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Application of Rectangular Small Loop Source Transient Electromagnetic Method in Hidden Defects Detection of Dykes and Dams

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Abstract： In the detection of dykes and dams by transient electromagnetic method, the conventional square coil can not be set up because of the limit of the width of the dam top and the width of the horse track. In order to better use the transient electromagnetic method to detect the levee leakage, an improved rectangular small loop source detection device is adopted in this paper. The characteristics of the core loop and the fixed source loop device can improve the detection efficiency while ensuring the detection accuracy. The results of field detection show that it is feasible to detect the leakage of the dam and the embankment by the method of detecting the transient electromagnetic leakage of the rectangular small loop source, and the result is better and the result is accurate and credible.
Key words： transient electromagnetic; rectangular small loop source; dykes and dams; leakage; detection

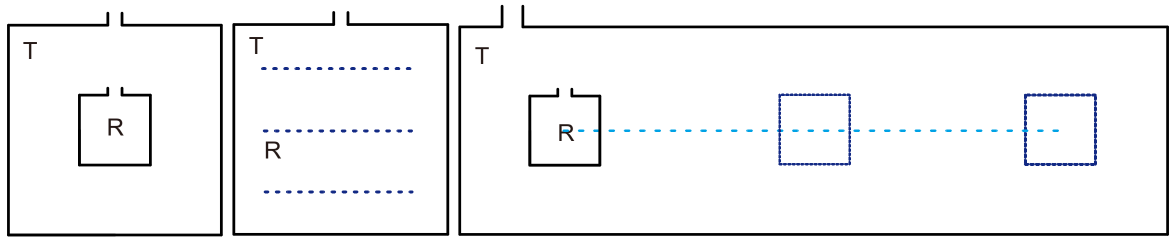
1 Introduction

Geophysical methods are used to detect the hidden danger of dikes and dams. The main methods are transient electromagnetic method, high density resistivity method, shallow seismic method, surface wave method, geological radar, radioisotope tracing method, temperature measurement method and flow field measurement method, etc. Because of the complexity of the structure of the dam, the wide range of hidden dangers and many kinds, and the limitation of site factors and more human interference, it is difficult to detect the hidden danger of the dam. The transient electromagnetic method has the advantages of fast detection speed, high resolution, no contact electrode, easy operation and so on. It is suitable for the special requirements of leakage detection of embankments and dams.

However, in order to study the transient electromagnetic detection devices in China, the large fixed source return line and the large rectangular loop device are used. The application range and object are basically for the prospecting and deep exploration, and the requirements for the detection field are relatively high. For the wider application of the engineering and environment detection, the small loop detection can only be used for the small coil area. The measuring device has little research on the problem of the small loop source. In this paper, based on the seepage detection of reservoir dams and levees, the conventional transient electromagnetic method collection device is combined with the actual situation of the field, and a rectangular small loop source transient electromagnetic detection device is proposed, and the feasibility of the installation is further verified by the basic theory of transient electromagnetic method, and the seepage of the dam is carried out through the seepage of the dam. Leak detection test, through actual detection results to test the feasibility of the detection method.

2 Working device

In the seepage detection of hydraulic structures, such as dams and dikes, the longitudinal dimensions of the top and the horse road are generally within the range of 10m because of the distribution of the dikes and dams, and the limitation of the site conditions leads to the inability to set up a large square emitter frame. In addition, the depth of the seepage passage is generally buried in the depth of tens of meters, and the depth of the buried depth is generally deep. Therefore, in order to use the transient electromagnetic method to detect the hidden leakage of levees, it is necessary to improve the central loop device so that it can be applied to the leakage detection of the dam. According to the structural characteristics of the dyke and the typical observation device of transient electromagnetic method, the improvement of the return line device is made, and the improved rectangular small loop device, as shown in Figure 1 (c).



(a) central loop device (b) fixed source loop device (c) rectangular small loop device.

