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Installation and Utilization of Automated Data Aquisition and Transmission System of the Tiltmetric Network in the Enguri Dam

Vakhtang Abashidze*, Tamaz Chelidze, Irakli Jibladze***, Teimuraz Tsaguria***

* *M. Nodia Institute of Geophysics, Tbilisi*
** *Academy Member, M. Nodia Institute of Geophisycs, Tbilisi*
*** *"ALGO",Ltd, 6, J.Bagrationi, 0160, Tbilisi*

ABSTRACT. The old observation system at Enguri High Dam based on tiltmeters' network (visual readings and data transfer to Tbilisi once per month) was unable to give operative, real time information on the current deformation processes in the dam body. Now an automated telemetric system is installed on the dam, which allows acquisition and transfer of data from three tiltmeter stations to Tbilisi, namely, to geodynamic laboratory of M. Nodia Instutute of Geophysics. The data transmitted have a form of electronic tables, which are operatively processed and analyzed in the laboratory. *© 2010 Bull. Georg. Natl. Acad. Sci.*

Key words: *Enguri Dam, tiltmeter network, automatic telemetric monitoring system, dam diagnostics.*

In the 1970s a 271.5 high arch dam, that has no analogy in the world's hydrotechnical construction for its technical parameters and engineering arrangements, was built on the river Enguri. Although its unique features inspire great proud, on the other hand it creates a great potential danger as far as it is built in a seismically active region of complex geological structure. For this reason, during its planning and constructing period and as well as nowadays it has been an object of geophysical, geodesic and other kinds of observation.

Tiltmeter and strainmeter monitoring of the foundation of the dam began in 1970 and is continued at present. Since 1998 tiltmetric monitoring has been carried out in dam body part as well. Today, 7 different points of the dam are observed (Fig. 1). As is shown in the Figure the points under monitoring are 360 m, 402 m and 475 m levels of sections 12 and 26 and on the 402 m level of section 18. The whole object is equipped with model 701-2 electrolyte tiltmeters constructed by the company "Applied Geomechanics". These tiltmeters with two coordinates and a platform are characterized by high accuracy; they are installed in such a way that the X-component shows the tilting of the dam to the reservoir or to the down stream toe and the Y-component - its tilting to the right or left banks. The reading device that was constructed at the Institute of Geophysics is visually checked daily or bi-daily. At the end of the month the material is sent to Tbilisi where the data are finally computerized, the diagrams are constructed and analysis on the strain state of the dam is made. At the end of the year a general report is made to the customer organization - "Engurhesi", Ltd.

As a result of the tiltmetric monitoring the general uniformity of the dam movement during the water regulation in the reservoir was revealed. In case the water level is minimized the dam tilts to the reservoir, and when it is full it tilts to the down stream toe. During such movements it forms hysteresis curves. The curve

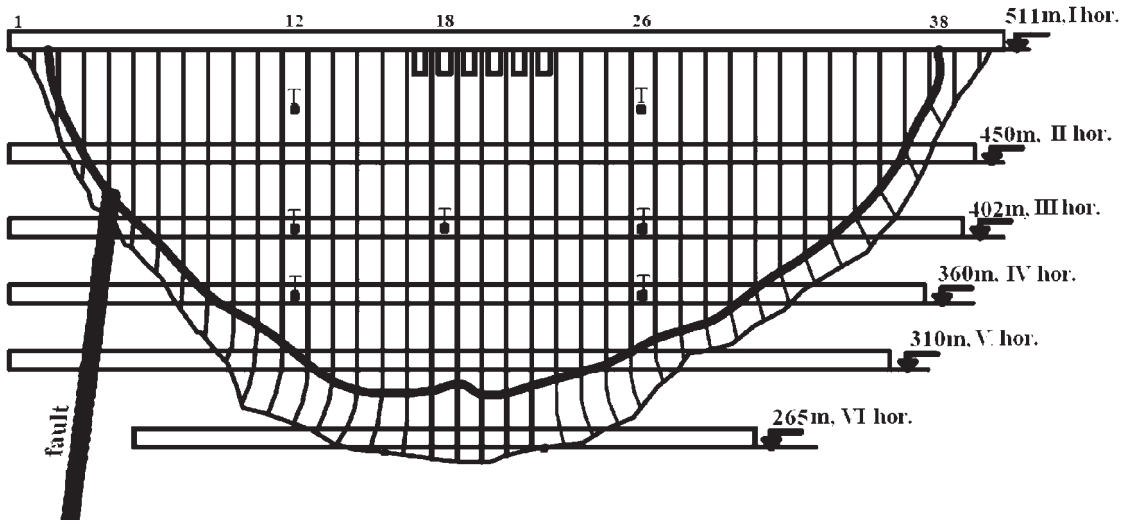

Fig. 1. Scheme of location of tiltmeter stations (T) in the body of Enguri Arc dam

