RESEARCH OF PHYSICAL PHENOMENA OCCURRING IN COMPLICATED DYNAMIC SYSTEMS AT SEISMIC LOADS

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Abstract – The informational-measuring system is developed, which realizes the continuous tracking, detection and registration of seismic events in digital and graphic forms. The system is set on "Her-Her" dam in Republic of Armenia. The results of measurings and analysis of dynamic processes parameters are stated, which are take place in body of dam. The system can be used for monitoring of other hydropower constructions and atomic power plants.

Hydropower constructions, their high dams at seismic loads behave as complex dynamic systems. During long-term exploitation because of different reasons irreversible processes take place in the body of dam, which can negatively be shown at earthquakes. For behavior forecasting of such constructions at seismic loads the network of complex instrumental and geophysical monitoring [1, 2] should be organized. The material getting in the result of this monitoring can serve as a base for constructions projecting methods perfection, right counting of seismic forces, as well as for conducting of necessary aseismic preventive arrangements.

With this aim the informational-measuring system (IMS) of monitoring and testing [3-5] is developed, which realizes the continuous tracking, detection and registration of seismic events in digital and graphic form. The system is set on "Her-Her" dam in Republic of Armenia. This water storage is located in Vayk Region of Republic of Armenia, on the feeder Her-Her of Arpa river at 5,5 km distance from Vayk town. The dam height is 71,5 m, the water storage volume 26 million m^3, water surface – 160 km^2. The water storage has also the local water-power plant by power of 0,5 MW. The water storage is constructed in 1982. IMS allows:

- to conduct continuous monitoring of exploitation object and to forecast the possible development of dangerous seismic deformations;
- to provide the storage of actual data on construction behavior during earthquakes.

IMS consists of hardware part and program control. In hardware part the seismosensors [2] are used:

- of C-069 type for measuring of seismomovements speed at dynamic processes;
- unicomponent accelerometer of OSP-2M type for movements acceleration measuring;
- three-componental bore hole accelerometer of C-062 type.

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Computer, printer, power supply unit, commutator of analog signals C-036 [3], 14-digit position module of analog input-output (ADC) of AI16-5A type of Fastwel firm are also the parts of hardware part. The module is executed in MicroPC format and is intended for converting of 16 voltage signals or 8 current signals into 14-digit position additional code. The resolving ability of ADC module is 14 position. The modules AI16-5A are put out only with connector ISA, so the computer motherboard should have ISA expansion slot. Commutator control is realized by module with the help of 8 channels of oscillations. On seismic event coming the system begins the recording of all sensors data in file, which then can be printed out in form of diagram or saved in diskette in digital form.

Any seismosensor (or their group) can serve as starting. To this seismosensor the definite threshold of sensitivity is being assigned (the value of the threshold can be changed by system program). When the signal is coming from any of events, the level of which exceeds the set threshold of sensitivity, the pointed seismosensor launches the system.

In fig.1 the general view of dam with allocation scheme of supervision points (SP) and objects of engineering-seismometric system on dam are given. In this case as starting seismosensor P1-S4 is chosen, which is set in SP-1 (table 1).

Continuous tracking in 2005 showed, that there were not earthquakes. Nevertheless rather interesting and useful information is obtained concerning local phenomena. The supervisions allow to fix the complex geodynamic processes, which take place in dam and its adjacent territory. For example, on 12 August, at 3.49 by local time the event took place, which can not be considered as seismic phenomenon by its character.

For the pattern to be clear, from the numeric data of recordings the time interval ± 0,5 s is taken relatively to the moment of system launch and in Excell program the recording of this interval is drawn (fig. 2). The recording step is equal to 5 ms, so in recording there are 200 points, 100 of them correspond to time interval before the event, and 100 points – after the event. The duration of the event amounts only 10 ms.

The obtained recordings of speeds and accelerations of occurred motion in body of dam are given in table 1. The general parameters of seismosensors are also given there. The epures of speeds and accelerations allocation by supervision points are drawn (fig.3), as well as by bore holes and inside pool of dam (fig. 4). The analysis of getting results allows to draw the following conclusions.

1. In all supervision points the vertical components both of speeds and accelerations are greater than the horizontal components.

