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Drillability in Hard Rock Tunneling by Drilling And Blasting

Usually the main subject in preliminary site investigations prior to tunnelling projects is the prediction of tunnel stability. During the last years in conventional drill- and blast tunnelling, problems have occurred also connected with the accurate prediction of drillability in hard rock. The drillability is not only decisive for the wear of tools and equipment but is - along with the drilling velocity - a standard factor for the progress of excavation works. The estimation of drillability in predicted rock conditions might bear an extensive risk of costs. Therefore an improved prediction of drilling velocity and bit wear would be desirable.

The drillability of a rock mass is determined by various geological and mechanical parameters. In this report some major correlations of specific rock properties as well as geological factors with measured bit wear and drilling velocity are shown. Apart from conventional mechanical rock properties (unconfined compressive and tensile strength, Young's modulus) a new property for toughness referring to drillability has been introduced: the specific destruction work W_z . This new property makes it possible to understand better the connection between drilling velocity and the main mechanical rock character. For monitoring and evaluation of the point load test a new statistical method has been introduced. As well as mechanical rock properties the influences of geological parameters on drillability were the main topic of the study. As the principal results of this dissertation can be recorded:

1. Drilling bit wear

- The bit wear increases with the equivalent quartz content. The equivalent quartz content builds the main property for the content of wear-relevant minerals.
- A correlation between bit consumption and technical machine parameters (power of percussive drill hammer, shape of drilling bits) has not been proved.
- For various groups of rock types different connections with the equivalent quartz content could be detected. Qualitative and quantitative bit wear is also dependent on the interlocking of microstructures or the quality of the cementation (e.g. porosity of sandstones). In hydrothermal decomposed rock and sandstone a connection with pore volume could be found. Even porosity is an indicator for decomposition or quality of the grain-to-grain strength in sandstones.

2. Drilling velocity

- First of all, drilling progress is dependent on technical machine parameters (power of percussive drill hammer, shape of drilling bits).
- In general, drilling velocity decreases with rising mechanical rock properties (unconfined compressive strength, Young's modulus, specific destruction work, tensile strength and rock density).
- Only three of the six treated rock properties - destruction work, unconfined compressive strength, Young's modulus, tensile strength, the relation of compressive/tensile strength ("toughness") and rock density showed a significant correlation with drilling rates: the destruction work can be noted as a highly significant, the unconfined compressive strength and the tensile strength can merely be described as significant parameters.
- Besides, drilling velocity is dependent on a whole lot of geological parameters. Those principal parameters include jointing of rock mass, orientation of shistosity (rock anisotropy), degree of interlocking of microstructures, porosity and quality of binder in sandstone, degree of hydrothermal decomposition and weathering of rock mass.

Further causes, such as primary stress conditions, fracturing / loosening of rock mass (e.g. in areas of landslides) could not be investigated in this dissertation.

On this knowledge basis a classification of drillability according to bit wear and drilling velocity has been worked out. To be used in the context of preliminary geotechnical site investigations of tunnelling projects a classification has been set up, allowing to predict drilling rates and bit consumption in rock using the main petrographical (equivalent quartz content) and mechanical rock properties (destruction work, unconfined compressive strength) with a sufficient accuracy. Knowledge of these relations and their causes is necessary to make the choice of drilling rigs easier, to estimate the working and drilling progress and - above all - to calculate drilling expenses. For this purpose an inexpensive but practical investigation program has been submitted, which helps to improve the estimation of rock drillability in planning future tunnel projects. Finally some hints are given for carrying out investigations in poor drilling and blasting conditions during running excavation works.