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RECENT MASTER'S THESES AT THE INSTITUTE OF ROCK MECHANICS AND TUNNELLING

ADVANCES IN THE DEVELOP-MENT OF A NOVEL ALOGRITHM FOR FRAGMENTATION ANALYSIS BASED ON PHOTOGRAMMETRY

Dipl.-Ing. Stefan Stauder

Sublevel Caving (SLC) is used as a mining method in LKAB's underground mine in Kiruna. Fragmentation in SLC is vitally important and further the fragment size distribution (FSD) in muck piles plays an important role regarding processing of the blasted material (Figure 1). The best way to obtain the FSD in muck piles is sieving. However, this is time consuming and increases the mining expenses. To over-come this problem, a new method for determining the FSD is currently under development. This new approach combines a 3D surface and image analysis derived from a 3D image and leads to an estimation of the FSD. Selected sets of muck pile photographs are used to generate a 3D image, which is consecutively analyzed with the BMX Fragmenter. Both, artificial and real data were used. The artificial muck piles were photographed at a limestone quarry in Austria, whereas the real data was pro-vided by the LKAB.

Figure 1: Setup for data acquisition in LKAB's Kiruna mine for the determination of the fragment sizes in a muck (c) LKAB, Runar Gudmundsson.

Each set is composed of at least four images, taken from fixed camera positions. After generating the 3D image, the software is able to detect the muck pile as the region of analysis. The delineation of individual blocks is based on the analysis of the gradient and the curvature of the muck pile surface and enhanced by an edge detection logic from image processing. Detected fragments are colored to ease visual in-spection regarding the plausibility of the determined grading curve. The computed FSD and a delineated muck pile are illustrated in Figure 2-a and 2-b.

