STUDIES REGARDING THE SAFETY IN OPERATION OF MILEANCA RESERVOIR

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***Abstract**: The dam of Mileanca reservoir, located on Podriga river, is an earth dam with a maximum height of 10,08 m, that provides a global retention to the canopy of 11,116 hm^3. Mileanca reservoir is one of the hydrotechnical constructions that were build to protect against the floods downstream villages: Mileanca, Drăguşeni, Havârna, Scutari, Ştiubieni, Săveni. Between the years 2008 and 2012 investment works were implemented, under the project „Safety re-inforcement of Mileanca reservoir, located on Podriga River, in Botoşani county". The project was set out to build the following works: rehabilitation of dam body (repairs to the concrete tiles on the downstream slope, sealing screen), rehabilitation of the hydromechanical equipments, rehabilitation of the bottom outlet, rehabilitation of the evaccuation channel of the surface outlet, installation of a water management information and warning-alarm system, rehabilitation of the behaviour monitoring system. This paper presents a brief history of the dam in its construction and exploitation phases, focussing on aspects regarding the behaviour monitoring of Podu Iloaiei reservoir during the years 1997-2017.*

***Keywords:** safety re-inforcement, rehabilitation of hydrotehnic constructions, behaviour monitoring*

1. Introduction

Mileanca reservoir operated by Water Basinal Administration Prut-Bârlad, is located on the territory of Mileanca village, Botoşani county, on the upper course of the Podriga river (cadastral code XIII. 1.10.6), the left tributary of the Başeu river, about 500 m upstream of the confluence of the Podriga and Lişmănita rivers. (*Figure 1*).

The reservoir commissioned in 1973 has the following functions:

- it contributes, along with other hydrotechnical works in the area, to the protection against floods for downstream settlements in the valleys of Podriga and Başeu rivers (Mileanca, Drăguşeni, Havârna, Scutari, Ştiubieni, Săveni);
- dilution flow for the Săveni wastewater treatment plant
- irrigation;
- fishing;
- salubrious flow downstream of the dam.