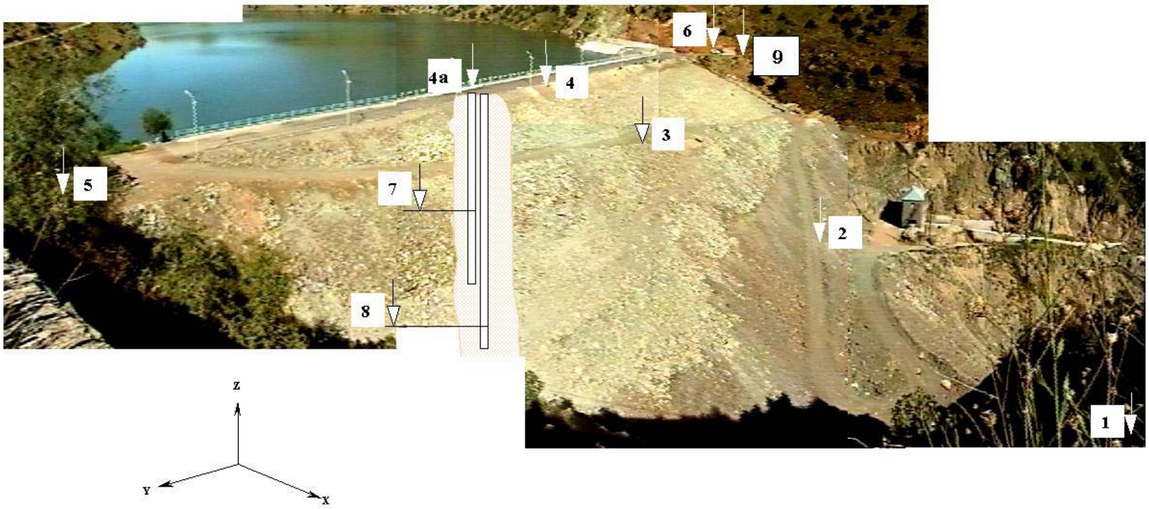

Fig. 1. General view of dam on “Her-Her” water storage; the arrows and numbers show the places of supervision points (1-8), as well as the registration hall (9)

2. The maximal accelerations (0,0397 m/s2 – the vertical component, 0,0034 m/s2 - the horizontal component) and speeds (0,0068 m/s - the vertical component, 0,0014 m/s - the horizontal component) are obtained in SP-6 (fig. 2, 3). The special interest is the vertical component of acceleration, which is almost single-order greater of accelerations obtained in rest of supervision points. It allows to conclude that the motion took place on the left hill which adjoins dam, in vertical surface, very close to Earth surface.

3. The epures of bore holes and inside pool comparison shows that the vertical component of accelerations in body of dam increases, amounting the highest value (0,0035 cm/s2) in first bore hole (17 m), then in SP-4 decreases (0,00225 cm/s2). And vise versa, in inside pool, in SP-3, which has the same hypsometric height as SP-7 located in first bore hole, the least values of vertical component (0,00191 cm/s2) are obtained. In contrast to vertical component of accelerations the horizontal component is less than in SP-1.

4. In bore holes the recordings of horizontal Y-component are also obtained. In SP-7 it exceeds two times the horizontal X-component, and in SP-8 - almost three times. It can serve as one more confirmation that in left hill region adjoining the dam the geodynamic process took place.

The concerned event is not an earthquake, as in recordings both longitudinal and transverse waves with their inputs are not marked out. Besides, the duration of event is very short, only 10 ms. In case of seismic events the seismic waves are spread from the depth to the surface. In our case the inverse view has a place, which is caused by event location focus (very close to Earth surface). All these allow to assert that deformation of dam is connected with pointed geodynamic event, and the system launching took place in the result of local processes in dam body.

The results of long-term exploitation show that the developed IMS can be successfully used also for seismic monitoring of other complex constructions (atomic power plants, bridges, etc.).

