

New results of the extensometric measurements at Budapest observatory

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Abstract

First in Hungary two extensometers were installed by the Eötvös Loránd Geophysical Institute between 1980 and 1990. Both instruments had been working till 1996. After a recording break of about 7 years the instruments were renewed in 2004 and the extensometers have been recording continuously since that year. In this paper the first data series are analysed. On the basis of the new data series the influence of environmental parameters is also investigated and the possible conclusions in connection with the stability of the observatory are drawn.

1. Introduction

The first extensometer in Hungary was installed by the Eötvös Loránd Geophysical Institute (ELGI) in Budapest in the frame of a scientific co-operation with the Geophysical Institute in Moscow (Latinina et al., 1984) in the spring of 1980. The displacement sensor of this instrument was a photo-recorder and in 1981 a capacitive transducer developed in the Geodetic and Geophysical Research Institute (GGRI) was mounted. The second extensometer was built at the end of the eighties. This later instrument was equipped with a capacitive sensor (Mentés, 1981, 1991).

In the middle of the nineties extensometric measurements in the observatory were finished due to technical and financial problems. In 2004 these instruments were renewed and equipped with new capacitive sensors which were produced in the GGRI and a new digital data acquisition system was installed by ELGI in the observatory.

In this paper the deformation registrations of the new instruments are presented and compared with the results of the former measurements. On the basis of registrations the influence of environmental parameters are also investigated and possible conclusion on the stability of the observatory is drawn.

2. The Mátyás-hegy Geodynamical Observatory

The Mátyás-hegy Geodynamical Observatory is situated in the NW part of Budapest in a natural cave formed by thermal water in limestone. The level of the karstic water is about a hundred meter deeper than the level of the station. The river Danube flows about 2 km far from the observatory. According to Latinina et al. (1984) the data series recorded earlier does not show any connection with the water level changes of the Danube but they can have a connection with the level variation of the karstic water. The instruments are installed in a distance of about 80-90 m from the entrance and 30-35 m from the surface, so the thermal variation at the instruments is very low, less than 0.1 °C which ensures stable thermal conditions for the extensometers (Varga and Varga, 1994). Figure 1 shows the ground plane of the observatory and the places of the instruments. The station is only a part of a complex cave system separated from it by walls. Thus the caves under and around the station are capable of raising even strong cavity effect in the observatory. The geographical position of the observatory and the parameters of the instruments are given in Table I. Figure 2 shows the

new digital recording and data transfer system of the geodynamical observatory. The data can be on-line transferred to the ELGI. The ADAMS type A/D converters have a resolution of 16 bits and the sampling rate is 1 minute. In the vicinity of each sampling time a simple averaging digital filter is applied over some seconds and it produces the sampled voltage value. Temperature and air pressure data are also measured in the gallery where the instruments are placed.

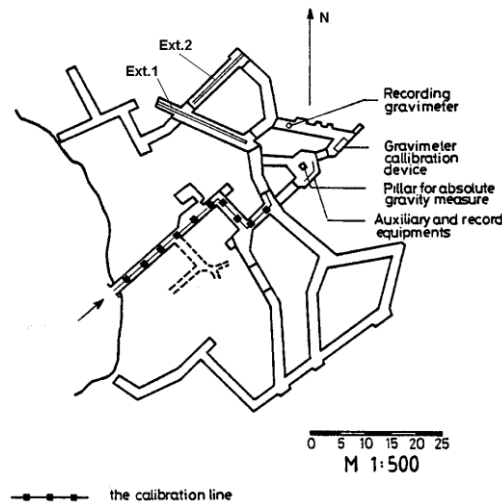


Fig. 1. The ground plane of the Mátyás-hegy Geodynamical Observatory

Table I. The parameters of the observatory and the instruments

Extensometer	Coordinates of the station			Azimuth	Length [m]
	Latitude	Longitude	Altitude [m]		
Ext.1	47°33'	19°01'	202	114°	21.3
Ext.2	47°33'	19°01'	202	38°	13.8