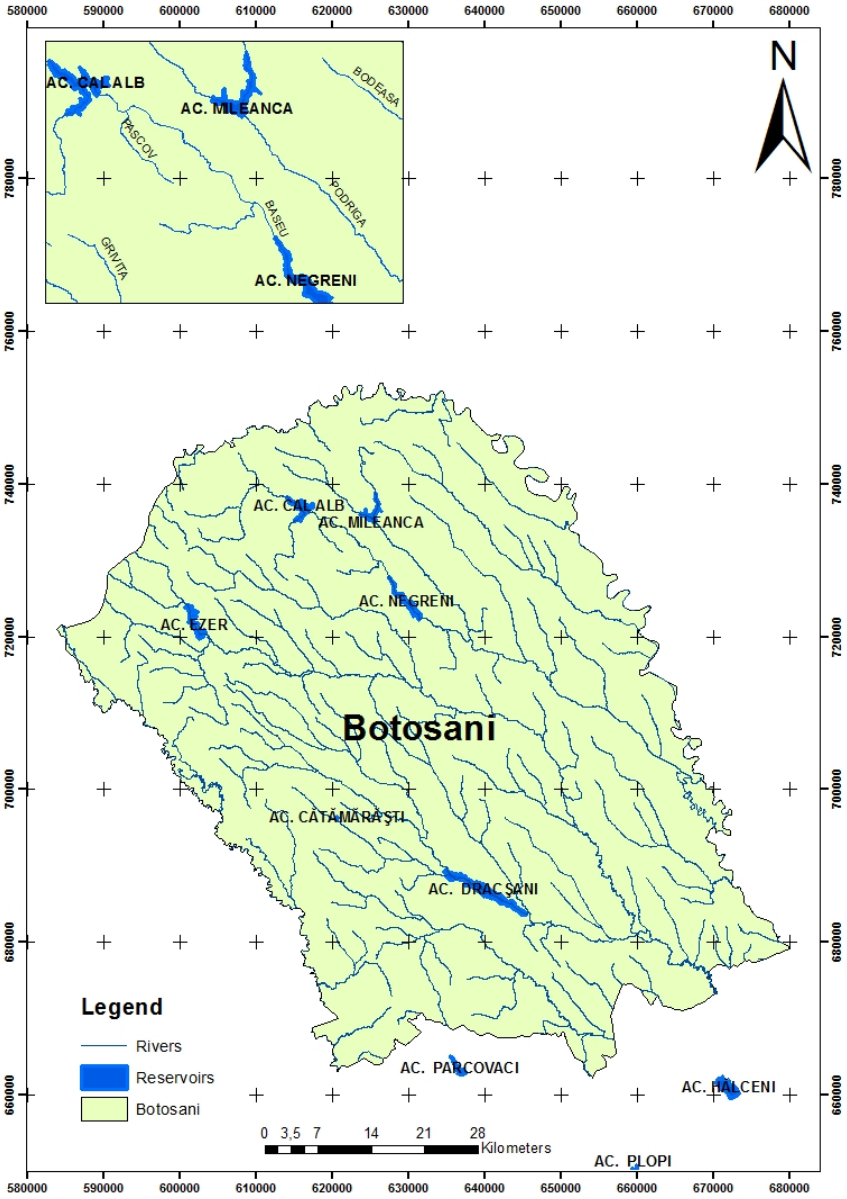

Fig. 1 Mileanca reservoir positioning map

2. Material and research method

HYDROLOGICAL DATA

The reservoir in question falls in the **III**nd class of importance and **B** category of importance. According to STAS 4068/2-62, Mileanca reservoir was sized using the flow with the probability of exceedance of 2% and was verified using the flow with the probability of exceedance of 0.5% with a 20% increase safety.

Podriga river has the following features (*Ministerul Mediului,1992*):

- catchment area in Mileanca retention section = 126 km^2;
- river length from spring to dam L = 15.0 km;
- multiannual average flow Qmm = 0.275 m^3/s

Characteristics of flood waves are presented in *Table 1.*

Table 1. Characteristics of flood waves

No	*Characteristics of flood waves*	
1	1.2x0.5% probability flow – m^3/s	234
2	0.5% probability flow - m^3/s	195
3	2% probability flow - m^3/s	125
4	Total time – hours	40
5	Increase time - hours	10
6	Form factor γ	0.35
7	1.2x0.5% probability volume – hm^3	11.796
8	0.5% probability volume – hm^3	9.830
9	2% probability volume – hm^3	6.300

GEOLOGICAL CHARACTERISTICS OF THE SITE

The site of the Mileanca reservoir is a part of the Moldavian Platform, which is characterized by uniformity of deposits that compose it. The foundation is made of marl clay horizon, at a depth of more than 7 m, consisting of marly clays, muddy clays, sand and yellow clay. The foundation is covered, in the basin, by the recent deposits, Quaternary.

COMPONENT WORKS OF MILEANCA RESERVOIR

a) The dam

Retention in Mileanca reservoir is made by a frontal dam made of silty clay, with a canopy length of 458 m, and a width of 5.0 m. The dam is provided with a drainage mattress of 0.5 m, located in the downstream third of the footprint base. Drainage culvert for water collection and drainage is 300 m long and consists of polyvinyl chloride pipes with Dn 300 mm.

