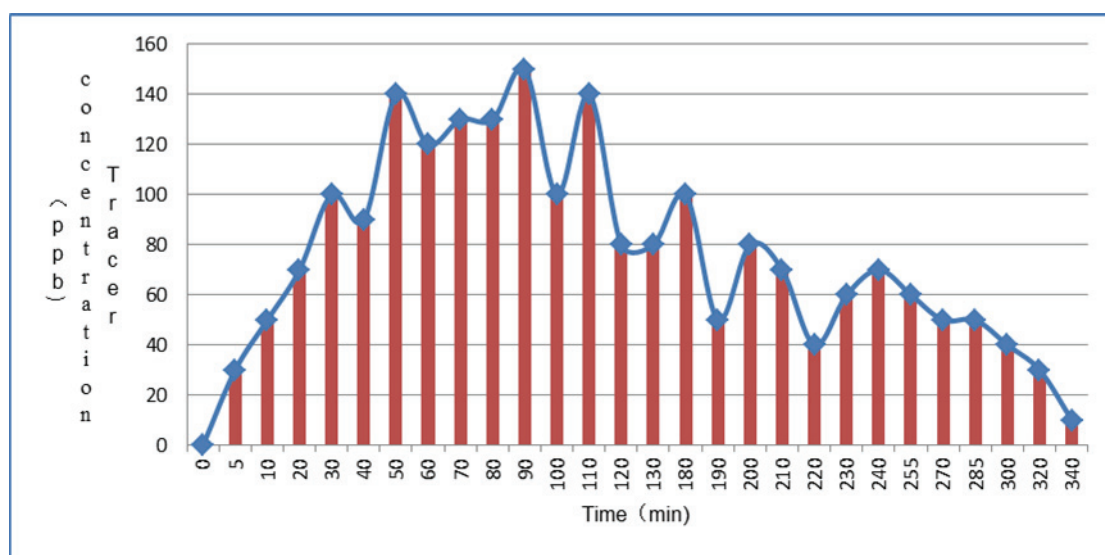


Fig.2 Concentration-time Diagram of the Water Sample What the PD13 Released and the Spring Point 1 Received

Conclusions

First of all, this experiment selects fluorescein as tracer due to its important features. For tracer for complex karst water environment, high visibility to naked eyes is very important, which can avoid major mistakes as prediction to the connection point is not mixed. Especially after the adsorption and improving miscibility processing performance, fluorescein is as good as tracer material. This experiment also applies domestic precision instrument type 722S spectrophotometer as testing instrument. Spectrophotometer is commonly used in chemical analysis; its visible wavelength range is 325-1,000 nm and is a quantitative colorimetric analysis instrument. Preparation of the full experimental is important premise, setting the delivery point and the receiving point in several leakage channels in the left abutment of the power station. Test results between points of analysis and judgment suggest that the leakage path is mainly from fissure leakage passage. The final test results show that the leakage passage is among various sites, and there is no leakage of groundwater from the rolls to the laboratory. To build reservoir in carbonate rock area, Karst leakage is a major problem that is often encountered and must be solved, the existence of seepage channel makes the reservoir have great potential danger; therefore, seepage prevention measures should be prepared

well to ensure the safety of the reservoir operation. By the tracer experiment, process of the construction of pumped storage power station can also be seen. Using the fluorescein tracer connected experiment to determine whether the leakage channels are present or not; more importantly is to comply with the tracer emissions and receiving quantity and the proportion of the tracer curve along with the change of time foreseeable seepage channel leakage process easily, this means that the size of the amount of seepage can be seen from this. Fluorescein tracer connected experiment will constantly improve, and will be better service for the water resources and hydropower engineering construction in the future.

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