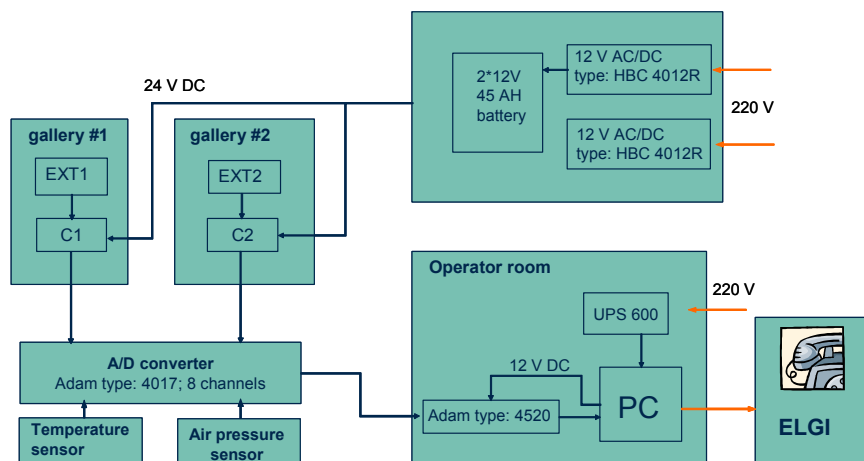


Fig. 2. Digital recording and data transfer system of the geodynamical observatory

3. Analysis of the strain measurements

The rebuilt extensometric station has been working since August 2004. From the measured data series a six months time interval (01. June 2005. - 07. December 2005.) was chosen. These data were processed and analysed in order to obtain information about the deformation measurement. Figure 3 shows the recorded raw data. Strain data of the long (Ext.1) and the short (Ext.2) extensometers along with air pressure and temperature data.