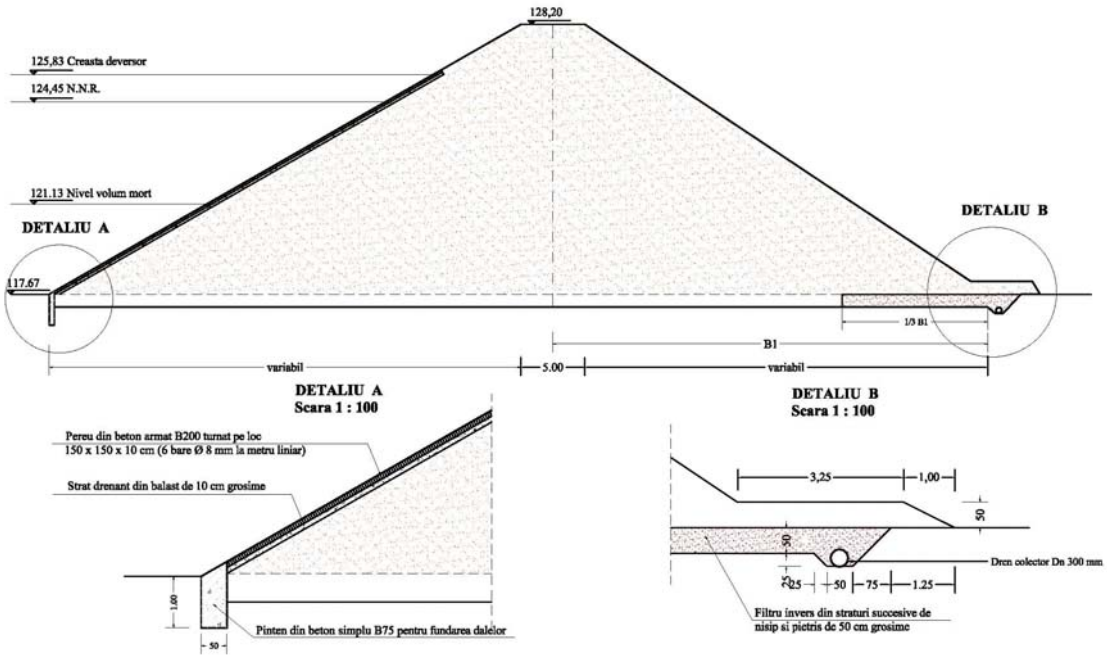

Fig. 2. Cross section of the dam body

The outlets of the dam are represented by: the high waters surface spillway, the medium water spillway and the bottom outlet in the shape of a circular opening, with the interior diameter of 1400 mm.

b) The surface spillway outlet consists of the following parts:

- the lateral threshold weir has no hydro-mechanical equipment. The concrete threshold weir has a triangular profile, with a length of 50.00 m spillway.
- the spillway channel is 50 m long and is made of reinforced concrete
- the link channel is 43 m long and is made of reinforced concrete
- the fast channel has a 18% slope and a length of 34.5 m. In order to reduce the water velocity, concrete beams were laid on the bottom, at a distance of 1.65 m between them.
- bridge that connects the dam with the left embankment is 30.0 m long and 1.0 m wide

c) Medium waters spillway

Mileanca dam is equipped with a medium water spillway that consists of 2 spillway orifices of 1.47 x 1.97 m each, placed in the lateral sides of the operation tower. The orifices have no gate and the water flow is uncontrolled.

d) Bottom outlet is a circular culvert with the diameter of 1400 mm and 65 m length. *(Figure 3*)

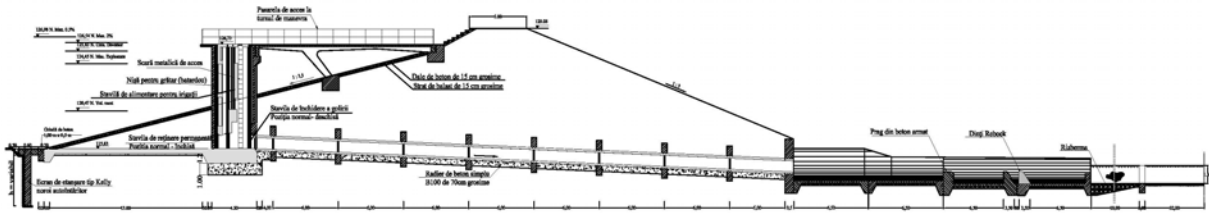

Fig. 3. Longitudinal section of the bottom outlet

Hydro-mechanical equipment for the bottom outlet consists of:

- metallic grid: 1800 x 2000 mm
- cofferdam 1800 x 2000 mm
- flat slide gate for draining the lake with dimensions of 1600 x 1800 mm, operated electrically, with normal position **closed**.

e) The water intake is located in center of the operation tower. There is a 390 x 1100 mm gate used mainly for irrigation water demand.

