Determining subsidence of soil layers in the process of building soil embankment

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Abstract

Nowadays, the deformation monitoring of dam work has done mainly by conventional geodetic methods, these advantages are high accuracy but which only allows to monitor the movement of dam at the top. Thanks to developing techniques which are able to monitor the settlement of layer soils while parts of structures are building. This paper presents the magnetic disk using for monitoring movement of embankment at HuongDien hydroelectric plant, Hue province.

Keywords: Soil layers,Subsidence, Rock movement, M*agnetic disk, HuongDien hydroelectric plant*.

1. The principle of operation of magnetic disk method

The magnetic disk, a kind of matter technical tool for monitoring the subsidence with layers, is firstly used to observe at a number of constructions such as hydroelectric dams, air platforms, roads, etc. These days, this instrument allows to measure and record data continuously, which is put into special positions to determine the subsidence in a continuous way (Ha, N.V (2013), Khanh. T (2010)).

The magnetic disk surveying method bases on electromagnetic field between a top reading and a round magnet ring which is fixed at stable soil, where the height of observation marks, as follows:

At the observation mark Pi (i=1,2,...,n) putting n magnetic disks with surface of disk is in the horizon, this surface creates a magnetic, when a wire fence is put on the disk, an electric current is created and detected by alarm accessories (alarm light, alarm ring). These signals help surveyors to determine when the wire fence lies on the surface of the disk. In the next step, the rule is rolled to measure a differential height between Pi and a reference datum (A) or another mark (O) which is fixed in a directional tunnel before (Fig. 1) (Ha, N.V (2013), Khanh. T (2010))..

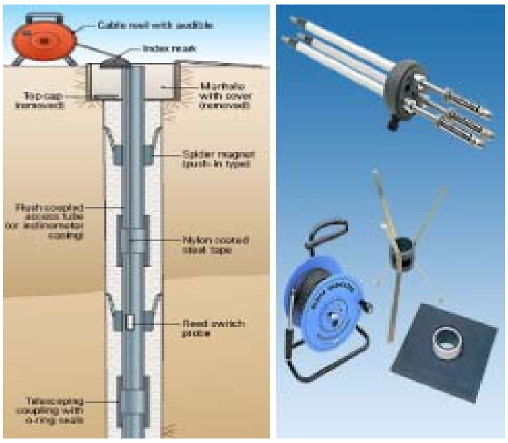

Fig.1. Diagram of magnetic disk monitoring design

If readings at O point and P point are Lo, Lp respectively then the height of P can be calculated, as in:

- Based on the height of point A (H_A):

$$H_P = H_A - L_P \quad (1)$$

- Based on the height of O (H_O):

$$H_P = H_O + L_O - L_P \quad (2)$$

The value of monitoring settlement points is determined by comparing the elevation points between two cycles like the conventional geodetic methods.

Accessories ofmagnetic disk are set into a borehole to monitor the vertical deviation taking into account structures. This technique can be applied to monitoring settlement at boreholes, struture of embankments, etc.

A magnetic disk system includes magnetic spider, magnetic mark, telescoping, direction of casing and cable in Fig.2, 3, 4, 5 below. The component of this equipment has also magnet disk which is set along the direction tube plays a role as the reference of observation marks P_1, P_2,...$P_{n.}$ These disks, covered by soil, can go down and go up when lateral earth movement occurring.