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Table 1. Recording values of event speeds and accelerations

SP number	Devise type	Recording number	Recording component	Recording parameter and devise sensitivity		Movement acceleration m/s2	Movement speed cm/s
				Acceleration V·s2/m	Speed V·s/m		
1	OSP-2MV	P1-S1	Z	44,5		0,60449	
	0SP- 2MH	P1-S2	X	49		0,41429	
	C-069V	P1-S3	Z		128,7		0,084693
	C-069H	P1-S4	X		120,4		0,053987
2	OSP-2MV	P1-S5	Z	44,5		0,37079	
	0SP- 2MH	P1-S6	X	49		0,13673	
	C-069V	P1-S7	Z		128,7		0,123543
	C-069H	P1-S8	X		128,4		0,061526
3	OSP-2MV	P2-S1	Z	44,5		0,19101	
	0SP- 2MH	P2-S2	X	61,25		0,13551	
	C-069V	P2-S3	Z		104,2		0,021113
	C-069H	P2-S4	X		114		0,012281
4	OSP-2MV	P2-S5	Z	49		0,30612	
	0SP- 2MH	P2-S6	X	44,5		0,22472	
	C-069V	P2-S7	Z		112,7		0,144632
	C-069H	P2-S8	X		124,6		0,082665
5	OSP-2MV	P3-S1	Z	44,5		0,45618	
	0SP- 2MH	P3-S2	X	61,2		0,20425	
	C-069V	P3-S3	Z		128,7		0,020202
	C-069H	P3-S4	X		128		0,011719
6	OSP-2MV	P3-S5	Z	49		3,97551	
	0SP- 2MH	P3-S6	X	49		0,3449	
	C-069V	P3-S7	Z		108,8		0,685662
	C-069H	P3-S8	X		112		0,142857
7 Bore hole (17 m)	C-062	P4-S1	X	100		0,351	
	C-062	P4-S2	Y	100		0,713	
	C-062	P4-S3	Z	100		10,88	
8 Bore hole (31,7 m)	C-062	P4-S4	X	100		0,311	
	C-062	P4-S5	Y	100		0,921	
	C-062	P4-S6	Z	100		0,803	