REHABILITATION WORKS

During the years 2008÷2012 investment works were implemented, under the project *„Safety re-inforcement of Mileanca reservoir, located on the Podriga River, in Botoşani County".*

The project was set out to build the following works: rehabilitation of dam body (repairs to the concrete tiles on the downstream slope, sealing screen), rehabilitation of the hydromechanical equipments, rehabilitation of the bottom outlet, rehabilitation of the evaccuation channel of the surface outlet, installation of a water management information and warning-alarm system, rehabilitation of the behaviour monitoring system.

CHARACTERISTIC LEVELS AND VOLUMES

The land rates reference plan is Black Sea 1975 and they were updated by topographic measurements performed by specialized staff from the Prut-Barlad Water Basinal Administration on the lake basin, dam body and related constructions in 2012 *(Table 2).*

Table 2. Characteristic levels and volumes

Parameters	***Characteristic levels***	***maBS***
Parameters determined by structural characteristics Parameters determined by the operating conditions	- bottom outlet sill	115,83
	-pipe intake level for irrigation water	116,53
	- medium waters spillway – operation tower	124,45
	-surface outlet - threshold weir	125,83
	- dam canopy	128,20
Parameters determined by structural characteristics	- normal retention level-N.R.L.	124,45
	- 2% probability of exceedance	126,54
	- 0.5% probability of exceedance	126,98
	Volumes	hm^3
Parameters determined by the operating conditions	- global (at dam canopy)	11,116
	- 2% probability level	7,702
	- at surface outlet - threshold weir	6,483
	- at N.R.L.	4,412
Parameters determined by structural characteristics	- total (0.5%2 probability level)	8,538
	- atennuation between 2% prob. level and N.R.L.	3,290
	- atennuation between 0.5% probability level and N.R.L.	4,126
	- safety (between the 0.5% probability of exceedance level and dam canopy)	2,578

Component elements of the behaviour monitoring system for Mileanca reservoir

According to the current legislation (NTLH–021/2002) **Mileanca** dam has a 0.33 risk index (established in the Evaluation of **Mileanca** reservoir safety in exploitation and the authorization number 565/2-25.11.2016), that fits the reservoir in „**B - special**”, category of importance. Monitoring behaviour is done accordingly to the „Project of special monitoring”.

Measuring installations for external stresses

- **3 vertical hydrometric stations are used to monitor hydrometric parameters for Mileanca reservoir:**

- on the upstream dam slope, near the operation tower, for tracking the evolution of the levels/volumes in the lake;
- at the surface outlet, downstream the threshold weir, for tracking spillway flows;
- at Podriga hydrometric station for tracking the evolution of outflow from the lake;

To follow the evolution of hydrological parameters in the reservoir and at the downstream hydrometric station a collecting/data transmission system for water management is in use a level sensor at the operation tower for real-time transmission of the data to the local dispatch and other levels of analysis: Botoșani Water Management System and Prut-Bârlad Water Basinal Administration.

- 1 rain gauge to measure rainfalls in the catchment of the reservoir (located near Mileanca dam)

Measuring installations of the dam response to stress

- For tracking the evolution of **vertical deformations** are used:

- 23 vertical axis landmarks on the dam;

- 1 fixed landmarks (in the left embankment of the dam);
- 2 fixed landmarks (in the right embankment of the dam);
- 1 landmark on the support pillar;

• For tracking the evolution of body dam seepage 12 piezometric wells, 8 seepage sewers and 2 outlet conduits for the dam seepage in the left and right branch in the bottom outlet channel are used;

• For tracking the evolution of seepage in the left embankment 10 seepage sewers and 1 outlet conduit for the embankment seepage in the evvacuation channel of the surface outlet are used; *(Figure 4)*.