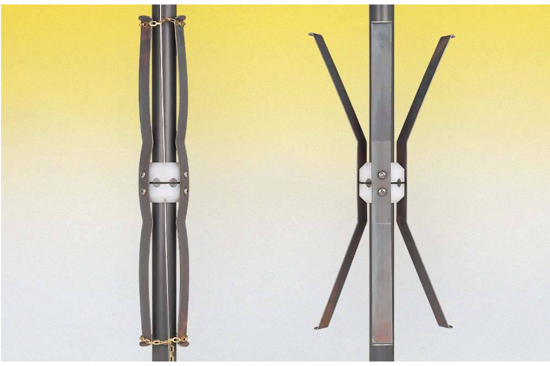

Fig. 2. Magnetic spider

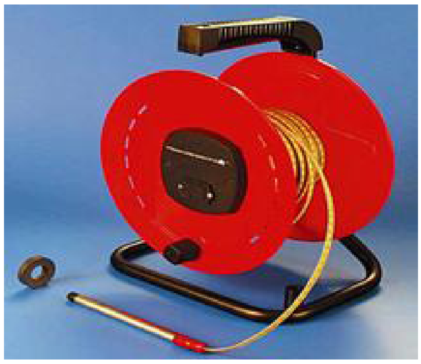

Fig. 3. Reel anEd Cable

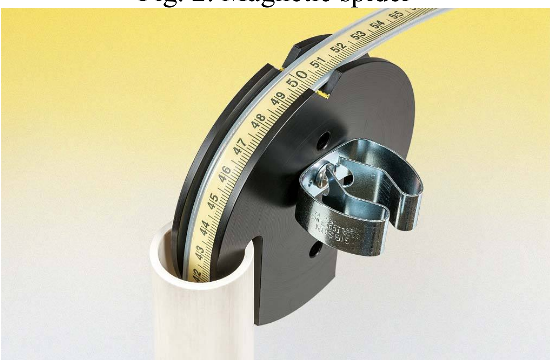

Fig. 4.Readout and direction of casing

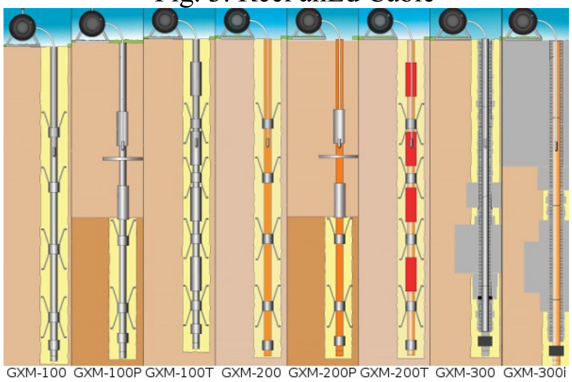

Fig. 5.Schematic of magnetic probe inserted in casing that is installed to monitor ground deformations

2. Determined the displacement by magnetic disk method

After finishing the setup work, the field work can be started. Data is stored reply on the deep of magnet disk that a probe in the orientation of casing is pulled up. When the probe is put into the magnetic field, a switch will stop and then light turn on, ring the bell. Surveyors measure the data by using metric ruler with millimeter segment, the depth is compared to A point. The process of field work is carried out as following:

Switching on the machine, dropping the probe at the bottom of casing, then pulling it until hearing a ring of bell (at the first time), next pulling it continuously until the ring of bell appears at the second time. At the first alarm it is to detect a rude position of magnet and to attach the attention of surveyor, then the second alarm we can achieve the fine position of magnet, its depth is able to measure by a string ruler. Continuously, pulling the probe at other observation marks until the last magnet.

When the casing is fixed at the basement, the elevation of each observation mark is compared to reference datum at the bottom of casing (O), or A point at the top of casing. The subsidence of monitoring points is determined by in comparison with between the current height and the height at the first cycle. (Ha, N.V (2013), Khanh. T, Phuc. N.Q (2002))

3. The accuracy of magnetic disk method

There are three mainly errors influence the precise of this method, including:

3.1 Reading error, sensitivity of equipment error (when putting measuring point on magnet surface) and variable length of bar error. According to the metric ruler with milimeter segment, the reading error is less than 0,5mm.

3.2 The secondary error is affected by the accuracy of instrument, to reduce this impact by computing the mean. (in practical, these differential value is not over 1 to 2 milimeter).

3.3 The variable ruler error is a change of length depended on temperature into casing. The variable value can be calculated following:

$$\Delta L_P = L_P.\alpha.(t - t_0) \quad (3)$$

It is supposed that, materials of ruler is an alloy (thermal expansion coefficient $\alpha \approx 1{,}25x10^{-5}$), the length L ≈ 50m, if the temperature changes ± (5÷10) degree celsius then the value of variable length is ± (3÷6) mm.

