Enhancement of shotcrete performance with bio-admixture

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# Abstract

This study explores the use of carrot juice as a sustainable alternative to petrochemical based admixtures for shotcrete. Currently, admixtures are mostly chemically synthesised and are derived from fossil fuels. Toxic substances can leach from admixtures and cause serious environmental pollution. Bio-admixtures have been proposed as an abundant alternative that is low cost and renewable. Low preparation time and accessibility along with the ability to improve the performance of shotcrete is key to their interest in industry. As a low cost globally available high yielding renewable resource with abundant spare capacity owing to waste generated by commercial carrot standards where up to 30% of the crop is sent to landfill (Pan et al. 2022) (Pan et al. 2023), carrot juice was chosen to be investigated.

Carrot juice acts as a retarder, reducing the setting time and improving the workability of the shotcrete mix before it is applied. The early age strength characteristics are critical for underground mining to maintain sufficient cycle times. It is expected that a re-entry strength of 1MPa is reached for safe entrance into an excavation, typically this is achieved after 2-4 hours (Rispin, 2017). The experiment tested 4 concentrations of carrot juice on two substrates being granite and sandstone representative of hard rock and underground coal environments. The strength was tested using a needle penetrometer until 1MPa was reached. The results found that all concentrations reached acceptable strength levels within 3hrs for sandstone. The optimal concentration for carrot admixture on granite was 4% reaching 1MPa between 5-5.5hrs after mixing; however, the control group reached 1MPa between 3-3.5hrs. The bonding strength tests found poor adhesion for all carrot concentrations on granite with all samples shearing at the substrate shotcrete interface before testing. The sandstone substrates performed better with the control group reaching 1400kPa, 5% carrot admixture yielded the greatest strength at 1000kPa. Ultimately, carrot juice shows promise as a novel solution with almost zero net environmental impact