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Thermal expansion of rocks, a part of extremely slow slope displacements

J. Vlcko, M. Jezny, T. Durmekova, P. Liscak, R. Adamcova, M. Brcek

(1) Department of Engineering Geology, Comenius University, Bratislava, Slovak Republic, (vlcko@fns.uniba.sk / Fax: 00421260296702 / Phone: 00421260296600)

Extremely slow deformations are a frequent phenomenon in the territory of Western Carpathians. These slope movements are in common generated by ***internal*** (geological, structural, morphological, geomechanical, hydrogeological, etc.) and ***external*** factors (climate factors as temperature, precipitation, air pressure etc.). One of several possibilities how to get more detailed information about kinematics of the rock displacements is monitoring. Within the monitoring records indicating rock slope movement besides real displacements (length/time) climate factors mentioned above are included. In our study, from among several external factors, we tried to estimate the daily temperature fluctuations influence on slope movement – i.e. its kinematics and dynamics as well as on monitoring recording sets. This paper describes the thermally induced influences on the rock mass behaviour (expansion, contraction) as well as the possibility of data records filtering and thus to bring representative and essentially correct data into slope activity estimations, geotechnical calculations as well as time prediction for potential failure.

The temperature monitoring we performed at Spis Castle (Eastern Slovakia), a monument included in the UNESCO World Heritage List. From a geological point of view, the Spis Castle is built on a travertine mound, which is underlain by Paleogene soft rocks formed by claystone and sandstone strata (flysh-like formation). Lateral spreading caused by the subsidence of the strong upper travertine into the soft underlying claystone has fractured and separated the castle rock into several cliffs. The differential movement (rate of displacement, direction) of individual cliffs is the phenomenon influencing the stability of the monument.

The history of monitoring at Spis Castle goes back to 1980 when three TM-71 devices

were installed. Six additional devices were installed later on following our survey carried out in 1992. It should be noted that only four of nine crack gauges operate, since unexpected visitors demolished the rest of them. We focused our attention to so called Perun´s rock, a southern part of the castle rock where three monitoring devices of crack-gauge type TM-71 were installed and the recorded rate of displacement 1 – 2 mm per year was recorded.

To learn more about thermal properties of travertine, the dominating rock type forming the subgrade of the monument, we undertook several laboratory and in situ experiments.

As far as the laboratory methodology concerns we followed the European Standards Proposal - "Natural stone test methods: Determination of the thermal expansion coefficient" which specifies methods to determine the linear thermal expansion coefficient of natural stone based on mechanical length – change measurements.

The study is also focused on modelling of heat flow in surface parts of rock massive. The temperature consequences of surface temperature changes however are almost never determined. A rock ground is affected by daily, weekly, seasonal or yearly fluctuations caused by air temperature changes. These cyclic fluctuations are partially transmitted to the interior of the rock mass by means of conduction, in accordance with Fourier‘s law and equation of conducting of the temperature. Measured data are subsequently compared with analytical modeling results. A simple analytical calculations and obtained field data confirm that daily surface temperature changes progress only to a depth of 1 m deep into the rock massive.