configuration depends on the speed of filling and discharge of the reservoir, its stationary condition, accelerations and variations of minimal levels in the reservoir in different years [1, 2]. The above mentioned hysteresis curves bear information on the elasticity character of the whole system (dam-base).

As is known, hysteresis is not observed in Hooke's bodies. The cracks in the body and other processes in it make it decline from its linear behavior. Therefore, we suppose that obtaining hourly data from the tiltmeters, their processing and analysis will give us a possibility to make a detailed diagnosis on the safety condition of the dam.

The earlier monitoring system was not suitable for operative transmission (in real time) of information on the deformation processes of the Enguri dam. From the technical viewpoint, the tiltmeter data compared to other kinds of data are more informative for their high accuracy and information transmission frequency. The tiltmetric monitoring may reveal such detailed changes in the dam movement that would not have been noticed by other methods. Therefore, such kinds of automatic system should be used on similar constructions of major importance together with other methods [3-6].

For the automated tiltmetric monitoring on the dam the Institute of Geophysics prepared a technical project. The organization "ALGO", Ltd was ordered to construct the telemetric apparatus in accordance with the project. After testing it in Tbilisi this apparatus was installed on the 360m, 402m and 475m levels of section 12 of the dam. The data acquisition and transmitting system is an apparatus-program complex that supports the collection of data in the form of an electronic data table and their transmission to the diagnostic center in Tbilisi for further processing and analysis of the material.

The system consists of several terminal controllers (in accordance with the quantity of points) and a central controller that is connected with the GSM/GPRS Modem (Fig. 2). The diagnostic center is equipped with a computer with a static IP address connected to Internet and supported by proper server programs. The number of the objects under monitoring and their geographic areas connected with one computer is limitless in the GSM/GPRS cover zones.

A terminal controller is a microprocessor with 3 similar inputs on the one hand, and RS485 interface - on the other. The number of inputs may vary according to the tasks. The diagram in Fig. 2 shows the controllers linked to a sensor that provide continuous measuring of the tilt X and Y components and the temperature t and their transformation into digital data. The terminal controllers are linked to the central controller by a RS485 bus-bar. The bus-bar is presented as a couple of overwound wires that are connected with all terminal and central controllers simultaneously. The permissible total length of the bus-bar is 1300 m. The maximal number of controllers connected to one bus-bar is 32.

The central controller receives information alternatively from the terminal controllers linked with the bus-bar, and then collects data in its memory and automatically transmits them by means of the modem in regular time intervals to the diagnostic center database. The transmitting time intervals are defined according to tasks and vary from one minute to several days. Extraordinary transmission of data from the objects is possible as well. The transmission is fulfilled by means of GSM/GPRS service that is quite necessary for the monitoring processes.

