EXPERIMENTAL DETERMINATION OF GEOTECHNICAL PARAMETERS OF PLANETARY BODIES – CHOMIK SAMPLING DEVICE EXAMPLE. K. Skocki[1], K. Seweryn[1], T. Kuciński[1], J. Grygorczuk[1], H. Rickman[1], M. Morawski[1]; [1]Space Research Centre of the Polish Academy of Sciences, Warsaw, Poland, kskocki@cbk.waw.pl

Introduction: The ongoing activities connected with the exploration of planetary bodies are currently focused on scientific remote [1] and in-situ [2] investigations. The physical parameters obtained from the research are usually useful for planetary history interpretation and planet evolution prediction. On the other hand several papers are related to the more technical research [9], [10]. This paper focus on the determination of mechanical parameters of the planetary regolith and its comparison with terrestrial analogs. It is important that the experimental data was acquired using penetrometer and sampling devices designed and developed for on-going space missions ex. MUPUS instrument for Rosetta mission for 67P/Chumurov - Garasimienko comet [3], [4] and CHOMIK instrument for Phobos Grunt mission [5]. The measurements of energy delivered to the regolith in function of total movement of penetrator will give important information about structure, texture and strength of sampled regolith. The results from CHOMIK instrument qualification model are presented in the paper in spite of the fact that Phobos- Grunt mission was failure.

CHOMIK instrument: CHOMIK (Fig. 1) planetary sampling device was designed for Phobos-Soil mission as a third member of penetrators' family developed in Space Research Centre PAS [6]. Its primary task is to collect the sample from the Phobos' surface. CHOMIK device was designed for effective working in microgravity conditions. It takes advantage of hammering action with an energy of about 1J to drive into the regolith. The hammering action takes place every 7-10 seconds. The goal of the penetrator is to collect 40 mm of regolith (0.5 – 4.8g mass). The instrument is capable of collecting sample in soft, granular and solid rocks (maximum demonstrated rock strength was several tens of MPa).

Measurement principle: The geotechnical parameters measurement principle is based on the derivation of regolith resistant force F_{env} generated during penetrator movement. This force is further used as an indicator of the geotechnical parameters like shear strength or bearing capacity. The force is calculated in the following algorithm:

- First the penetrator progress vs. hammering stroke is measured by the instrument (this procedure is implemented in all SRC penetrometers and sampling devices).

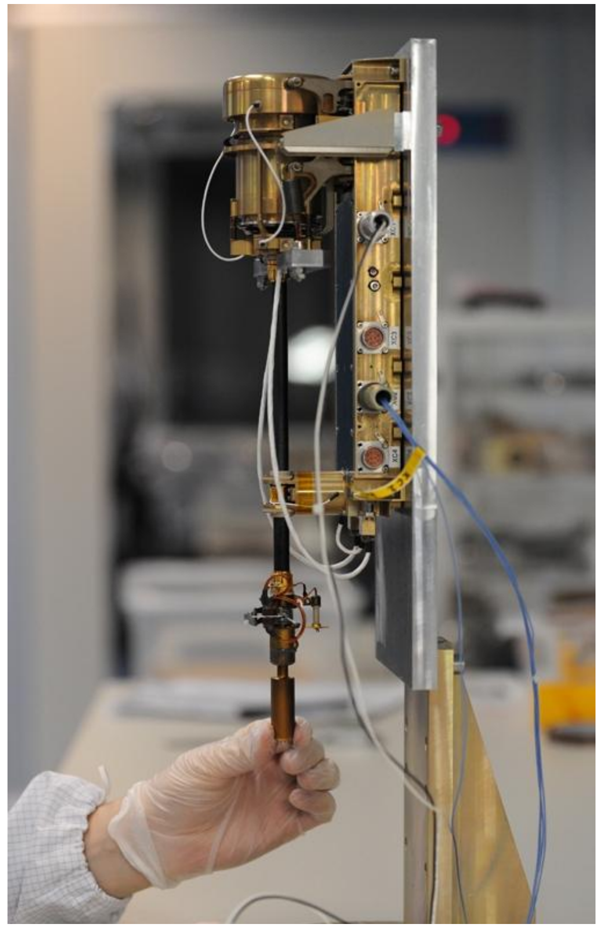

Figure 1: CHOMIK sampling device during laboratory tests in the sand like material. The instrument consists of hammering device (cylinder on top of the instrument), guiding tube and sample container with release mechanism

- Then the progress is expressed as a function of energy delivered to the surrounding medium. It can be done using penetrometer simulator developed in SRC [7].
- Finally acquired data is compared to the regolith simulation [8] or database of measurements done in earth conditions.