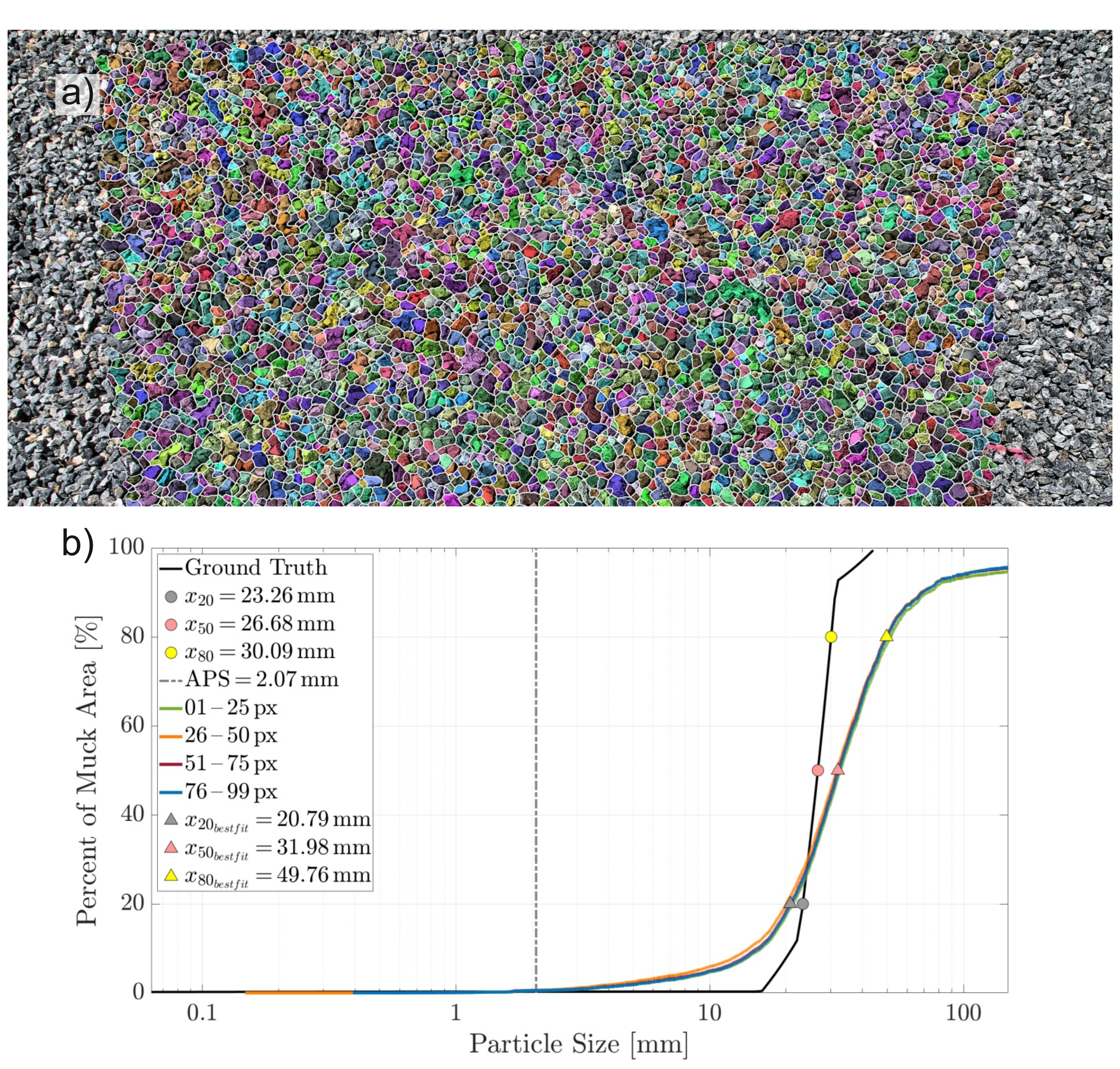

Figure 2: Fragment detection with the BMX Fragmenter; a) data from a limestone quarry b) corresponding FSD.

As shown in Fig. 2-a, the delineation of the frag-ments via the BMX Fragmenter works well, despite some artefacts remain at the boundaries of the muck pile. Taking a closer look, some delineated particles seem to be fused from adjacent fragments or a disintegration of a bigger block. Such false positives shall be minimized in future analysis. Con-sidering the correlation between the FSD and the ground truth (Figure 2-b), the FSD approximates the ground truth fairly well at the lower and central part, but the error increases around x80. Summarizing, it can be stated at this point that the fragment delineation and FSD analysis, implemen-ted in the BMX Fragmenter, work well and need only limited amount of manual intervention.

RADIAL BEDDING OF SEGMENTAL LININGS AT SHIELD TBM DRIVEN TUNNELS

Dipl.-Ing. Melissa Preschan

For tunnels with shielded TBM advance, an annular gap between rock mass and segmental lining is created. This gap has to be backfilled as soon as possible. The properties of the used backfill material crucially affect the load-bearing behaviour of the overall system consisting of rock mass, backfill and segmental lining. In German-speaking parts of Europe, the segmental linings are often dimensioned by means of the elastic bed-ded frame model method. When applying this method, the lining seg-ments are discretised as straight or curved beams, using elastic bedding springs to simulate the subsoil reaction. The spring stiffness is defined by the bedding modulus kr. Hence, the bedding modulus constitutes an im-portant input parameter when dimensioning the lining segments. The bedding modulus for circular tunnels was investigated using numerical simulations. The study showed that at present analytical approaches are only applicable under certain conditions. Most notably under plastified rock mass conditions the bedding modulus is overestimated to a consid-erable extend. This limits the applicability of the analytical approaches. Originating on the basic formulation of the bedding modulus as the rela-tion between stresses and corresponding deformations (kr = pi/ur) a new calculation method was developed. The method provides the separate consideration of the backfill layer and the rock mass (Figure 3).

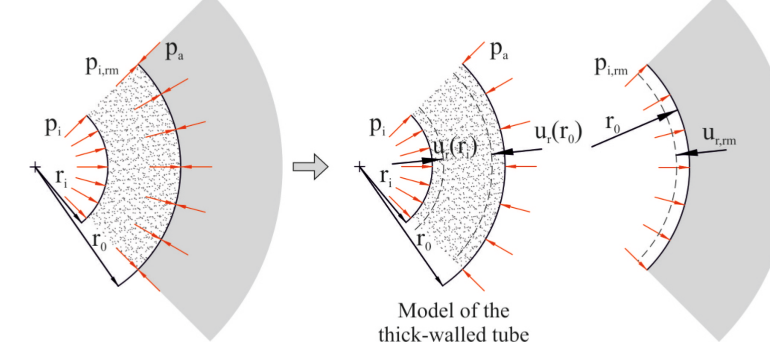

Figure 3: System sketch of the new calculation method.

