KNOWLEDGE RESULTING FROM THE GEO-MECHANICAL MONITORING OF THE ROCK MASSIF AT DRILLING

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ABSTRACT

Monitoring systems of the rock disintegration process set in drilling and driving in the rock mass provide scanning and quantification of input (thrust, revolutions, power supply) and output (drilling rate, disintegration energy, working ability) values of the process.

The systems also enable obtaining the information on mechanical properties of the drilled rocks. The problem arising in the process is their interpretation as the relations between mechanical rock properties and individual monitored values show the ambiguity.

The paper introduces the approach to eliminate the ambiguity. The data on drilled rock mechanical properties acquired in a way mentioned above are not reliant to mechanical logging and may be used for rock mass failure zones prediction.

KEYWORDS: drilling, monitoring, rock, drilling rate, rock compression strength

1. INTRODUCTION

Given the current use and development of monitoring systems at drilling and driving of rocks the possibility emerges to obtain information about the mechanical properties of drilled rocks and for mechanical coring itself, (Zeman a Müller, 1980; Miska a kol., 1977; Howarth, 1986). In our works (Bejda a Miklúšová, 1995; Bejda a Miklúšová, 1996; Miklúšová a kol., 1996) we have pointed to an ambiguity in the relation between the momentary drilling speed and the so called compression strength of rocks, which is used by many schools as a value by which the rock's drillability can be characterised.

2. EXPERIMENTAL RESULTS

When analysing momentary drilling speed quantity we have focused on one of the strength characteristics, namely the quantity of the rock compression strength σ_m, obtained by means of the standardized method used in geological research. A momentary drilling speed correlates very well with the compression strength of drilled rocks, but only of a certain group, certain classification, and thus in relation to the rock compression strength it is an ambiguous value.

Let us analyse, for example, the results which we have obtained at the stand laboratory research of impregnated and inserted bits with a diameter of 46 mm. The monitoring of the dependencies of the reduc-ed momentary drilling velocity values and a compression strength has proved that certain rocks show a great dispersal of values. This group includes rocks with significantly granular structure, where at least one group of grains was much bigger than the size of the disintegration elements - the diamond grains of the impregnated tools. These rocks have been eliminated from the set, and the others were di-vided into three classes. These are documented by figure 1.

The figures show both experimental points (marks) and calculated data (lines). A function in the following form was used for the calculation

$$v = A_i \, \sigma_m^{\alpha_i} \,, \qquad (1)$$

where

v - momentary drilling speed, mh^{-1}

σ_m – compression strength, MPa

A_i , α_i – correlation coefficients

i = 1, 2, 3 – class marking.

The figure prove that only rocks belonging to the same class can be compared with each other (figure 1 show rocks divided into three classes, i = 1, 2, 3).

It means that if we do not know into which type according to the prevailing mechanism of its disintegration the rock belongs to, the relation (1) cannot be used for the rock strength characteristics assessment. This fact has also been pointed out in the work of Weis, (Weis et al., 1980).

It must be mentioned that due to the fact that in the formula for the calculation of a specific disintegration energy the momentary drilling speed is included too, the statement about the ambiguity concerns this energy as well.