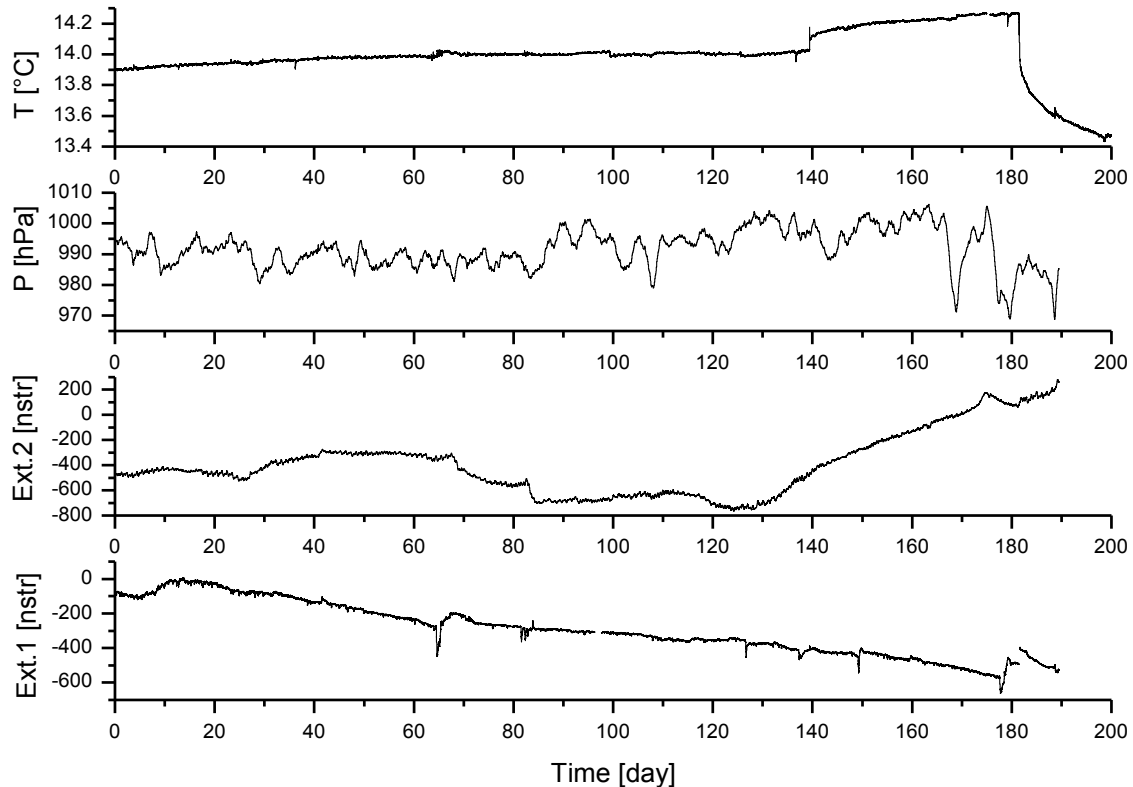


Fig. 3. The measured raw data in the Mátyás-hegy observatory between 01. June 2005 and 07. December 2005

Fourier analysis was carried out on the deformation data series to inspect the behaviour of the instruments in the tidal frequency bands and to get an idea about how successful was the installation of the new electronics onto the quartz tubes. If a clear resolvable tidal spectrum is resulted like in the case of many geodynamical extensometers, the working conditions of our instruments can be regarded as adequate. From Fig. 4. one can observe, that tidal spectrum lines are not obtained from the long extensometer (Ext.1) data – only slightly emerging blurred peaks can be observed in the diurnal band – in contrast with Ext.2 which produces the proper spectral contents of tidal rock deformations. It is obvious that Ext.1 does not work properly and something is erroneous in the instrumental system.

Data of Ext.2 were analysed and processed by Eterna 3.3 software and the results for the tidal constituents are presented in Fig. 5. and the numerical values are listed in Table II.

