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INVESTIGATING MORPHOLOGY AND PHYSICAL PROPERTIES OF PORTLAND CEMENT INCORPORATING NOVEL DEEP EUTECTIC SOLVENT

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OBJECTIVE OF THE STUDY

The present study aims to synthesize a choline chloride–ethylene glycol deep eutectic solvent (DES) and investigate its role as a multifunctional additive in Ordinary Portland Cement (OPC-53) cement. The effects of DES on hydration characteristics, setting time, workability, mechanical properties, microstructure, and grinding efficiency were evaluated to determine its potential for improving cement performance while promoting sustainable and energy-efficient cement production.

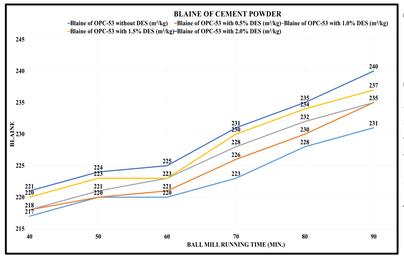
SYENTHESIZE OF DES

$$[(CH_3)_3N^+CH_2CH_2OH]Cl^- + 2HOCH_2CH_2OH \xrightarrow[\text{Stirring}]{\text{60–70 °C (20-25 min.)}} ChCl.2EG$$

Choline chloride — Ethylene glycol — DES

Choline chloride was used as the hydrogen bond acceptor (HBA), while ethylene glycol served as the hydrogen bond donor (HBD). The DES was formed through strong hydrogen-bond interactions between the chloride anion of choline chloride and the hydroxyl groups of ethylene glycol.

BLAINE STUDIES



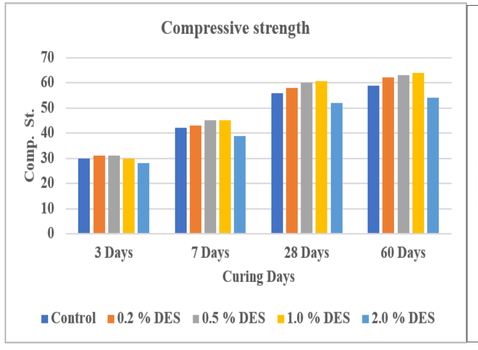
The use of DES increased the Blaine fineness of OPC-53 cement, indicating enhanced grinding efficiency. Consequently, the target fineness can be achieved with lower grinding energy compared to cement without DES. The reduction in energy consumption supports sustainable cement manufacturing and is consistent with the sustainability objectives outlined in the UN Sustainable Development Goals (SDGs).

SETTING TIME

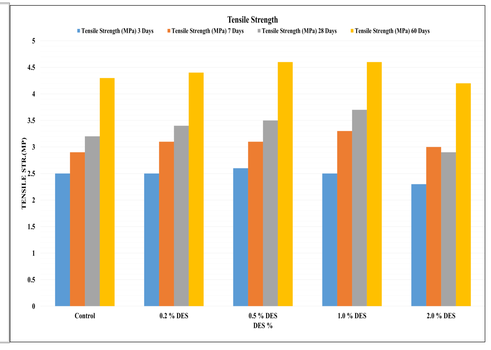
Sample	Initial Setting Time (Min.)	Final Setting Time (Min.)
Control	170 ± 10	205 ± 12
0.2 % DES	182 ± 10	221 ± 12
0.5 % DES	187 ± 10	228 ± 12
1.0 % DES	192 ± 10	236 ± 12
2.0 % DES	197 ± 10	245 ± 12

The increase in initial and final setting times demonstrates a retarding effect of the additive on cement hydration, resulting in extended workability and delayed formation of hydration products due to additive–cement interactions.

COMPRESSIVE STRENGTH

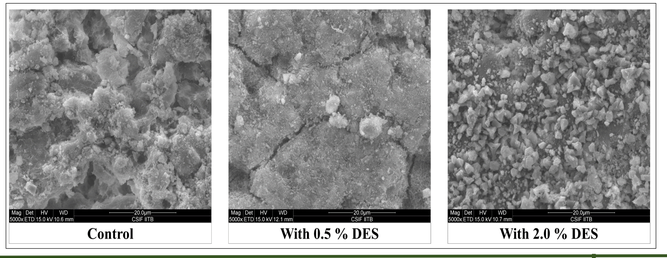


TENSILE STRENGTH



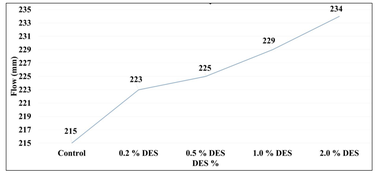
- **Strength increased with curing age due to continued hydration.**
- **1.0 wt.% DES showed the highest strength, indicating optimum performance.**
- **2.0 wt.% DES reduced strength, due to excessive hydration retardation.**

ENVIRONMENTAL SCANNING ELECTRON MICROSCOPY STUDIES



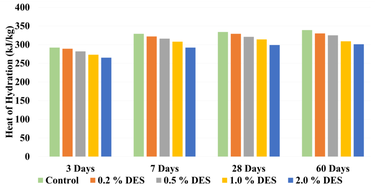
The control sample shows a porous, loosely connected C–S–H matrix, while 0.5% DES produces a denser and more compact structure. Higher DES dosage leads to sharper, granular, and more crystalline particles.

FLOW STUDIES



The increase in flow with DES addition indicates improved cement particle dispersion and enhanced workability, leading to reduced interparticle attraction and better rheological behavior.

HEAT OF HYDRATION STUDIES



Reduced heat of hydration indicates controlled hydration at optimum DES dosage, while excessive reduction may delay strength development