Figure 1 transient electromagnetic observation device for rectangular small loop source

Because the space shape of the embankment and the dam surface is a rectangular strip, the square launching coils of large length can not be set up. In order to ensure sufficient launching magnetic moments, two kinds of rectangular return devices are used according to different ground conditions: the length of 3m x 7m is adopted in the top of the dam, the horse road and the foot of the dam at the narrow plane width. The square small launch frame; in the slightly wider width of the dam and the top of the embankment, a rectangular 5m 15m large rectangular transmission line can be used. The receiving line frame is at the center of the rectangle, the size of which is 1m x 1m, starting from the 1.5m of the left border frame and moving along the long edge with the interval of distance, and the distance between the measuring points can be set flexibly according to the need of the detection.

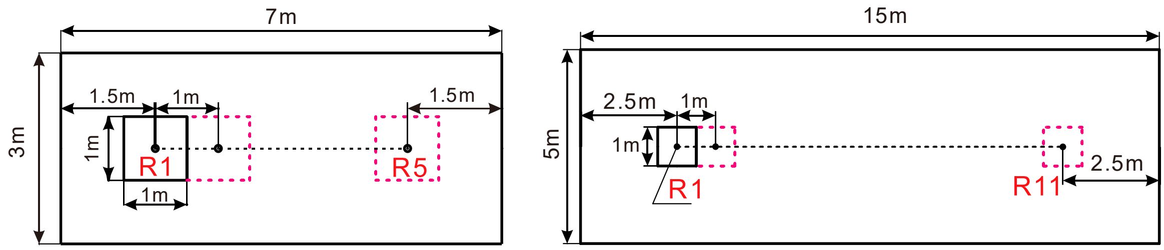


Figure 2 two types of rectangular wire frame detection device

Using the above observation device, the distance between the measuring points is 1m. The transmission line adopts the 1~3 turn, the transmission current is 3 A, the receiving device adopts the Nano transient electromagnetic system (Nano TEM) of the GDP-32 multi-function electric instrument, and the transmitting system adopts the NT32 and NT20 transmitter according to the different conditions.

3 Data processing and data interpretation

Because the device system of the small loop source transient electromagnetic detection device is different from the conventional loop device, the processing and interpretation of the data are different. Because there is no software that is used for data processing and inversion of the rectangular small loop source transient electromagnetic method at present, the existing transient electromagnetic method is used to deal with commercial software. In order to process and retrieve data, the following steps are taken in dealing with field measured data.

(1) Data sorting: Reordering the data observed at different points in the measuring line according to the order number from small to large, the X coordinates and Y coordinates are both logarithmic coordinates, and the induction electromotive force curve of each measurement point is obtained. The correlation calculation is obtained through the selection of the device and the induction electromotive force curve of all measuring points. The reference curve of the line.

(2) Preprocessing: According to the selection of the current turn off time, the induction electromotive force curve of each test point is adjusted, including the elimination of the invalid data at the beginning of the turn off time and the end of the curve, and the induction electromotive force curve of the intermediate attenuation section is retained. This step needs to be adjusted repeatedly according to the results of the curve and the inversion chart, and each selection is different at each time. By comparing the curves and the results, we select the best processing plan for subsequent calculation.

(3) Filtering: The induction electromotive force curve of all measuring points is filtered according to a given reference curve, including distortion and singular value elimination, attenuation trend filtering, path smoothing, smoothing of point measurement and so on.

(4) Unit coefficient matrix: As the existing commercial software is a square loop device, when calculating the unit coefficient of a rectangular small loop, it is necessary to use the device parameters according to the field measurement, including the length of the coil, the area of the coil, the number of coil turns, the emission current, the length of the power supply wire, the length of the receiving coil, the surface of the coil. The product, turn number and turn off time are converted into the equivalent parameters of the square emission loop of the equivalent area, and the coefficient matrix of the device is calculated.

(5) The positive and negative calculation and mapping: According to the above parameters, the appropriate parameters are set and the FDTD forward method based on non uniform dissection is used to perform the forward modeling. The commercial inversion software is used for the inversion operation and combined with the actual geological data for mapping and interpretation.