This allows the calculation of the deformations on the inner surface of the annular gap by means of common approaches. Subsequently, the bedding modulus can be determined (Figure 4).

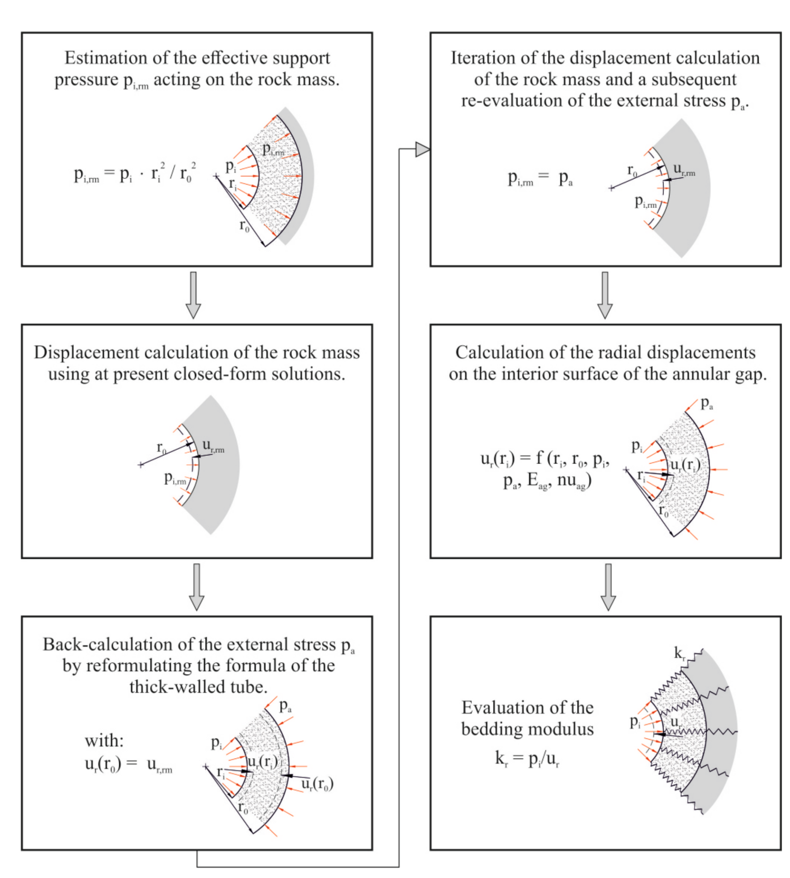

Figure 4: Graphical representation of the calculation steps.

The comparison of the new calculation method and the numerical results proved the correctness (Figure 5). This allows a closed-form and straightforward calculation method for the determination of the radial bedding modulus.

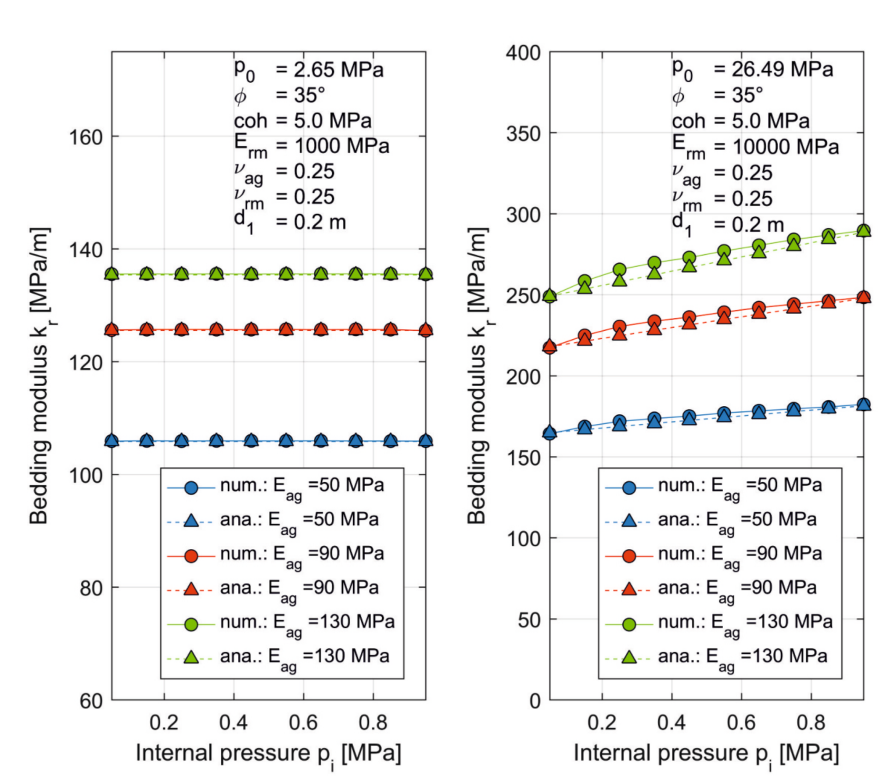

Figure 5: Comparison of the new method and numerical results.