3.4 The value of root mean square error is approximate ±(5÷8) mm[Khah. T] following by magnetic disk method. To improve this precise needed to modify an effect of temperature during at the measuring moment. Normally, to solve this task the instrument must check and calibrate before utilization. The thermal expansion coefficient (α) needs not only to determine but also measures temperature of casing throughout the monitoring process. The thermal expansion coefficient can be compute at The Quality Assurance centre. However, the detecting temperature of casing is very difficult because it is necessary more accessories and applied a strict procedure so that one economic advantage of this method is reduced labor time and travel.

It could be indirectly defined deviation of a length of ruler, as in: O point is holed into a firm soil and it has a reference height Ho. For each cycle, It is necessary to determine elevation of A point (at the top of casing see Fig. 1) using a geometric method. The real distance between two point A, B is adjusted a thermal deviation, It can be calculated by:

$$L_0 = L_0^{'} + L_0^{'}.\alpha.(t - t_0); \quad (4)$$

$L_0^{'}$ is a measuring length.

vì: $L_0 = H_A - H_0$, so that:

$$\alpha(t - t_0) = \frac{H_A - H_0 - L_0^{'}}{L_0^{'}} \quad (5)$$

Substitute the left side of equation (1.8) for the respective element of the right side in equation (6), compute the deviation for length or ruler at monitoring moment P, written by:

$$\Delta L_P = \frac{L_P(H_A - H_0 - L_0^{'})}{L_0^{'}} \quad (6)$$

Hence, the computation of the direct deviation by equation (3) using parameter α, t it is hard to solve) that can be replaced by the indirect method with an easier process.

Magnetic disk method, a convenient procedure, is used to monitor subsidence for many soil layers at the same horizontal position. In this case, setting up observation marks are simple in comparison with conventional methods.

4. Exprimental deformation monitoring for soil layers using magnetic disk method

To carry out the deformation monitoring of each soil layer in earth's womb, at the dams of Huong Dien hydroelectric plant with the height 65m, drilling a borehole with 27m depth, at the bottom of the borehole setting up a reference datum, then five equipments are installed to monitor at the depth 22m, 17m, 12m, 7m, 2m, respectively. Observation and reference marks are set in May 21st 2011, the defomation monitoring is be continuously done to July 25nd 2011. A monitoring equipment includes a coil of wire and a probe made of GeoKon see Fig. 6. The result of monitoring through five cycles and the value of subsidence given in table 1, diagrams of Fig. 7.

Fig. 6. Schematic structure of monitoring equipment using the magnetic disk

Table 1. Consequence of subsidence monitoring
Construction: Dam soil

Date : 19/5/2011
The height of reference datum:65m

Date /month /year	Subsidence 1 (mm)	Subsidence 2 (mm)	Subsidence 3 (mm)	Subsidence 4 (mm)	Subsidence 5 (mm)	Total of Subsidence (mm)
21/05/2011	0	0	0	0	0	0
22/05/2011	-4	-6	-12	-24	-24	-70
23/05/2011	-8	-12	-21	-37	-37	-45
24/05/2011	-11	-17	-29	-43	-47	-32
25/05/2011	-14	-20	-36	-49	-55	-27
26/05/2011	-17	-20	-44	-57	-64	-28
27/05/2011	-18	-23	-48	-64	-69	-20
…	…	…	…	…	…	…
11/07/2011	-20	-25	-56	-82	-95	0
18/07/2011	-20	-25	-56	-82	-95	0
25/07/2011	-20	-25	-56	-82	-95	0

