PREFACE

This research addresses pressing concerns about the Earth's finite resources and their sustainable utilisation. The focus revolves around concrete, a widely used material but a major contributor to environmental issues due to the production of Portland cement. This crucial binding material is responsible for significant CO_2 emissions, impacting climate change. Concrete, inherently eco-friendly, poses a challenge due to the environmental implications of Portland cement. To enhance sustainability in construction, the emphasis is on utilising concrete with reduced reliance on Portland cement.

The primary challenges include reducing clinkers in concrete production and emitting less CO_2 while ensuring reliability and significantly enhancing durability. Durable and high-strength concrete is a key consideration for future materials and eco-efficiency. The research delves into finding suitable supplementary cementitious materials (SCMs) to replace or partially replace Ordinary Portland Cement (OPC). These materials, both natural and artificial, include pozzolanic materials, calcined clays, limestone, fly ash, ground granulated blast furnace slag, and silica fume.

Natural pozzolans, such as metakaolin, stand out due to their advantages, including lower processing temperature, reduced greenhouse gas emissions, and smaller embodied energy. Additionally, the study explores the use of nanoparticles, particularly nano-sized silicon dioxide or nano-silica in concrete, highlighting its high pozzolanic activity and enhancement in mechanical and durability properties. The need for a ternary blended composition of concrete mix, combining cement with two SCMs, is stressed for creating high-quality concrete with reduced environmental impact. The synergy of metakaolin and nano-silica particles in concrete is explored for improved performance and cost-effective construction. The research objectives are outlined, focusing on investigating the combined influence of metakaolin and nano-silica on mechanical properties and durability performance. Thermal stability analysis, microstructural analysis, eco-efficiency assessment, and economic evaluation are integral components of the study.

The experimental program comprised two phases, with the first phase dedicated to mortars and the second phase focusing on concrete mixes. Sixteen mortar compositions were examined and categorised into binary and ternary groups, with subsequent testing for compressive strength. The dosage of metakaolin and nano-silica was determined based on pozzolanic efficiency for the subsequent investigation of concrete mixes. In the second phase, eight distinct metakaolin and nano-silica concrete compositions were created and tested for mechanical properties and durability parameters. The eco-efficiency and cost index were assessed, considering sustainability and economy based on mechanical properties and carbonation resistance.

This research aims to contribute valuable insights into utilising metakaolin and nano-silica as alternative cementitious materials, addressing performance and sustainability concerns in the construction industry.