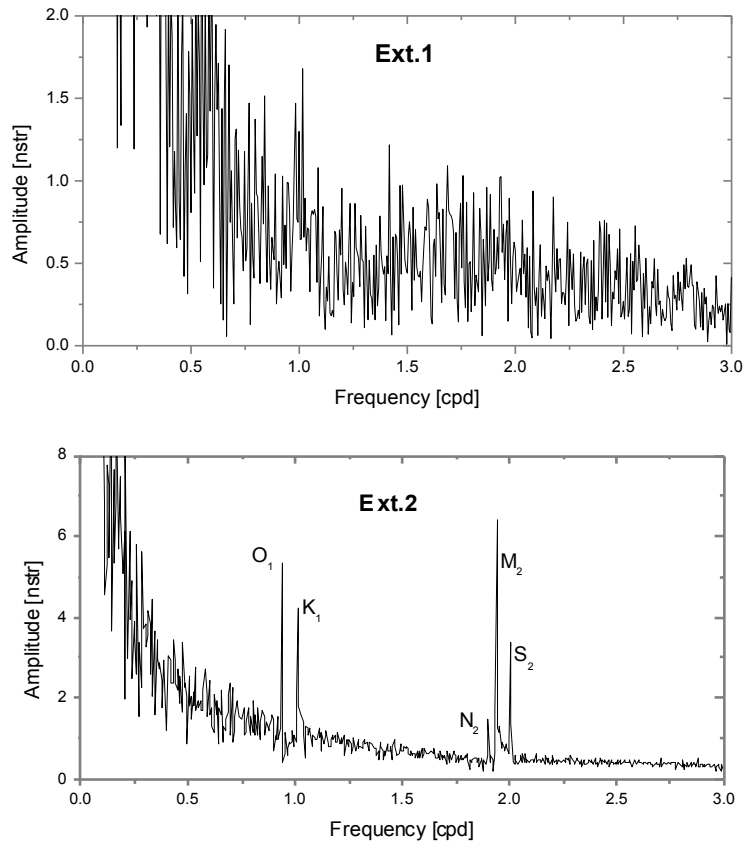


Fig. 4. Fourier amplitude spectra of the extensometric data

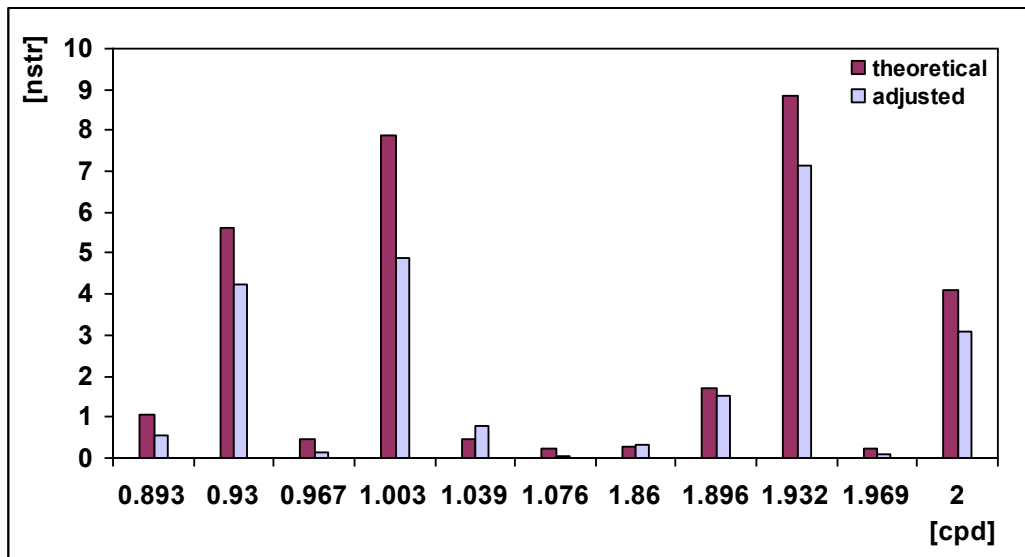


Fig. 5. Theoretical and calculated tidal amplitudes from data series of 01. June 2005.-07. December 2005. time interval, measured by the short extensometer (Ext.2) in the Mátyás-hegy observatory

Table II. Tidal parameters obtained from Ext.2

wave	measured amplitude [nstr]	amplitude factor	standard deviation	phase lead [degree]	standard deviation [degree]
Q ₁	0.5424	0.5055	±0.199	-0.564	±22.657
O ₁	4.2227	0.7535	±0.044	7.150	±3.365
M ₁	0.1339	0.3039	±0.490	-12.791	±92.410
K ₁	4.8763	0.6189	±0.038	14.231	±3.476
J ₁	0.7639	1.7334	±0.553	50.006	±18.286
N ₂	1.5320	0.9059	±0.092	16.384	±5.795
M ₂	7.1469	0.8091	±0.018	18.219	±1.304
L ₂	0.0894	0.3580	±0.506	-8.9869	±80.999
S ₂	3.0990	0.7542	±0.032	20.490	±2.435

The tidal factors in the semidiurnal frequency band are about 15% higher than the amplitude factors obtained in the diurnal frequency band. This situation is similar to the characteristic of tidal adjustment from data of e.g. the Sopron observatory (Mentes and Eper-Pápai, 2006) but the difference between the amplitude factors is smaller in the case of Budapest. The possible cause of the above mentioned difference was investigated by means of Fourier transformation of the residual data (Fig. 6.), from which it can be seen that in the semidiurnal band disturbing deformation effects are present.

