Photogrammetric face documentation and its correlation with blasting performance parameters

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ABSTRACT: In recent decades, far-reaching developments and innovations have been achieved in tunnelling with regard to the execution of the work to be carried out, data acquisition and analysis. This master's thesis deals with digital face logging as an essential basis for geological analysis and investigates the relationships between interface distances, drilling speed and specific explosive consumption using photogrammetric images and automated data acquisition.

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KEYWORDS: Conventional tunnelling, photogrammetry, discontinuity distance, explosives consumption, drilling speed

1 INTRODUCTION

The efficient and safe execution of blasting operations in tunnelling poses a central challenge, especially in geologically complex rock formations, as a precise adjustment of drilling speed and explosive consumption to the geological conditions is required. [1], [2] Modern technologies such as photogrammetry have established themselves as efficient tools for recording and analysing geological structures and enable a more precise investigation of the influences of interfaces on the performance parameters of tunnelling. [3]

The aim of this work is to analyse the central parameters - drilling speed and explosives consumption - using a reference project and to investigate their dependency on separation surfaces. For this purpose, 3D models from photogrammetric images as well as automated processes and software solutions are used to collect representative data and compare it with an existing study.

2 MAIN BODY

In the main part, a reference project is analysed in order to investigate the influence of geological interfaces on drilling speed and explosives consumption. A preliminary literature research forms the basis by analysing theoretical principles, existing studies and relevant methods. Subsequently, photogrammetric 3D models, automated data collection and software-supported analyses are used. The results are compared with an existing study in order to evaluate optimisation potential and transferability to future tunnel construction projects.

2.1 Digital local breast documentation

Digital face documentation enables detailed recording of the geological structures at the face using photogrammetry. The 3D models generated provide precise data on interface distances, roughness and flatness. This information supports the optimisation of the tunnelling work by enabling adjustments to be made to the actual geological conditions. However, there are limitations in the case of soft rock, as important features of the face can be altered by the mining process. Despite these challenges, the method offers significant advantages over traditional methods and is used as an essential basis for further analyses; an example of this is illustrated in Figure 2-1.

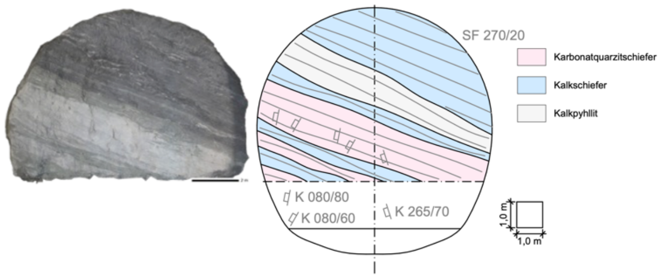

Figure 2-1: Site survey in area B

2.2 Basics of the rock solution

The fundamentals of the rock solution in blasting tunnelling, based on the study by Kurosch Thuro and Ralf J. Plinnin-ger, concentrate on the performance and wear parameters of cyclic tunnelling methods, especially in soft limestone. The drillability, defined by the drilling speed, is largely determined by the performance classes of the rotary hammers as well as by the geological properties of the rock, such as strength and interface spacing. The study shows that narrow parting surfaces promote the formation of macro and micro cracks, which leads to a significantly higher drilling speed in shell limestone, while wider parting surfaces have constant or reduced speeds. Similarly, the interfaces influence the blastability, measured in terms of specific explosive consumption: denser interfaces lead to more efficient energy transfer and lower consumption, while higher charge quantities are required for wider interfaces in shell limestone. [4]

2.3 Key principles of the reference project

Three tunnel sections (A, B and C) located in different geological formations were investigated as part of this work: A and B in schist and C in gneiss. Sections A and B were partially excavated with a pre-excavated crown and subsequent bench and floor driving, while section C was fully excavated. A pumpable emulsion explosive (RIOMEX MU) was used exclusively for the blasting work, which was prepared on site during the loading process using a mixer-loader and pumped directly into the boreholes. The drilling work was carried out with a semi-automated drill rig, which drilled around 100 to 120 boreholes per strike and automatically recorded comprehensive drilling data such as impact pressure, rotation speed and drilling depth. Photogrammetric 3D images were created to document the interface distances, which enabled a detailed analysis of the geological structures with the help of point clouds and 3D models, as shown in Figure 2-2.