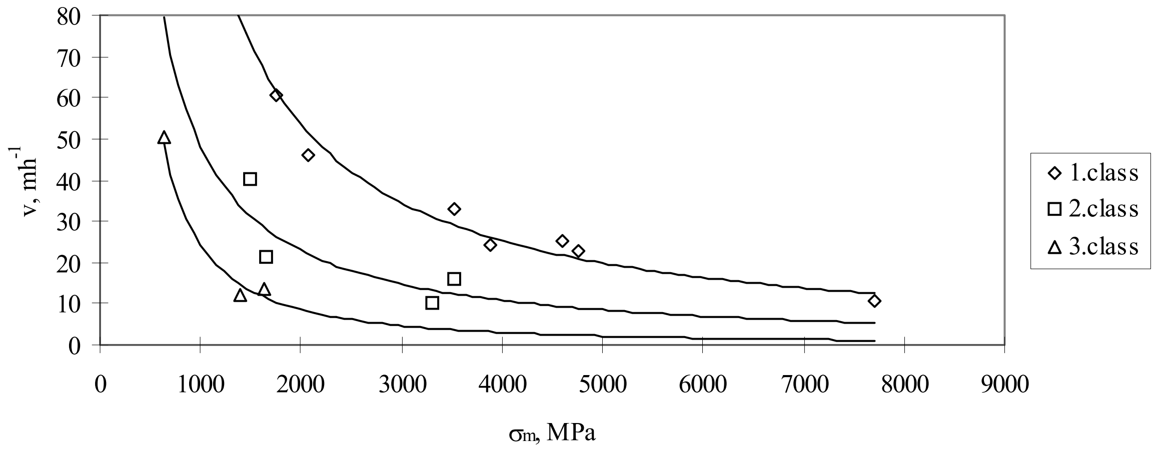

Fig. 1 Dependency of the momentary drilling speed on the compression strength of rocks, at drilling by means of inserted tools

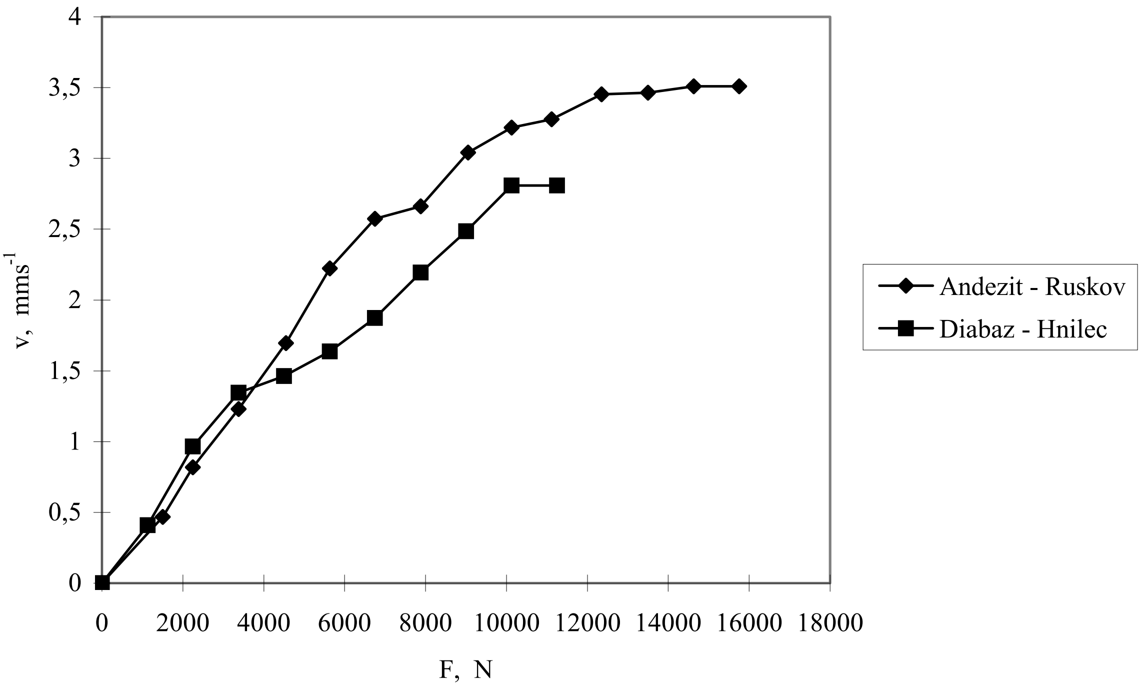

Fig. 2 Dependency of the momentary drilling speed on the thrust at constant revolution n = 16,67s^{-1}
Andesite - Ruskov - σ_m = 4 211 MPa, Diabase - Hnilec - σ_m = 1 055 MPa

Therefore we have been searching for ways to eliminate the stated ambiguity. For each drilling technology an optimum drilling mode in accordance with certain criteria was looked for (Sekula et al., 1991). The viewpoint prevails that the mechanical coring should then be performed at the constant drilling mode, which corresponds to the stated optimum conditions.

