Nano graphene platelet tailored shotcrete concrete for refinement of permeability in tunnels

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Abstract

Purpose – Tunnels are means of transport in mountainous region which have continuous ingress of water. The incorporation of graphene nanoplatelets (GNPs) in shotcrete will refine the pore and limit the ingress of water as this study aims to enhance the performance, durability and sustainability of shotcrete used in lining of tunnels.

Design/methodology/approach – An experimental investigation was conducted wherein shotcrete mixes were prepared by adding various dosages of GNPs by weight of cement to the mixes varying from 0.25% to 1%. The mixes were tested for key properties including compressive strength, flexural strength, permeability, durability and microstructural characteristics. The performance of the GNP-enhanced mixes was then compared to that of conventional shotcrete.

Findings – The results showed significant improvements in the mechanical and durability properties of the shotcrete with the inclusion of GNPs. Notably, there was a substantial reduction in permeability, suggesting better resistance to moisture ingress and environmental degradation. Improved bonding and refined microstructure were also observed, indicating enhanced long-term performance.

Research limitations/implications – Further research is needed to evaluate long-term field performance, scalability and cost implications of GNP incorporation in large-scale shotcrete applications.

Practical implications – The improved properties of GNP-enhanced shotcrete can lead to extended service life and reduced maintenance in tunnel and underground projects, offering practical benefits in both construction efficiency and life cycle cost savings.

Social implications – The use of durable and sustainable materials like GNP-enhanced shotcrete supports environmentally responsible construction practices and contributes to the development of safer, longer-lasting infrastructure.

Originality/value – This research introduces the novel application of GNPs in shotcrete to overcome common limitations such as cracking, high permeability and poor tensile strength. The findings contribute to the development of advanced, nanoengineered shotcrete materials for more resilient and sustainable infrastructure in challenging underground environments.

Keywords EDS, Durability, Freeze-thaw, Water ingression, Workability, Compressive strength, SEM, Graphene nano platelets, Flexural strength, XRD, XRF, Pull out test, Shotcrete, Concrete, Plasticizer

Paper type Research paper

1. Introduction

Carl Ethan Akeley, 1907, an American taxidermist and inventor, developed a technique to apply mortar using compressed air to repair the facade of the Field Columbian Museum in Chicago. Spraying dry concrete mix through a nozzle with water added just before application is known as cement gun technology, and the process is gunite. A significant advance in development in 1950 marked the beginning of the wet-mix process, where premixed concrete was pumped through a hose and sprayed with

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