Testing procedure: Various solid and granular planetary analogs are prepared with well-known geotechnical parameters (measured with the use of typical geotechnical methods). The sampling was performed both in laboratory conditions and in simulated planetary environment (low pressure, low temperature). For laboratory tests the movement of sampler into the analog is measured mechanically (direct measurement), with use of slow-motion camera (optical measurement – Fig. 2) and from instrument telemetry. For vacuum-chamber tests only telemetry is operationally used. Collected data are reduced and total energy for sampler movement into analogs is determined. Additionally, the detailed movement action of hits in different analogs and in different stages of sampling action are analyzed to obtain sampling behavior. Data are stored in database for further analyses and operational use.

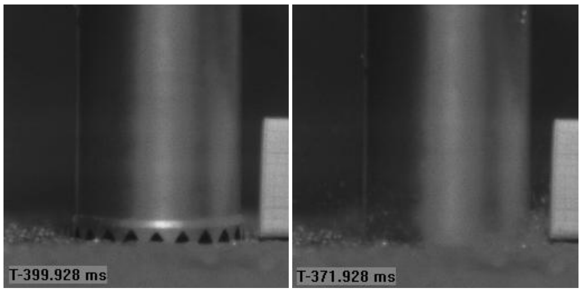

Figure 2: slow-motion camera analysis of hammering process in Foamglas F solid, porous rock sample

The numerical simulation [7] of sampling action for simplified analogs was used to compare the results – example is provided in Fig. 3.

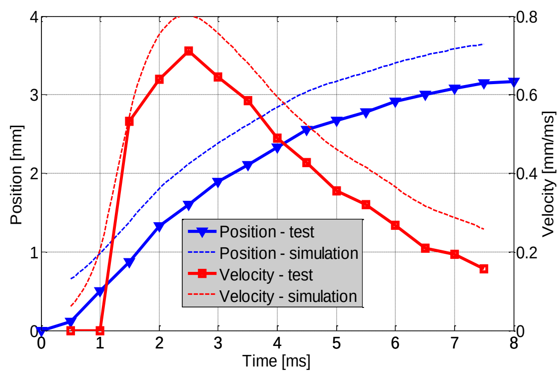

Figure 3: position/velocity in the first phase of movement during sampling with maximum energy stroke

Functional and geotechnical tests results: The series of functional tests were performed during preparation of flight model of CHOMIK instrument.

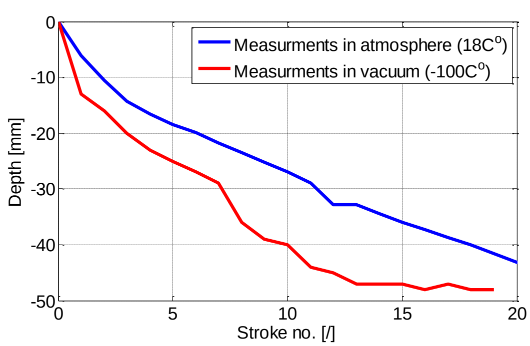

Figure 4: CHOMIK sampler efficiency tests in laboratory and vacuum-chamber in different temperatures

The tests show that this device completely fulfill rigorous requirements for interplanetary mission. Tests in the laboratory conditions as well as in thermo-vacuum chamber with use of granular and solid-porous materials demonstrated correct sampling process for granular and solid samples', and correct releasing of the sampling container. Tests showed the slightly higher hammering efficiency in vacuum than in laboratory conditions (Fig. 4). The geotechnical tests allow to create the database of resistant forces dependencies wrt. the penetrator movement for different regoliths. The tests were performed for pure sands and silts, mixed analogs of planetary bodies (example: phobosian analog prepared by IKI Moscow, AGK2010 and CHENOBI analogs of Moon regolith), as well as solid rock samples up to 15MPa strength. Characteristics of sampling actions were recorded and finally geotechnical tests based on recognizing of prepared analogs were made. Tests show the capability of in-situ recognizing of basic rock/soil types and parameters of planetary bodies. The enhanced tests focused on recognizing the internal structure of analogs (layering), grain size, shape and sorting are in progress.

Conclusions: CHOMIK geotechnical capabilities were demonstrated for various rocks/soils expected on Phobos and Moon surface. The mechanical properties of sampled soils can be directly measured using presented method. In-situ measurements of planetary bodies compared with previously prepared typical sampling data for different soil/rock analogs should give the information of geotechnical parameters and additional sedimentological data for better characterizing and understanding properties of planetary sediments. Such analyses will enhance our knowledge about the current state and geotechnical properties which can be useful for future planetary exploration.

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