In our search for the optimum it is necessary to carry out drilling tests with several combinations of various values of the axial thrust and revolutions. The most accessible is the procedure in which certain constant revolutions are set and the thrust is changed from zero to the maximum possible value. Figure 2 shows an example of such a test carried out under the stand laboratory conditions.

The courses in these figures show that they are characterized by local extremes. We have analysed various mathematical procedures that would enable an analytical description of the experimental courses of the same character as in figure 2. Let us describe the dependency of the drilling speed on the thrust by means of a function in the following form

$$v(F)=n_j\left\lfloor A_{v1}\,e^{k_{v1}|F-F_1|}+A_{v2}\,e^{k_{v2}|F-F_2|}\right\rfloor, \qquad (2)$$

where

n_j - a value of the selected revolution level, s^{-1}

F_1 - a thrust at which the function (1) reaches the first extreme value, N

F_2 - a thrust at which the function (1) reaches the second extreme value, N

A_{v1}, A_{v2}, k_{v1}, k_{v2} - constants.

Within the range of the examined drilling parameters enabled by our stand, i.e., n $\in$ (0; 30 s^{-1}) and F $\in$ (0; 20 000 N), it has been shown that the thrust value F_1 depends on the size of the tool disintegration element. As the disintegration element size increases, the values of the thrust F_1 shift towards higher thrusts.

Another very important piece of knowledge is, that with the same size of the disintegration element and changes of rocks in the experiment, the value of the thrust F_1 increased with the increase of the compression strength value σ_m of the drilled rocks. Figure 3 shows the dependency of the thrust values F_1 on the compression strength σ_m of the drilled rocks that has been detected additionally on sampled rock cores obtained by means of diamond core bits.

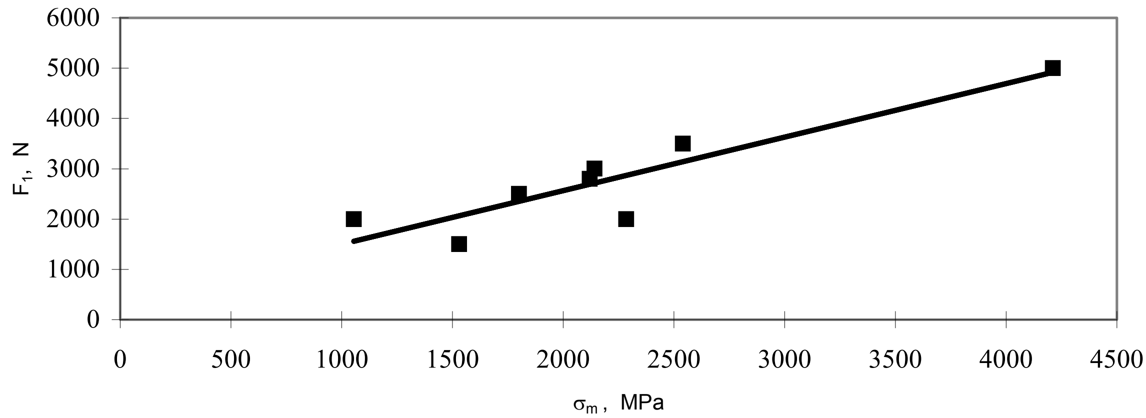

Fig. 3 The dependency of the thrust values F_1 on the rock compression strength during drilling by means of a diamond bit with a diameter of 46 mm

The thrust value of the second extreme point F_2 probably depends on the construction characteristics of a tool. For example, with regard to the impregnated diamond bits it can be assumed that as the thrust increases, the entire segment of a bit operates as a disintegration element, therefore there is a dependency of the value F_2 on the number of drilling fluid channels of the impregnated tools.

3. CONCLUSION

The mechanical coring during drilling that is commonly used in drilling practice does not allow unambiguous information about the strength characteristics of the rocks in a massif to be obtained. The enhancement of methodology based on the use of monitoring materials described in the present article enables additional data to be obtained on the classification of the rocks and its allocation into individual classes in accordance with the mechanism that prevail in the rock disintegration process with a particular drilling technology and thus to unambiguously determine the rock's strength.

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