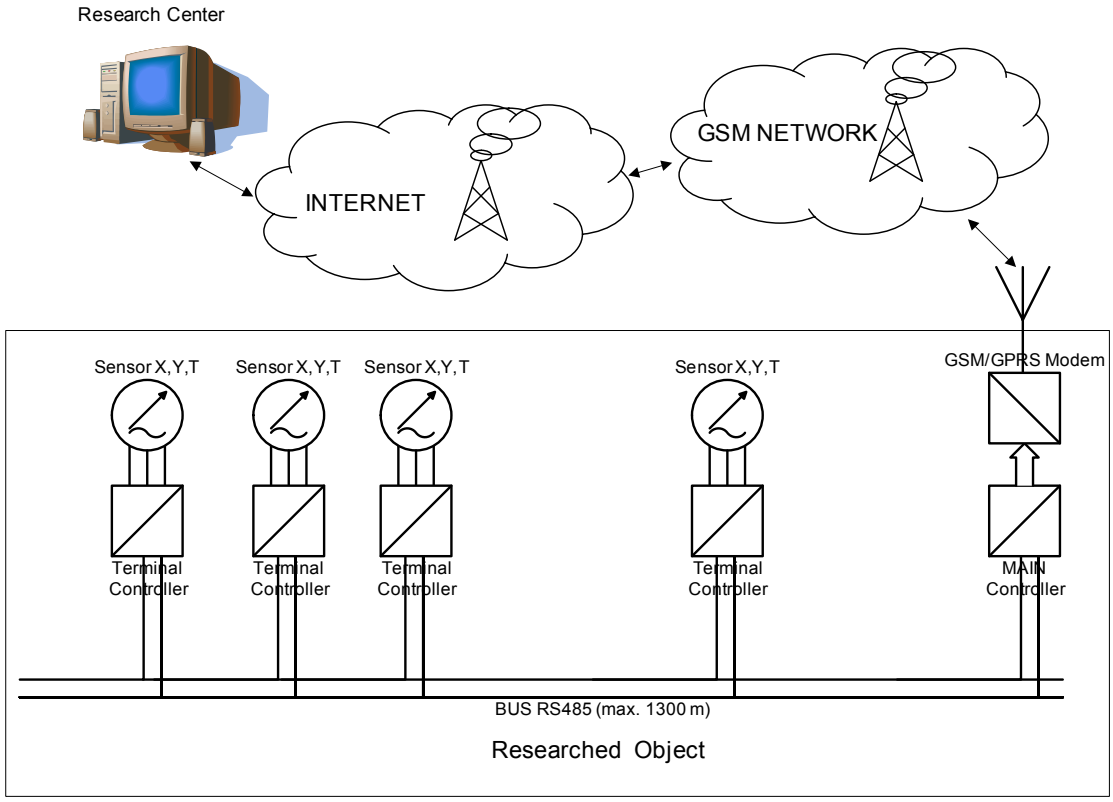

Fig. 2. Scheme of data acquisition and transmission

Table

Tiltmeter data from the Enguri Dam

№№	Date	Time	P1	X1	Y1	t1	P2	X2	Y2	t2	P3	X3	Y3	t3
1	22.04.10	10:19:01	Y	3.6485	5.1989	13.4	Y	5.0691	4.0770	13.2	Y	3.0610	2.0767	13.7
2	22.04.10	10:20:01	Y	3.6485	5.1989	13.4	Y	5.0690	4.0771	13.2	Y	3.0611	2.0777	13.7
3	22.04.10	10:21:01	Y	3.6487	5.1989	13.4	Y	5.0691	4.0770	13.2	Y	3.0614	2.0771	13.7
4	22.04.10	10:22:00	Y	3.6487	5.1989	13.4	Y	5.0691	4.0769	13.2	Y	3.0607	2.0766	13.7
5	22.04.10	10:23:00	Y	3.6488	5.1989	13.4	Y	5.0693	4.0771	13.2	Y	3.0628	2.0780	13.7
6	22.04.10	10:24:00	Y	3.6487	5.1989	13.4	Y	5.0695	4.0771	13.2	Y	3.0645	2.0783	13.7
7	22.04.10	10:25:01	Y	3.6485	5.1989	13.4	Y	5.0695	4.0771	13.2	Y	3.0608	2.0768	13.7
8	22.04.10	10:26:00	Y	3.6486	5.1990	13.4	Y	5.0694	4.0770	13.2	Y	3.0611	2.0765	13.7
9	22.04.10	10:27:00	Y	3.6486	5.1991	13.4	Y	5.0694	4.0771	13.2	Y	3.0625	2.0776	13.7
10	22.04.10	10:28:00	Y	3.6485	5.1990	13.4	Y	5.0696	4.0771	13.2	Y	3.0609	2.0763	13.7
11	22.04.10	10:29:01	Y	3.6487	5.1990	13.4	Y	5.0694	4.0771	13.2	Y	3.0618	2.0802	13.7
12	22.04.10	10:30:01	Y	3.6487	5.1990	13.4	Y	5.0694	4.0770	13.2	Y	3.0596	2.0754	13.7
13	22.04.10	10:31:01	Y	3.6487	5.1989	13.4	Y	5.0694	4.0772	13.2	Y	3.0624	2.0753	13.7
14	22.04.10	10:32:01	Y	3.6487	5.1990	13.4	Y	5.0693	4.0770	13.2	Y	3.0621	2.0763	13.7
15	22.04.10	10:33:00	Y	3.6487	5.1990	13.4	Y	5.0691	4.0769	13.2	Y	3.0612	2.0777	13.7
16	22.04.10	10:34:00	Y	3.6486	5.1990	13.4	Y	5.0693	4.0770	13.2	Y	3.0636	2.0773	13.7
17	22.04.10	10:35:01	Y	3.6486	5.1990	13.4	Y	5.0691	4.0769	13.2	Y	3.0578	2.0748	13.7
18	22.04.10	10:36:00	Y	3.6486	5.1990	13.4	Y	5.0693	4.0771	13.2	Y	3.0603	2.0760	13.7
19	22.04.10	10:37:01	Y	3.6486	5.1990	13.4	Y	5.0693	4.0770	13.2	Y	3.0639	2.0775	13.7