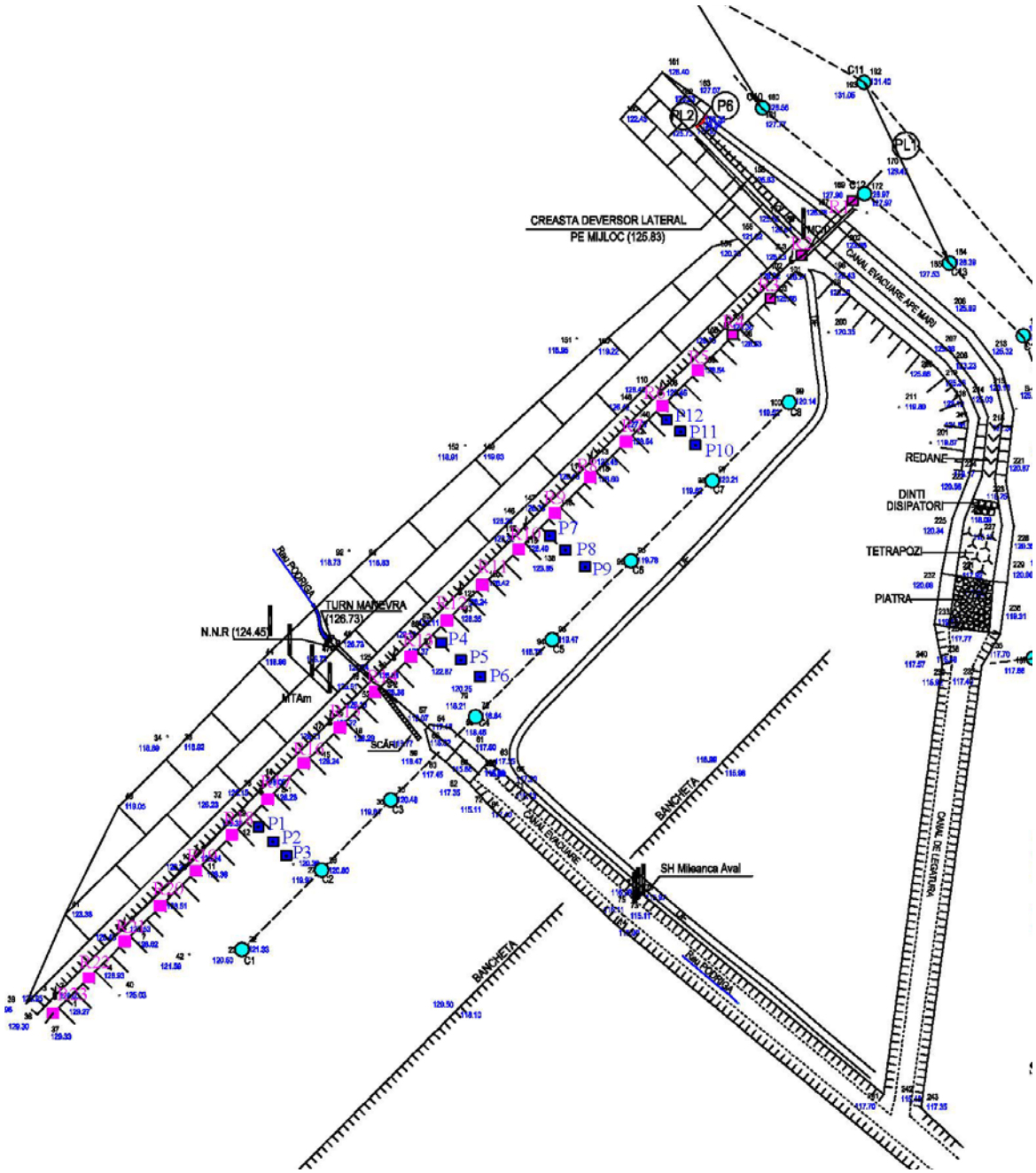

Fig. 4. Dam body plan view with the location of the measuring installations.

3. Results of the theoretical and experimental study

Recording and analysis of special events in Mileanca reservoir behaviour
Special events recorded during operation
No atypical behavior of the dam has been recorded since commissioning and until now.