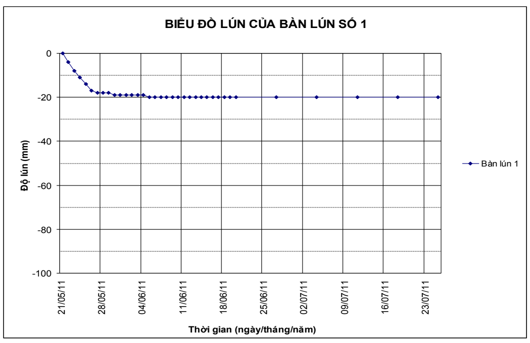

Fig. 7. Graph of subsidence 1

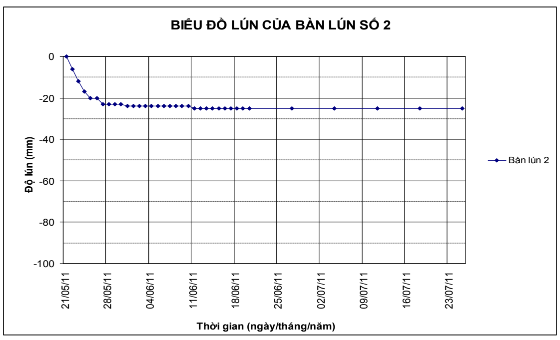

Fig. 8. Graph of subsidence 2

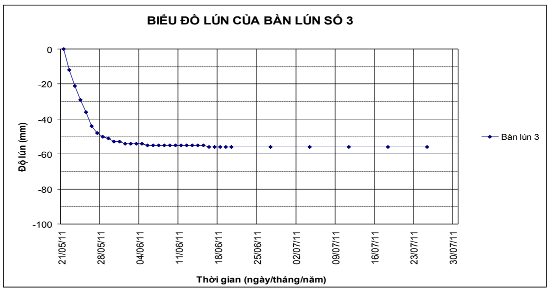

Fig. 9. Graph of subsidence 3

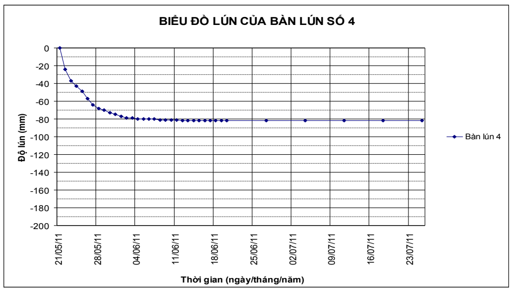

Fig. 10. Graph of subsidence 4

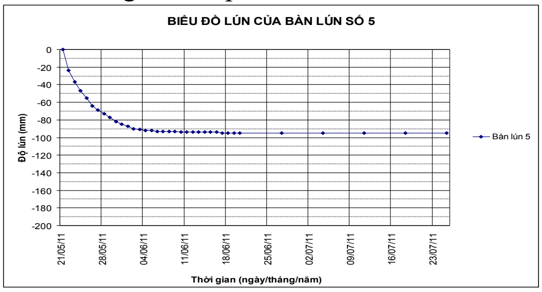

Fig. 11. Graph of subsidence 5

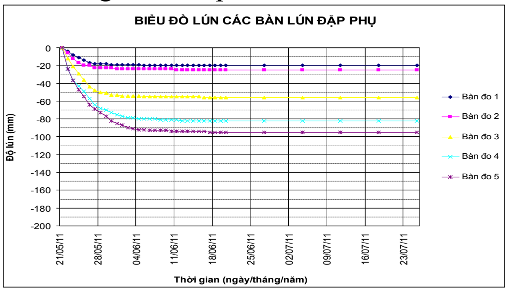

Fig. 12. Graph of subsidence for all of them

5. Conclusions

It can be apply the magnetic disk method for determining the subsidence of soil layers in structures, such as tunnel mines, open mines, embankments, airports, and routes...

This method allows to compute an elastic soil internal structure, so It can be evaluate both deformation and its cause to predict for safety of construction.

Based on experimental results, it can be calculated the subsidence of each cycle with a reliable accuracy.

It can be combined an inner soil monitoring and a surface monitoring to analyse causes of subsidence for unstable positions like above undergrounds.

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