The central controller in the data exchange process functions as FTP client by means of the GSM/GPRS modem, and the computer in the diagnostic center is supported by FTP server and a special utility that provides the input of the data received from the client into the database. The central controller is operated

and configured by SMS directives from the research center.

The central controller in regular time intervals receives the data from the terminal controllers and saves them in its memory. The database records the arrival time and the ordinal number of the data. Moreover, it informs about the presence or absence of electric power both for the central controller and for each terminal controllers. In case of electric failure the controllers are fed from the local batteries.

The memory size of the central controller is 262144 bytes. In the case of 3 terminal controllers the average size needed by one datum is 105 bytes. Thus, in a minute data transmission regime the whole memory is sufficient to save information for 41 hours. It is obvious that the information keeping duration will increase for a longer interval regime that is intended in the nearest future.

As an example, we present a Table of data received from the Enguri Dam by means of Internet on 22.04.10 from $10^h\ 19^m$ to $10^h\ 37^m$ in a minute regime, where X_1Y_1, X_2Y_2 and X_3Y_3 are the apparatus data respectively for the 360 m, 402 m and 475 m levels of section 12 and t_1, t_2 and t_3 are the temperatures of the cells where the apparatuses are installed. Hereby, the information about the electric source Y is also presented (Table).

After processing of the above material we obtain information about the dam tilts in angle seconds or about its displacement against the dam axis according to the current technogenous and tectonic processes.

It is doubtless that the accurate data received in short time intervals from tiltmeters will give us huge information about the technical state of the dam. As we mentioned above, due to financial conditions such automatic apparatus is now installed only at 3 points. Thanks to financial support of the Board of the Enguri Dam the remaining (four) stations will also be equipped in 2010 by modern apparatus that is quite significant for the operative diagnostics of the dam.

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გეოფიზიკა

ენგურჰესის კაშხლის დახრისმზომთა ქსელის მონაცემთა შეგროვებისა და გადმოცემის ავტომატური სისტემის დაყენება და ამუშავება

ვ. აბაშიძე*, თ. ჭელიძე, ი. ჯიბლაძე***, თ. ცაგურია***

* *მ. ნოდიას გეოფიზიკის ინსტიტუტი, თბილისი*
** *აკადემიის წევრი, მ. ნოდიას გეოფიზიკის ინსტიტუტი, თბილისი*
*** *შ.პ.ს. "ალგო", ჯ. ბაგრატიონის 6, 0160, თბილისი*

ენგურის მაღლივ თაღოვან კაშხალზე დახრისმზომთა ქსელის საშუალებით დაკვირვებების ადრე არსებული სისტემა (ვიზუალური დაკვირვებები და მასალის თვის ბოლოს თბილისში გადმოგზავნა) არ იძლეოდა საშუალებას, კაშხალზე მიმდინარე დეფორმაციული პროცესების შესახებ ოპერატიულად, რეალურ დროში მიგვეღო ინფორმაცია. ამჟამად 3 სადგურზე დაყენებული მონაცემთა შეგროვებისა და გადაცემის ტელემეტრიული სისტემა წარმოადგენს აპარატულ-პროგრამულ კომპლექსს, რომელიც უზრუნველყოფს ენგურის კაშხალზე გაზომვების შედეგად მიღებული მონაცემების შეგროვებას ელექტრონული ცხრილის სახით და გადმოცემას კვლევის ცენტრში - თბილისში, გეოფიზიკის ინსტიტუტის გეოდინამიკურ ლაბორატორიაში მასალის ოპერატიული დამუშავებისა და ანალიზისათვის.

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