INTRODUCTION

The planet Mars (Fig. 1) is one of the most attractive targets for space missions in the present and the next decades. Even though the planet is already quite well mapped from the orbit, in situ exploration on the surface is much less advanced. Because of its small and light weighted construction type, the penetration test is a useful investigation method for space missions. As an additional advantage the penetration cone can be implemented in different other instruments. This was planned for the European Mars/NetLander mission with the instrument SPICE (Soil Properties: thermal Inertia and Cohesion Experiment), where the force sensors for the penetration tests were integrated into the conical legs of the seismometer.

SELECTION OF MATERIALS

The first step was to find materials that are suitable for the penetration tests and which come close to the actual martian soil with regard to geotechnical parameters. For that reason following points were taken into account for the selection of the materials.

As a result of former missions there are estimated parameters for the surface material of Mars. Based on this data several martian analogue materials were selected. Because the availability of these analogue materials is quite limited, similar local materials were chosen. The range of the used materials concerning the grain size is from fine silt to coarse sand. Further the bulk density is varied for the tests.

The two selected Martian analogue materials are JSC-Mars 1 from Johnson Space Centre (Hawaii) and the Salten Skov iron precipitate from Denmark, which were both available only in limited amounts. However, the determination of the parameters was done with both materials as long as there was enough mass to perform the laboratory tests, since part of the material had to be destroyed or made useless for further usage. For the future some more of the material will have to be ordered for tests in a larger container volume.

In addition to the Martian analogue materials local materials were selected. These are two silty sands called Schwarz UK4 and Fohndorfer Halldit, and a silty material called Feichtinger Quarzmehl 10000. The two sands are quite similar to the analogue materials and both were already used earlier in the laboratory. In addition, the silty material can be mixed with the sands to enlarge the material database for synthetic Martian analogue material.

GEOTECHNICAL LABORATORY TESTS

The selected materials were characterized with the standard geotechnical tests to determine the relevant soil mechanical parameters: grain size distribution, grain density, strength and stiffness parameters, etc. Because of the dry environment on the Martian surface all parameters have to be determined for dry samples. But usually most of the geotechnical parameters are determined for samples saturated with water. For that reason some of the tests cannot be done with standard methods, but have to be modified, for example the determination of the maximum density. So one has to be careful with the comparison of parameters found in literature.

The scientifically most improved test to determine the strength parameters (angle of internal friction, cohesion) and stiffness parameters (Young’s modulus, Poisson’s ratio) is the Triaxial test (Fig. 3). The second part is the data acquisition device necessary to sample all experimental data and control the performance of the test rig. A fast PC and a new DAQ-card complemented with the I/O box equipped with galvanic separation modules was purchased and the data acquisition and drive control software was implemented successfully.

Numerical Simulation

To evaluate the results received from instruments on planet Mars we are faced with different boundary conditions that can not be considered correctly in a laboratory test, e.g. the gravity. Therefore, it is necessary to have a comparison matrix with previously investigated materials. So to predict realistic results for penetration tests under Martian conditions it is unavoidable to use a numerical program with a previously calibrated soil model. Additional to the modelling with the Finite Element Method (FEM) it is planned to use a software based on the Discrete Element Method (DEM) to simulate the penetration process.