

DESIGN AND DEVELOPMENT OF SMART SOIL NAIL FOR REAL TIME SLOPE MONITORING

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Landslides and geotechnical structure failures are significant natural and engineering hazards that can lead to severe damage to infrastructure, loss of life, and economic setbacks. These failures are often triggered by various factors such as intense rainfall, earthquakes, poor drainage, slope overloading, or inadequate construction practices. In many cases, slopes and retaining structures become unstable due to the gradual weakening of soil strength over time or sudden external forces. Identifying the variation of stress, moisture and other parameters in soil is crucial for designing effective stabilisation systems and implementing early warning measures, especially in vulnerable or high-risk areas. This study focuses on the design and development of an instrumented soil nail system capable of remote health monitoring for slopes and other geotechnical or civil engineering structures. Soil nailing is a reinforcement technique, used to reinforce in situ ground to stabilise it more effectively and economically, in which the reinforcing slender elements (typically steel bars), called soil nails, are inserted into a soil mass by different installation methods such as driving, jacking or pre-drilling. The nailing technique is extensively applied to slopes, excavations and retaining walls. Instrumentation of soil nails using strain gauges and moisture sensors to measure the stress and moisture content to identify changes that occurred in soil would help to identify landslides and designing effective stabilisation systems.

Prior to instrumentation, numerical simulations were performed using ANSYS and GeoStudio to investigate stress distribution and deformation behaviour under various surcharge loads. High stress areas were identified from the model, and the placement of strain gauges were planned accordingly. A novel instrumentation approach was adopted by replacing traditional grout with welded iron nails on the reinforcement bar surface to improve mechanical interlock and reusability, as supported by numerical comparisons and literature findings. The instrumentation phase included the fabrication of soil nail and bearing plate, integration of strain gauges with a custom electronic circuit, and development of a remote data acquisition system incorporating a microcontroller, HX711 strain amplifier, and moisture sensing unit.

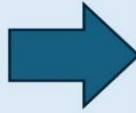
Comprehensive calibration of the system was conducted under controlled bending and axial loading conditions, including temperature compensation. Performance evaluation was carried out using a small-scale model tank, simulating rainfall with a sprinkler system and applying varying surcharge loads through a hydraulic jack. Tests were conducted across different soil types, and the results were compared with theoretical predictions and numerical model outputs.

Keywords: Soil nail, Numerical modelling, Strain gauges, Moisture sensors, Data acquisition system, Testing platform

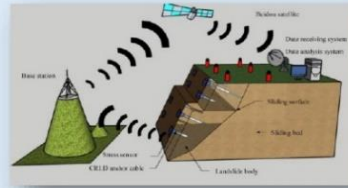
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SMART SOIL NAIL FOR SLOPE MONITORING.

PROBLEM

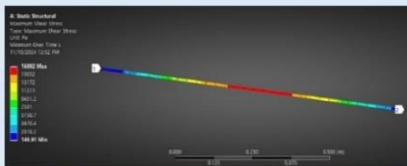


SOLUTION - SMART SOIL NAIL

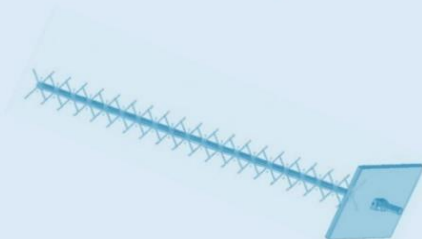


PLANNING - DESIGN

- ❖ Initial material and soil nail sizing selection.
- ❖ Strain Gauge Placement Location Identification – Ansys Model.



- ❖ Strain Gauge Type Selection - Foil Type BF350 Strain Guage
- ❖ Strain Gauge Placement Method Identification – Numerical Modelling and Literature.
- ❖ Finalize the Design



FABRICATION AND TESTING

- ❖ Smart Soil Nail Fabrication.



- ❖ Data Acquisition System Development.



- ❖ Applied On Testing Platform.

