Anchor Bolt Distributed Fiber Optic Sensor



Overview

This paper presents a new self-sensing anchor with embedded optical fibers (made using an improved stirrer) and proposes an intelligent tunnel rock monitoring system.

Key Takeaways

Distributed fiber optic sensors embedded in anchor bolts enable full-length, real-time monitoring of axial forces and strain along the bolt, providing detailed insight into structural stability.

Overview

Distributed fiber optic sensors (DFOS) integrated into anchor bolts are designed to measure axial strain and stress along the entire length of the bolt, rather than at discrete points. Traditional monitoring methods, such as dynamometers, strain gauges, or fiber Bragg grating sensors, typically provide data only at specific locations, which limits the understanding of the bolt's performance within surrounding rock or soil.

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S technology overcomes this limitation by offering continuous, high-resolution monitoring along the bolt axis, capturing both axial forces and shear stress distribution in real time.

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Principle of Operation

In a self-sensing fiber optic anchor, the bolt acts as a composite beam within stratified rock or soil. The embedded optical fiber deforms synchronously with the bolt under axial tension and shear forces. By measuring the strain at multiple points along the fiber, the axial force distribution can be calculated using the bolt's elastic modulus, diameter, and the distance between sampling points.

This allows engineers to identify critical zones such as the borehole area, loosening zones, stable zones, and anchoring zones. ApplicationsDFOS-equipped anchor bolts are particularly useful in: Tunnel construction: Monitoring axial forces in bolts installed in surrounding rock to detect loosening zones and ensure tunnel stability. Slope stabilization and retaining walls: Providing continuous feedback on anchor performance in soil or rock slopes.

Long-term structural monitoring: Capturing strain evolution over time in critical civil engineering structures, including excavation pits and deep foundations. AdvantagesFull-length monitoring: Unlike point sensors, DFOS provides continuous data along the entire bolt. Real-time data acquisition: Enables proactive adjustments in construction or maintenance operations.

Enhanced safety: Early detection of loosening or stress concentration zones reduces the risk of structural failure. Integration with intelligent monitoring systems: Data can be used to optimize construction parameters, such as TBM driving speed and support installation.

Implementation Considerations

Fiber placement: Optical fibers are embedded inside grooves within the bolt to ensure synchronous deformation and protect the fiber from surface shear stresses. Data interpretation: Strain measurements are converted into axial force and shear stress using established formulas, allowing engineers to map stress distribution and identify potential failure zones. Environmental conditions: DFOS performance can vary with temperature, moisture, and rock or soil type, requiring calibration and validation against traditional measurement methods.

In summary, anchor bolts with distributed fiber optic sensors provide a powerful tool for structural health monitoring, offering continuous, real-time insight into axial forces and stress distribution, which enhances safety and efficiency in civil and geotechnical engineering projects.

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Article Content

A New Self-Sensing Fiber Optic Anchor to Monitor Bolt Axial ...

This paper presents a new self-sensing anchor with embedded optical fibers (made using an improved stirrer) and proposes an intelligent tunnel rock monitoring system.

A New Self-Sensing Fiber Optic Anchor to Monitor Bolt

This article proposes a new self-sensing optical fiber anchor, made by improving the stirrer, to monitor the axial force on the bolt and the loose zone of surrounding rock.

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Monitoring and correction of the stress in an anchor bolt based on ...

The axial stress and shear stress of the bolt are measured by the method of inserting the fiber optic sensor into the anchor rod. The measured value is higher than the actual value of the

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Buchmayer et al. presented a tunnel monitoring approach based on distributed fiber optic sensing (DFOS), which monitors hundreds of strain and temperature sensing points inside the

Distributed fibre optic sensing during different anchor pullout tests

This paper gives an overview of the sensor systems used, the obtained results of the anchor pullout tests, gathered experiences and finally gives a brief concept of a monitoring anchor for long term

Distributed Fiber-Optic Sensors for Monitoring Slow ...

This paper presents two recent applications of distributed fiber-optic sensors on slow-moving landslides: in one application, they are the basic element of a smart inclinometer; in the

(PDF) Embedded quasi-distributed fibre optic sensors for long-term ...

Quasi-distributed fibre optic strain sensors are centrally positioned in the complete length of these anchors to detect the long-term behaviour of the tendon bonded to the rock foundation.

A distributed self-sensing FRP anchor rod with built-in optical fiber ...

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In this paper, a distributed self-sensing FRP anchor rod is proposed by using built-in optical fiber sensor. The characterization and self-sensing property of this proposed anchor rod were

Bolt axial force monitoring based on fiber grating technology

Compared with traditional electrical sensors, fiber optic sensors offer numerous advantages, including excellent resistance to electromagnetic interference, high-temperature and

A Technic for Ground Anchor Force Determination from ...

Previously, we propose a way to monitor the tensile force of the anchor by measuring the strain field on a bearing plate using a distributed fiber optic sensor (OFDR) and experimentally

A load measuring anchor plate for rock bolt using fiber optic sensor ...

Therefore, it is very important to monitor the load level of the rock bolts. In this short communication, we propose a smart anchor plate, a simple but effective device that uses fiber Bragg

Distributed fibre optic sensing during different anchor pullout tests

Although ground anchors are widely used in fields of civil engineering, as in soil and rock stabilization or anchoring structures, such as excavation pits, retaining walls or tunnel constructions, the load

A New Self-Sensing Fiber Optic Anchor to Monitor Bolt Axial ...

This new self-sensing fiber optic anchor was first applied to an open TBM tunneling project in an inclined shaft in the Kekegai coal mine, and monitoring data indicate that self-sensing

Recent progress of using Brillouin distributed fiber optic sensors for ...

Abstract Distributed optical fiber sensors (DOFS) have been attracted significant attention from geotechnical engineering communities for a few decades. Innovative development of structural

Corrosion monitoring of rock bolt by using a low coherent fiber-optic ...

The sensing fiber was configured as one arm of the fiber-optic Michelson interferometer. The acceleration corrosion experiments demonstrated that a uniform interface between cement and

A New Self-Sensing Fiber Optic Anchor to Monitor Bolt Axial Force

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Fiber optic sensors can achieve distributed, long-term, and real-time automated monitoring, making them a research hotspot in the field of underground engineering deformation monitoring [1, 2].

Augmenting the in-situ rock bolt pull test with distributed optical ...

Within this context, a technique using distributed optical fiber strain sensing (DOS) is presented as a sensing based methodology to augment the assessment of ground anchors/support

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