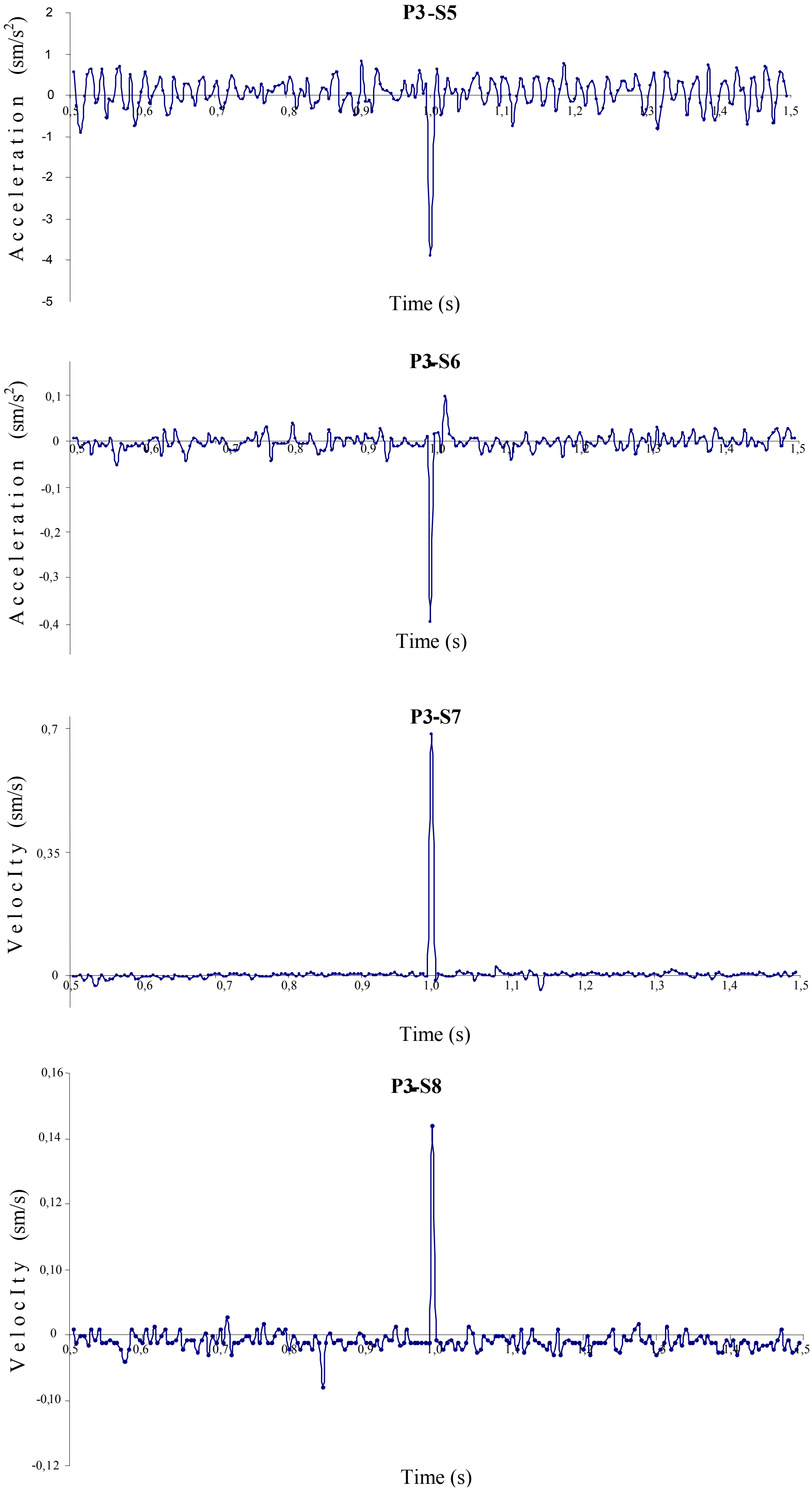
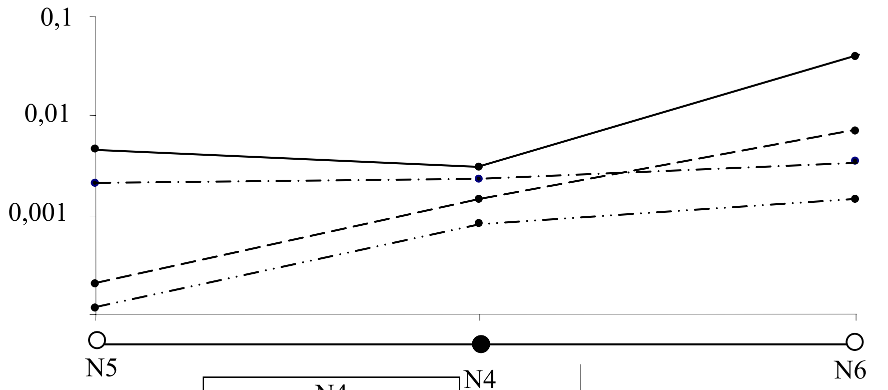
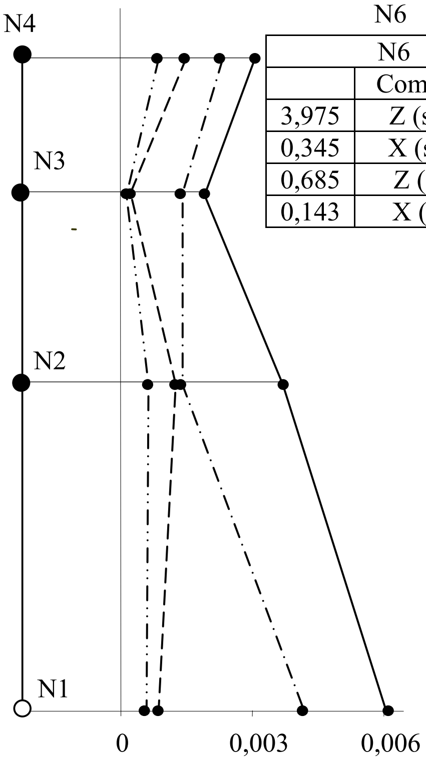


Fig. 2. Event recording in supervision point SP-6 in digital form



N5	
	Component
0,456	Z (sm/s²)
0,204	X (sm/s²)
0,020	Z (sm/s)
0,012	X (sm/s)

N4	
	Component
0,306	Z (sm/s²)
0,224	X sm/s²)
0,145	Z (sm/s)
0,083	X (sm/s)
N3	
0,191	Z (sm/s²)
0,136	X sm/s²)
0,021	Z (sm/s)
0,012	X (sm/s)
N2	
0,371	Z (sm/s²)
0,137	X sm/s²)
0,123	Z (sm/s)
0,062	X (sm/s)
N1	
0,604	Z (sm/s²)
0,414	X sm/s²)
0,085	Z (sm/s)
0,054	X (sm/s)



