

BUSITEMA UNIVERSITY

FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MINING ENGINEERING

FINAL YEAR PROJECT

**DEVELOPMENT OF A PREDICTIVE MODEL FOR FAILURE
RISK IN UNDERGROUND MINE TUNNELS**

By

MUGANGA SCOFIELD

This Final Year Project Report is submitted to the Department of Mining Engineering in partial fulfillment of the requirement for the award of the degree of Bachelor of Science in Mining Engineering of Busitema University.

MAY 2025



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BU/UP/2021/3446

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DR. JOSEPH DDUMBA LWANYAGA

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ABSTRACT

Underground mine tunnel failures pose severe safety and operational challenges, particularly in structurally complex regions such as the Greenstone Belt of Tiira, Uganda. These failures are commonly driven by poor geotechnical design, unassessed rock properties, and excessive overburden stress, often resulting in injuries, fatalities, equipment loss, and halted operations. To address this, the study aimed to develop a predictive model to assess tunnel failure risks and improve the design of underground mines.

Field and laboratory data were collected from both failed and stable tunnel zones, focusing on parameters such as rock stress, specific gravity, tunnel dimensions, and overburden pressure. Laboratory analysis included uniaxial compressive strength testing. Statistical tools including Kendall's Tau and Spearman's rank correlation were employed to identify key predictors. A machine learning model, specifically a Random Forest Classifier (RFC), was trained on the labeled dataset and evaluated using performance metrics like accuracy, precision, recall, and AUC.

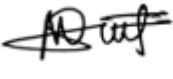
The RFC model achieved high predictive performance: 90.5% accuracy, 92.3% precision, and an AUC of 0.99. Sensitivity analysis revealed rock strength, specific gravity, and overburden stress as the most influential variables affecting tunnel stability. Conversely, wider tunnel dimensions were associated with increased failure risk.

The study demonstrates the potential of integrating machine learning into geotechnical engineering to predict tunnel failures effectively. This approach supports data-driven design in early-stage mine planning and enhances operational safety. It also contributes to sustainable mining practices aligned with SDG 8 and SDG 9.

Key words; underground mine tunnel failures, rock properties, overburden stress, geotechnical engineering, machine learning model, failure prediction and operational safety.

DECLARATION

I **MUGANGA SCOFIELD, BU/UP/2021/3446**, declare to the best of my knowledge that the work presented in this project report is my own effort and has not been published or submitted previously to any university or higher institution of learning for the award of a Bachelor of Science in Mining Engineering.

Sign 

APPROVAL

I **MUGANGA SCOFIELD**, submit this report of my final year project to the faculty of engineering in the department of mining engineering for examination with approval of my supervisors.

Mr. Bagoole Christopher

Assistant Lecturer

Department of Mining Engineering

Faculty Of Engineering and Technology

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Dr. Joseph Ddumba Lwanyaga

Senior Lecturer

Department of Water Resources Engineering

Faculty Of Engineering and Technology

Busitema University

Signature... 

DEDICATION

This research is dedicated to my guardian, my mother and my lecturers for their efforts towards my academics. They have stood by me and always believed in me. May the almighty God bless you.

ACKNOWLEDGEMENT.

First of all, I thank the almighty God for His protection and wisdom He granted to me throughout my education.

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LIST OF ACRONYMS

AUC	Area Under the Curve
FN	False Negative
FP	False Positive
MEMD	Ministry of Energy and Mineral Development
ML	Machine Learning
OAT	One-At-A-Time
RFC	Random Forest Classifier
RF	Random Forest
ROC	Receiver Operating Characteristic
SDG	Sustainable Development Goal
SG	Specific Gravity
SMOTE	Synthetic Minority Over-sampling Technique
TN	True Negative
TP	True Positive
UCS	Uniaxial Compressive Strength

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