DEVELOPMENT OF A POST PROCESSING AND ANALYSIS ROUTINE FOR THE AE-TESTING METHOD FOR ROCK BURST PRONE ROCKS

Dipl.-Ing. Andreas Wenig

The Acoustic Emission Testing (AET) is part of the non-destructive test-ing methods and is a versatile method for investigating materials in all fields and professions. In mining and tunnelling, it is used to track and predict rock mass failure like rock burst. Although there are many codes and standards of how to set up the measurements, there are no sophisti-cated codes or guidelines of how to post-process and analyse the results. The Rock Mechanics and Tunnelling laboratory at the Graz University of Technology conducts AE-measurements (Figure 6) and a practical direc-tive was developed, to post-process and analyse the results.

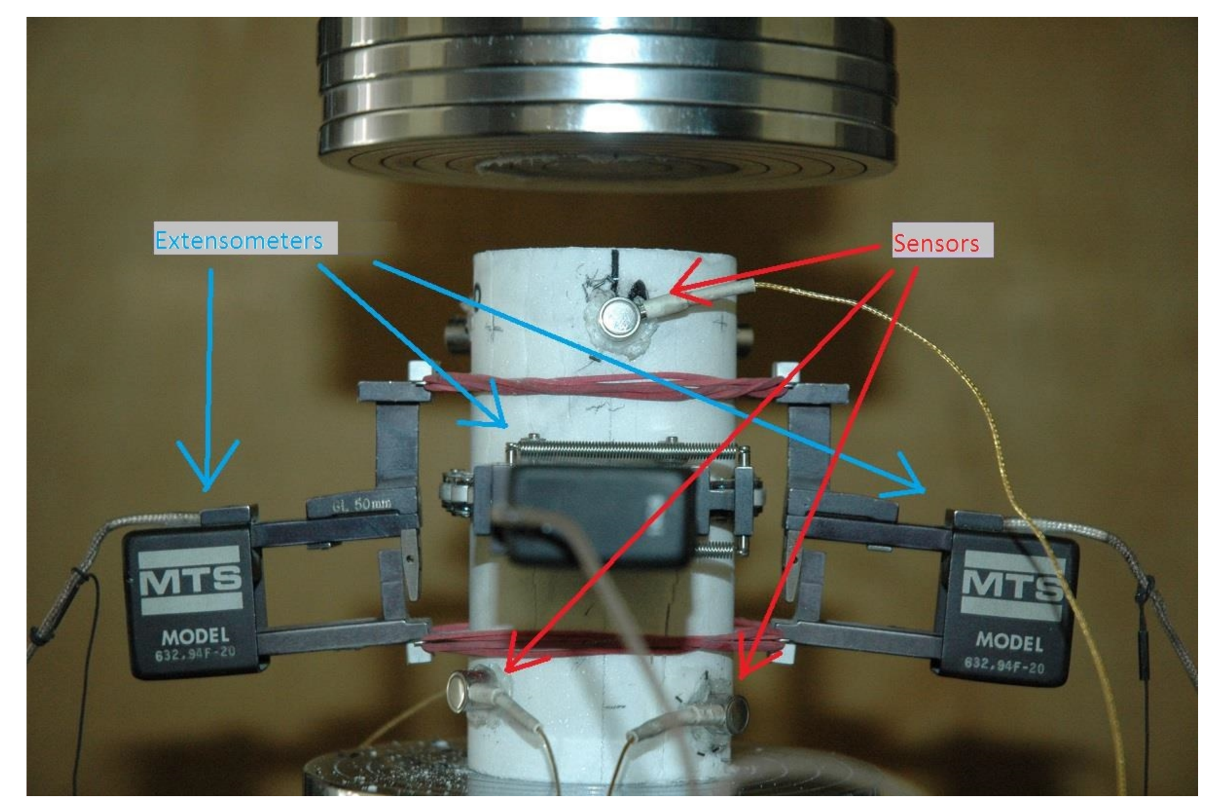

Figure 6: Testing setup under uniaxial loading, consisting of a chain-extensiometer to measure lateral deformation, extensiometers for axial deformations and AE-sensors.