External stresses recorded during the years 2000 – 2017

The database with water levels in the reservoir, rainfalls, floods recorded between the years 2000 - 2017, provided by the Water Basinal Adminstration Prut-Barlad, was used for the interpretation of the reservoir behaviour *(Table 3).*

Table 3. External stresses between the years 2000 and 2017

Year	Water level (maSL)			Level difference (m)	Precipitation (mm)		
	Maximum level	Minimum level	Average level		Annual total	Maximum	
						daily	monthly
2000	125,66	121,00	123,02	4,66	503	232,1	133
2001	125,45	121,26	123,00	4,19	736,4	171,5	94,2
2002	125,56	121,28	123,59	4,28	481,5	85,2	28,1
2003	125,41	121,78	123,29	3,63	376,4	120,2	27,2
2004	123,65	120,79	122,19	2,86	324,5	60,4	20,5
2005	**126,97**	120,82	123,26	6,15	784,4	267,4	109
2006	125,79	121,38	123,10	4,41	525	144,6	51
2007	122,50	121,03	121,74	1,47	499,9	107,9	52
2008	125,25	121,70	123,54	3,55	655,8	138,4	57
2009	125,13	119,33	122,96	5,80	475,3	121,2	74,7
2010	Empty lake				824,9	225,1	75,9
2011					332,1	120,7	35,5
2012	119,26	119,02	119,14	0,24	421,7	77,5	29,4
2013	124,48	119,00	122,20	5,48	469,6	104,1	34
2014	123,22	119,43	121,69	3,79	542,3	170,9	44,6
2015	123,68	121,49	122,57	2,19	239,1	45,6	22,1
2016	121,93	120,92	121,45	1,01	597,6	154,7	55,5
2017	124,00	121,93	123,31	2,07	195,7	48,5	16,4

We can observe that the maximum water level in the reservoir (126,97 maBS) was superior with 0,79 m to the surface outlet - threshold weir (126,16 maBS in the year 2005, before the recent measurements). The surface spillway that was deteriorated during the evacuation of flows was later repaired, during the works implemented under the project *„Safety re-inforcement of Mileanca reservoir, located on the Podriga River, in Botoșani county”*.

Visual observations

a) Integrity of the structure, including the foundation and the embankments

The visual observations made by the operation personnel didn’t reveal any structural changes of the dam’s body and foundation or of the embankments.

b) Reservoir and embankments

No changes in embankments or lake bordeline geometry were reported and no ravines, landslides or leakings were revealed.

c) Outlets

The outlets of the Mileanca dam have a good tehnical status.

d) Status of the upstream and downstream channels

The technical status of the upstream and downstream channels is very good.

e) Hydro-mechanical equipments

The hydro-mechanical equipments were rehabilitated in the year 2012.

Evolution of monitored parameters

Analysis of the behaviour in time of the reservoir was done studying the evolution of the response parameters (hydrostatic level in the piezometric wells, infiltrations, vertical deformations) to the external stresses. Data interpretation was completed by direct visual observations made during the entire existence period of the Mileanca reservoir.

a) Infiltrations

The variation of the hydrostatic levels in the piezometric wells was the first response of dam body to the external stresses: reservoir water level variations, rainfalls and temperatures. Suggestive graphics were drawn with the hydrostatic levels in the piezometers, the precipitations in the dam area and the water level in the reservoir during the analyzed period of time 2000 – 2017. The graphics have shown a poor correlation between the water level in the reservoir and almost all the hydrostatic level in the piezometric wells. Depression curves drawn for the five control sections occupy small areas of the dam body, as the seepage waters are collected by the filter drain and then routed through collection - evacuation culverts to the evacuation channel of the bottom outlet channel. The depressions curves follow the initial prognosis and the design behaviour models, as they are below the designed depression curves.

The drainage system of dam and the foundation consists mainly of the draining mattress and the draining wells and the collection - evacuation culverts, that are monitored in the 2 outlet conduits for the dam seepage in the left and right branch in the bottom outlet channel. The measuring points of seepage through the dam are positioned at a lower elevation, in the bottom outlet channel. The extreme values of the flows in the analyzed period of time were 0.005-0.021 l/s in the right branch and 0.048-0.500 l/s in the left branch.

At the measuring points of seepage through the left embankment, the extreme values of the flows in the analyzed period of time were Q=0.005-0.0420 l/s.

b) Compactions

During Octomber 1997 – May 2017, 17 cycles of observation were carried out.

Observations were made on a number of 23 mobile landmarks for compaction, planted on the dam canopy.