N6	
	Component
3,975	Z (sm/s²)
0,345	X (sm/s²)
0,685	Z (sm/s)
0,143	X (sm/s)

———— Z (sm/s²)
— · — · — X (sm/s²)
– – – – – Z (sm/s)
— · · — · · — X (sm/s)

○ - Point of supervision on a ground

● - Point of supervision on a dam

Fig. 3. Speeds and accelerations allocation epure by supervision points

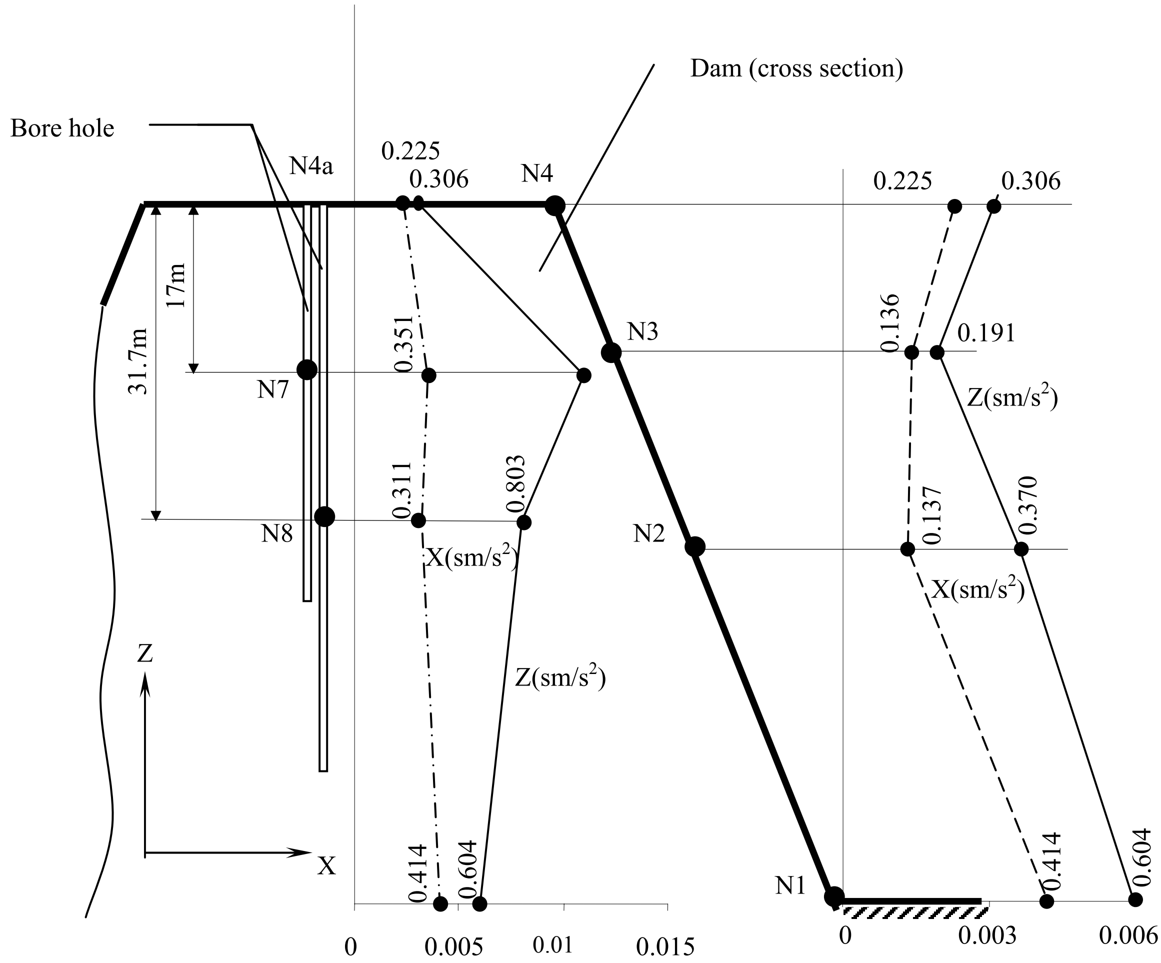


Fig. 4. Accelerations allocation epure by bore holes and inside pool.