In the above steps, the (2) to (5) steps are required to adjust the parameters of the forward and inversion calculation repeatedly according to the calculation results of different parameters, until the appropriate detection results are obtained.

4 Application example

After the construction of the two phase cofferdam anti seepage wall in a hydropower station in Yunnan, there are several leakage points in the bottom of the cofferdam in the upper and lower reaches of the cofferdam, and the peak value of the measured leakage is up to 2000~2500m3/h. Due to the existence of seepage point, the excavation progress of foundation pit is seriously affected, and the stability of cofferdam and safety of construction personnel and equipment are also endangered.

In order to find out the specific location of the leakage point, a variety of detection methods have been taken, because the top width of the cofferdam is narrow, only 5m is wide, and the heavy construction machinery has passed from time to time, and the detection results are not ideal. Finally, we try to use the GDP-32II type transient electromagnetic instrument to use the rectangular small loop source device to test the test. In addition, in order to improve the accuracy of the detection results, the EM34-3 type geodetic conductivity meter is also used to carry out comprehensive detection. According to the actual situation of the site, the detection points are carried out in two steps: first use the transient electromagnetic instrument and the earth conductivity meter to carry out the general survey of the moment of the weir at the top of the cofferdam. When the suspected abnormal parts are found, the location of the site is encrypted.

Line layout: Each line is arranged on the surface of the cofferdam and the axis of the dam. The line length of the downstream cofferdam is 150m (0+43.025~0+193.025). The layout of the survey line is shown in Figure 3, and the line position of the two instruments is the same.

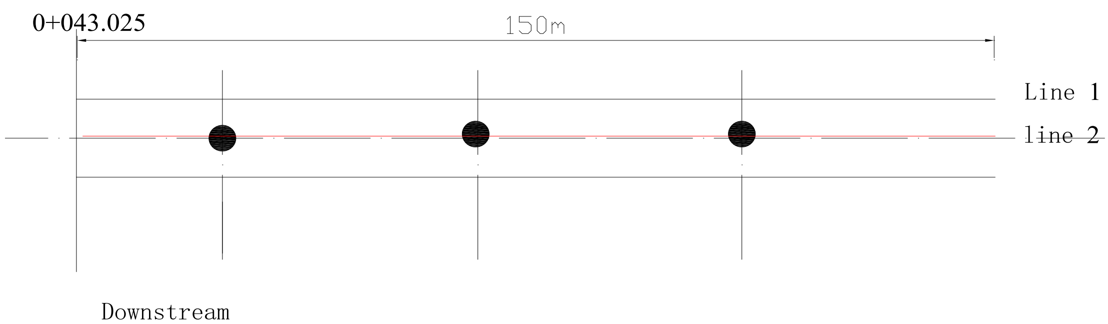


Figure 3 line layout of Cofferdam at the top of the cofferdam

Device selection: As the crest is narrower, there are metal drains on both sides of the cofferdam, and there are many electromagnetic interference factors. In order to reduce interference and improve the signal to noise ratio, the 5m x 7m rectangular small wire frame detection device is used, the receiving line frame is moved five times, the transmission line frame is moved once, the closing time is 0.0012s, and the number of turn number of the transmitting and receiving coils. It is 2 turns and the emission current is 3A.

The detection results: The detection results after the inversion treatment of the small line source transient electromagnetic method of the cofferdam line (1) is shown in Figure 4. The longitudinal axis indicates the depth of the detection, and the transverse axis indicates the number of the line.