By analyzing the temporal evolution chart of the vertical deformations we have observed a normal evolution of the compaction phenomenon. *(Figure 5*)

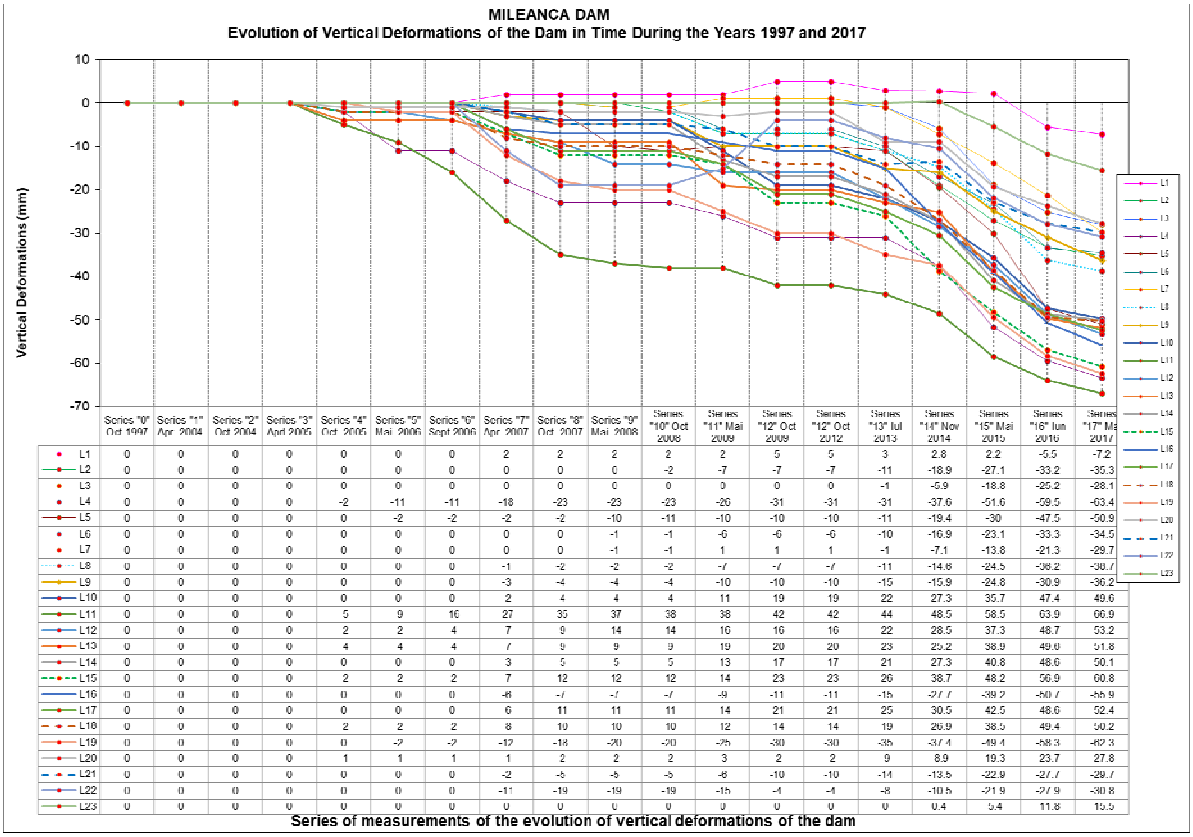

Fig. 5. Evolution of Vertical Deformations of the Dam During the Years 1997 and 2017

4. Conclusions

The special events recorded during the construction and during the operation of the dam have imposed the implementation of a systematic behaviour in time monitoring of the hydrotechnic constructions at Mileanca reservoir. The behaviour in time monitoring performed by interpreting the visual observations and the measurement data from gauges, in relation to external stresses on the dam, allows rapid reporting of exceedances of critical thresholds at monitored elements and of the atypical behaviours of the dam.

The investment works that were implemented, under the project *„Safety re-inforcement of the Mileanca reservoir located in river Podriga catchment area, in Botosani county”* have improved the technical status of the dam and ensured the safe exploitation of the reservoir.

The exploitation of Mileanca reservoir was done with an increased degree of safety. The behaviour monitoring of Mileanca reservoir is recommended to be continued accordingly to the "Project of special monitoring".

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