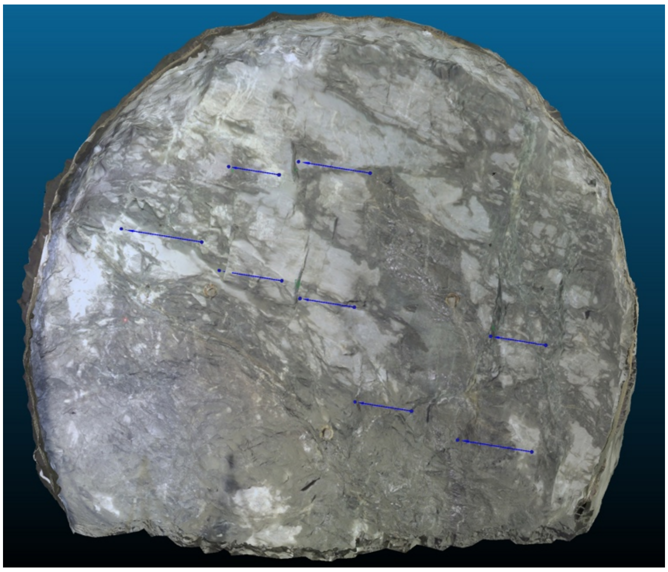

Figure 2-2: Example of recording the separating surfaces

2.4 Comparison with existing research

Compared to the existing study by Kurosch Thuro and Ralf J. Plinninger, which focussed on shell limestone, the current study shows clear differences in slate and gneiss. In the existing study, it was found that smaller separation distances lead to higher drilling speeds and an increase in cracks in the rock. At the same time, the specific explosive consumption increased with larger fissure spacings.

In the current study, however, no clear tendency between the interface spacing and the explosive consumption could be established. Similarly, the drilling speed remained constant with increasing spacing in both rock types. These deviations can be attributed to different input parameters, in particular the varying rock properties and the explosives used.

3 CONCLUSION

Photogrammetry has established itself in tunnelling as an important tool for the precise recording of geometric structures of the tunnel face, especially under time-limited conditions. While it enables detailed digital models for analysing interface distances, it is dependent on on-site analyses for non-geometric phenomena such as water ingress or fissure filling. Despite its accuracy, it cannot be used optimally everywhere, as important features can be lost when analysing soft rocks, for example.

In the master's thesis, interface distances within schist and gneiss formations were analysed, whereby predominantly wide interface distances were determined. In comparison to the study by Thuro and Plinninger, which analysed mu-schelkalk, there are differences: While a clear correlation between interface spacing and specific explosive consumption is visible in the existing research, no clear trends could be identified in the current work. The results underline the importance of input parameters such as rock and explosive type for the analysis and make it clear that the findings should be transferred to other projects with caution, as geological variations play a significant role.

4 OUTLOOK

Photogrammetry still plays a subordinate role in practice, but offers great potential for the optimisation and precise cost calculation of projects. It is recommended that the use of this technology be strengthened by suitable software solutions and increased automation in order to minimise human influences during data evaluation.

The analysis of interfaces with performance parameters should always be adapted to local conditions in order to guarantee the quality of the results. A differentiated investigation of the geological units, particularly in the case of schist and gneiss formations, is necessary as these vary greatly in their composition and compressive strength. To date, there has been no detailed analysis that also includes other rock types. Future research should therefore close these gaps in order to gain more widely applicable and more precise findings.

REFERNECES

[1] B. Maidl, H. G. Jodl, L. Schmid und P. Petri, Tunnelbau im Sprengvortrieb, 6. Aufl. 2018. Springer Berlin / Heidelberg, 1997, ISBN: 3-540-62556-9. DOI: https://doi.org/10.1007/978-3-642-60723- 3.

[2] R. Schillinger, Sprengtechnik in der Praxis, 2., vollständig überarbeitete Auflage. München: Carl Hanser Verlag GmbH & Co. KG, 2023. DOI: 10.3139/9783446476219. Adresse: https://www. hanser-elibrary.com/doi/abs/10.3139/9783446476219.

[3] S. Eder, H. Kontrus und M. Egger, „Anwendung photogrammetrischer Tunnelscans für die geolo- gische Dokumentation“, 22. DGGT Fachsektionstagung Ingenieurgeologie, 2021.

[4] K. Thuro und R. J. Plinninger, „Geologisch-geotechnische Grundlagen der Gebirgslösung im Fels“, in Fels- und Tunnelbau II, Ser. Kontakt und Studium, K. Eichler u.a., Hrsg., Bd. 684, Renningen-Malmsheim: Expert, 2007, S. 112–160.