Four of several previously tested samples, have been processed and analysed within this master thesis (Figure 7). One goal was to be able to distinguish the crack level indicators with the AE-measurements, which could be achieved with a combination of AE-energy and pattern recogni-tion. The results of those analyses were compared with the volumetric strain analysis and could be confirmed. Another goal was to compare the AE-results from differ-ent rock types. It can be said, that the hits- and the energy-comparison are shown to be applicable and correlations be-tween hits/energy and rock parameters can be drawn. On the other side, an event-comparison between different samples was not leading to sat-isfying results to this point.

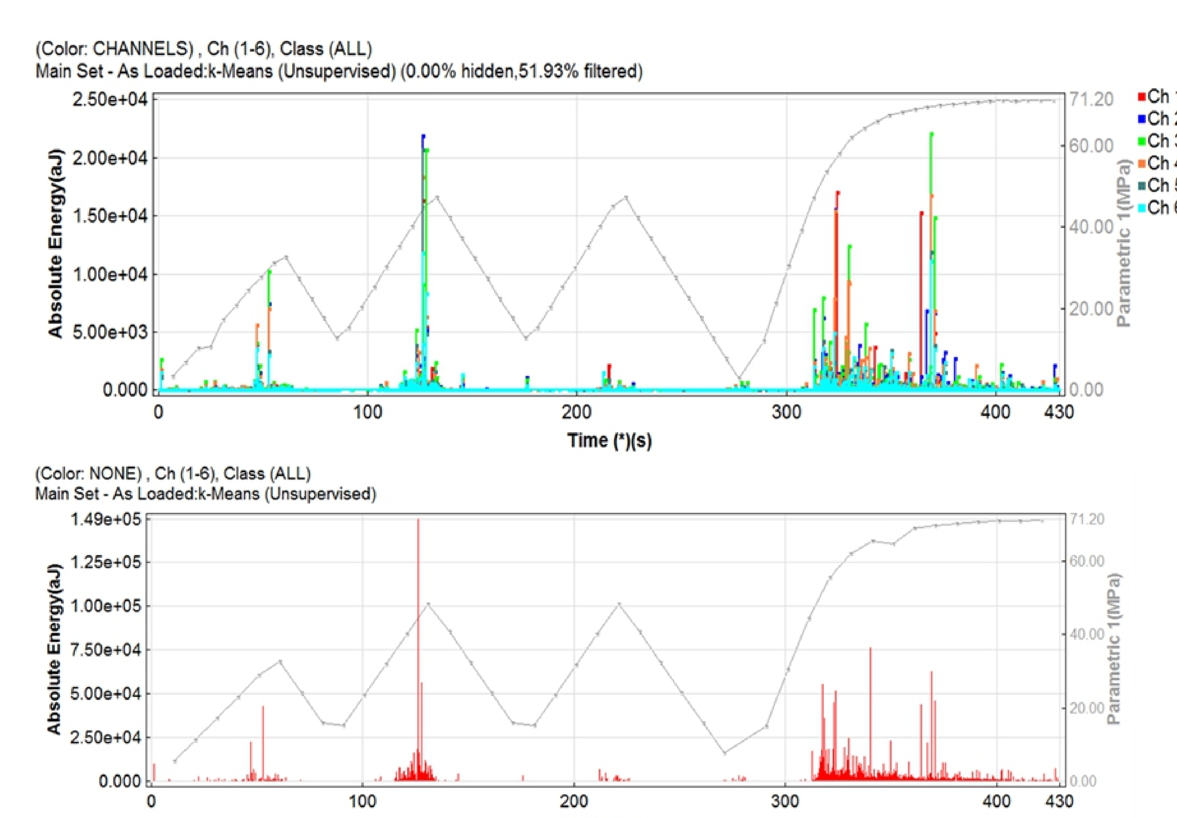

Figure 7: Absolute energy [aJ] versus time without post-failure.

With this proposed directive, more samples can be post-processed and additional conclusions can be drawn.

REFERENCES

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