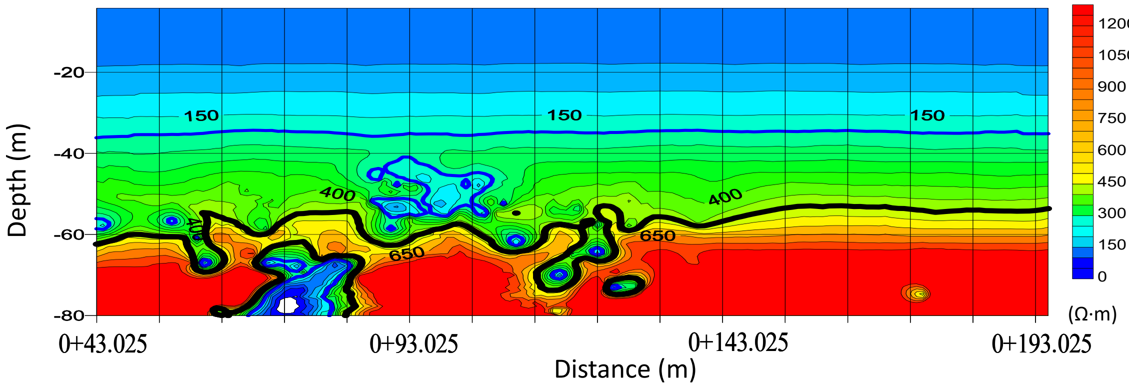


Figure 4 the inversion result of small loop source transient electromagnetic method in line 1

The results of the earth conductivity meter in line 1 are shown in Figure 5.

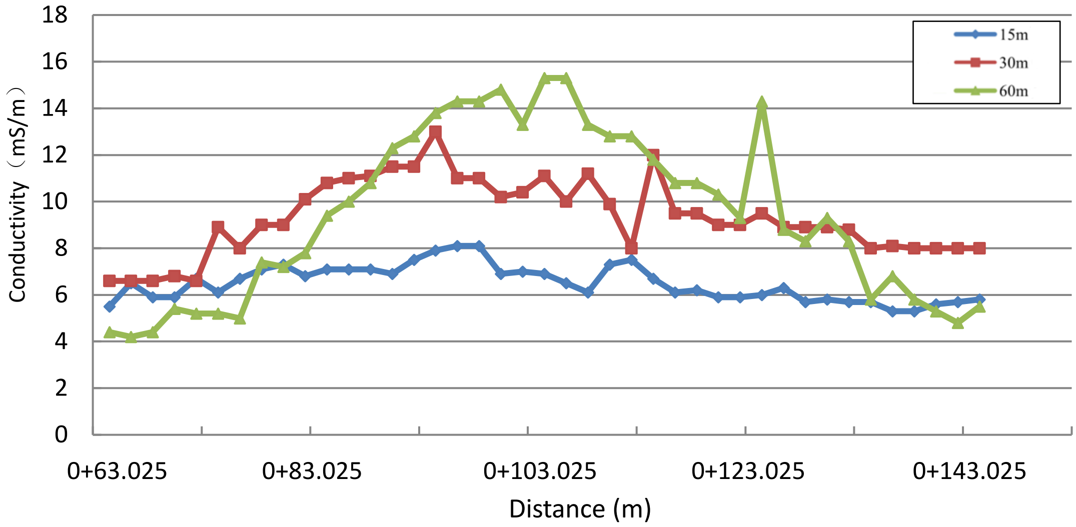


Figure 5 the result chart of the depth of the earth conductivity meter in the measuring line 1

Compared with Figure 4 and Figure 5, it is found that there is a low resistivity anomaly area in the position of pile number 0+83~0+93 and depth 40~55m in the result profile of the small loop source transient electromagnetic method, and the trend of the 30m and 60m sounding curves in the range of 0+83~0+113 is also found to be gradually increasing in the range of the pile number 0+83~0+113. It shows that there is a low resistivity anomaly area in the section, which shows that the detection results of the two methods are consistent. Compared with the site construction data, the site is in the interior of the seepage proof wall, which reflects that the impermeable wall may have discontinuous defects in the impervious wall, and the defect area is the main cause of the leakage.

