

RECONSTRUCTING ROCK TEMPERATURE PROFILES FROM FIELD MEASUREMENTS USING FINITE ELEMENT MODELING AND INVERSE ANALYSIS

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Abstract

Rock temperature evolution plays a key role in the development of freeze thaw cycles that contribute to progressive rock damage and rockfall formation. Understanding the spatial and temporal distribution of temperature inside rock masses is therefore essential for studying thermally induced degradation processes in natural rock slopes. However, in situ measurements typically provide temperature data only at a few discrete depths, which makes it difficult to determine the complete temperature field within the rock.

This study presents a computational framework that combines field measurements, finite element simulations and optimization techniques to reconstruct the temperature distribution inside rock formations. Temperature sensors installed at several depths in exposed rock faces record temperature data at regular time intervals and transmit the measurements to a central database. Since temperature measurements are available only at a limited number of depths, inverse numerical analysis is used to infer the full temperature evolution within the rock.

Heat transfer in the rock mass is modeled using a one dimensional transient heat conduction model based on the finite element method. The reconstruction of the temperature field is formulated as a sequential optimization problem. In the first step, the thermal diffusivity of the rock is determined by minimizing the discrepancy between measured and simulated temperatures. In the second step, the unknown temperature boundary condition at the rock surface is identified through an optimization procedure. The optimized parameters are then used in a final simulation to compute the continuous temperature profile throughout the rock depth. The methodology was applied to several monitored rock faces and produced stable and physically consistent temperature profiles. The reconstructed temperature fields reveal the propagation of temperature variations into the rock mass and allow the identification of zones and time periods where the temperature drops below freezing. This enables a detailed analysis of freeze thaw cycles and provides valuable information for investigating thermally induced rock damage and rockfall processes.