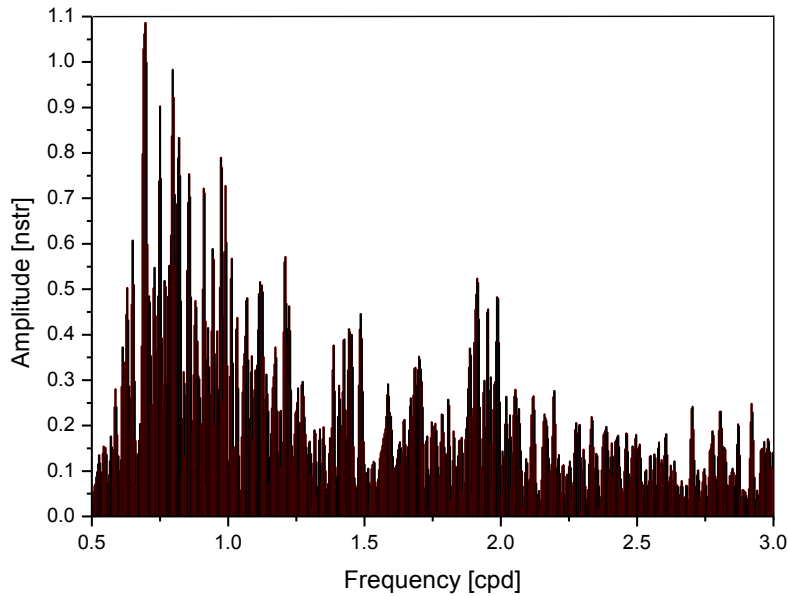


Fig. 6. Amplitude spectrum of the residual curve of Ext.2 data

4. Investigation of the meteorological effects

In spite of the fact that the air pressure and temperature variations were not measured outside the observatory a good estimation of the stability of the station can be achieved using air pressure and temperature data recorded inside the measurement gallery.

In Fig. 3. we can see that no close correlation exists between the strain data and inner temperature and air pressure variations but there are some obvious relationship. The reason of the temperature change of 0.1 °C magnitude in the second half of November (day 140) is still unknown. Presumably the same effect caused both the step in temperature and the change of the direction and the steepness of the strain curve of Ext.2. The second high step in temperature data occurred in the beginning of December (day 180). It obviously induced changes in both strain data series. We can observe from the data that the magnitude of the air pressure variations increased in the second half of November and this effect influenced the strain meters, too. The reason of these effects is still unknown probably they can be in connection with the cave system.

The long-term temperature and air pressure variations inside the station according to the new measurements are 0.3869 °C/year and 0.006 hPa/year. The annual temperature variation is somewhat lower than it was stated earlier (Varga and Varga, 1994).

The long extensometer (Ext.1) was left out from any further investigations due to technical problems of the instrument. In the first step regression method was applied. To calculate the long-term effect a polynomial of ninth order was fitted to the strain curve and it was plotted vs. air pressure and temperature. To get the short-term effect the polynomial was subtracted from the strain data and the remaining curve was also plotted vs. air pressure and temperature. In each case a regression line was calculated and the steepness gives the strain rate caused by temperature and air pressure variations. The results are given in Table III.

Since the temperature variation is very low within the station, its effect onto the strain data could not be calculated reliably. We can assume that the outside temperature variations are more than a hundred times higher than measured inside. In this case the temperature effect values from Table III. should be divided by hundred. The obtained values seem to be realistic: 17.27 nstr/°C (long-term) and -2.94 nstr/°C (short term).

Table III. Air pressure and temperature effects

	Air pressure effect [nstr/hPa]	Temperature effect [nstr/°C]
Long-term effect	-9.02	1727
Short-term effect	-12.64	-290

Conclusions

Results of the Fourier and tidal analysis show that only the short extensometer (Ext.2) is working properly. The behaviour of the long extensometer (Ext.1) is very interesting. Sometimes it is sensitive to the same disturbances as the Ext.2 as it can be seen in Fig. 3. but it does not record the high frequency tidal deformation variations. The reason can be either of instrumental origin or other effects which obscure the tidal variations.

The analysis of the meteorological effects shows that the station is stable for tidal and tectonic measurements. It means that its sensitivity to the changes of meteorological influences is not higher than in other geodynamical stations of Hungary, in addition on the basis of tidal analysis the Budapest station is more stable than Sopron from point of view of disturbing deformations induced by environmental effects.

The measurements carried out between 1990 and 1992 (Varga and Varga, 1994) show an average magnitude of the seasonal variations of about 700 nstr which corresponds to the long-term effects calculated by us. Sometimes very steep changes of the displacements occur in the earlier records similarly to the steep change beginning from the day 130 on Ext.2 in Fig. 3. The reason of these changes is unknown. Probably they are in connection with the airing of the surrounding cave system or with the karstic water under the station. To study these irregular changes it would be useful to investigate the level variations of the karstic water and the river Danube during the deformation measurement time periods.

Acknowledgements

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