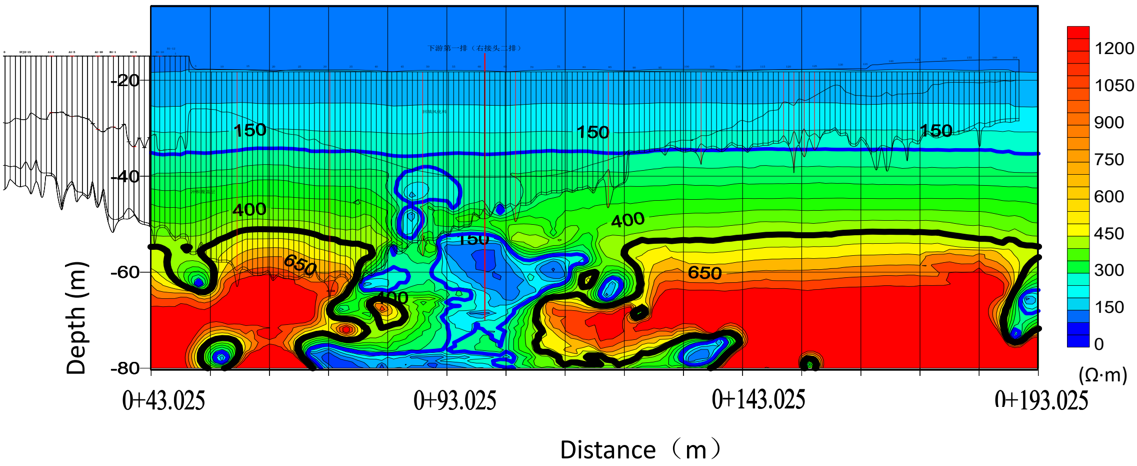


Figure 6 the inversion result of small loop source transient electromagnetic method in line 2

The inversion result of the small line source transient electromagnetic method, as shown in Figure 6, shows the depth of the longitudinal axis and the horizontal axis to represent the pile number. In order to accurately display the actual location of the leakage and facilitate the grouting and blocking, the construction section of the impervious wall is superimposed in the result map of the line 2.

The results of the earth conductivity meter in line 1 are shown in Figure 7.

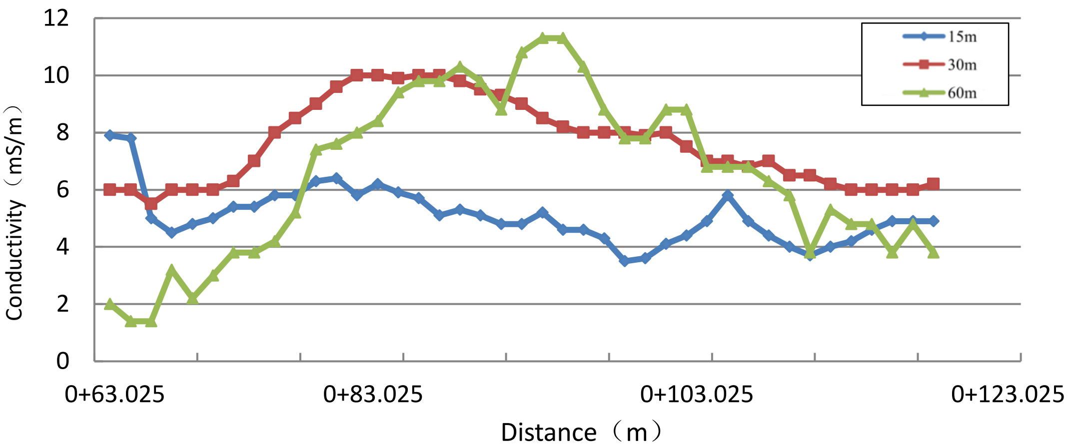


Figure 7 the result chart of the depth of the earth conductivity meter in the measuring line 2

The comparison between Figure 6 and Figure 7 shows that there is a low resistivity anomaly area in the depth 60~70m of the pile number 0+93~0+103, and there is a low resistivity anomaly area at the depth of the pile number 0+118~0+123 and the depth 50-60m. In the depth profile of the earth conductivity meter, the 30m and the 60m sounding curves are all shown. Electrical conductivity increases with pile number 0+83~0+113. In contrast to the construction drawings of the impervious wall, it is found that the site is located in the bedrock below the impervious wall. By consulting the engineering geological data of the site, there may be a broken zone in this part and the influence of the groundwater, thus showing a low resistance phenomenon. In addition to the above two parts, the position of the pile number 0+185~0+193 and the depth of the depth of 60~70m is also presented. There is a low resistance state.

A comprehensive analysis of Figure 4 to Figure 7, combined with the relative position of line 1 and line 2, shows that the high quality of the high spray wall in the downstream cofferdam is generally good, and the local inhomogeneity is not uniform. The seepage water in the cofferdam is mainly permeated by the rock fracture zone, and the main parts are concentrated in the pile number 0+93~0+103 and the depth of 60~70m.

The results show that according to the detection results, the owner organization construction unit has carried out drilling verification in the area of the upstream pile number 0+83~0+103 of the impervious wall and the depth of the depth of 40~60m. 4 inspection holes are drilled in this area, of which 3 holes are seeping in the bedrock, and the location and depth of seepage are in accordance with the results of transient electromagnetic method. In addition, two grouting and plugging were carried out on the drill hole according to the results of the detection. In the process of grouting, it was found that the leakage of water from the cofferdam was gradually cloudy. After the completion of the grouting, the leakage flow gradually decreased to 500m3/h, which was about half of the amount of leakage before treatment, greatly reducing the amount of drainage work and saving electricity and people. It can save a lot of funds to replay the impervious wall and bring great economic benefit to the project. The detection results also laid the foundation for the successful closure, guaranteed the foundation pit excavation in accordance with the normal progress, eliminated the hidden danger of the upper and lower cofferdam, ensured the safety of the cofferdam, ensured the normal construction of the foundation pit and the hydropower station, and had a huge social benefit.

5 Conclusion

According to the field conditions, two rectangular small loop transient electromagnetic detection devices are designed according to the field conditions, and the process of data processing and interpretation suitable for small loop source transient electromagnetic detection is set up according to the conditions of the field conditions. The spot detection test of leakage hidden danger has been carried out in the engineering field, and the location of the hidden leakage is found, and the direction for the treatment of the hidden leakage is found, and the results of the detection have been well verified. It is proved that it is feasible to detect the leakage of the dam and the Levee by the method of detecting the transient electromagnetic leakage of the rectangular small loop source, and the result is good and the result of the detection is accurate and credible.

Reference

[1] Fang Chun Gang, Yao Chenglin, Jia Yongmei. Nondestructive testing technology and instrument for hidden dangers and seepage of embankments [M]. Beijing: China Water Conservancy and Hydropower Press, 2010.
[2] Fang Chun Gang, Lu Ying, Ge Huaiguang, et al. A new method for detecting hidden danger of piping leakage in Chinese reservoir levees [J]. water conservancy and hydropower technology, 2001, 32 (03): 66-69.
[3] Fang Chun Gang, Lu Ying, Ge Huaiguang, et al. Transient electromagnetic testing for hidden danger of levee leakage [J]. hydropower automation and dam monitoring, 2002, 26 (5): 38-41.
[4] Fang Gang, Ge Huaiguang, Jia Yongmei, and so on. The technical problems of transient electromagnetic method used in detecting hidden leakage of levee [J]. dam observation and geotechnical test, 2001, 25 (5): 21-24.
[5] Fang Chun Gang, Ge Huaiguang, Jia Yongmei, et al. Transient electromagnetic method is used to detect hidden danger and leakage of levees. [J]. dam observation and geotechnical test, 2001, 25 (6): 30-32.
[6] Lin Zhi Guang, Mei Han. Analysis of the development of hidden danger detection technology in China from the application of SDC-3 type dam hidden trouble detector [J]. Guangdong water conservancy and hydropower, 2004 (3) 14-16.
[7] Yao Cheng Lin, Li Ping, Zhao Wenbo, et al. Safety inspection and evaluation system for hidden dangers of dams, [M], 2005,14-24.