EVALUATION OF THE FIRE PERFORMANCE OF CONCRETE CONTAINING GRAPHENE OXIDE (GO)

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Master of Science (Major Component Research)

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Thesis submitted in partial fulfillment of the requirements for the degree
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DECLARATION

I declare that this is my own work and this thesis/dissertation does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other University or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. I retain the right to use this content in whole or part in future works (such as articles or books).

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The above candidate has carried out research for the PhD/MPhil/Masters thesis/dissertation under my supervision. I confirm that the declaration made above by the student is true and correct.

Name of Supervisor: Dr. T.G.P.L.Weerasinghe

Signature of the Supervisor: Date: 07/02/2026

DEDICATION

This thesis is respectfully dedicated to my supervisor, Dr. T.G.P.L Weerasinghe, for his invaluable guidance, academic support, and continuous encouragement throughout my MSc studies.

I also sincerely acknowledge Prof. Jagath Manathunga, whose academic advice and guidance motivated me to pursue the MSc programme.

Finally, this thesis is dedicated to my family for their unconditional love, patience, and constant support, which have been my strength.

Finally, I dedicate this thesis to all the lecturers and teachers who have guided me with knowledge, patience, and dedication, and who have helped shape my academic journey.

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ABSTRACT

Concrete stands as one of the most widely used construction material in Sri Lanka, as in most other countries. But, still, its performance under elevated temperatures remains a critical concern, particularly regarding loss of strength and spalling. Incorporation of graphene based materials (e.g., GO) has emerged as a more effective approach to improve the thermo-mechanical performance of concrete. Sri Lankan graphene is recognized globally for its high purity, making it a valuable candidate for producing GO-based concrete with potential export value. Despite extensive studies shows GO's impact on structural integrity under ambient conditions, limited research has addressed its fire performance.

The study evaluates the role of synthesized graphene oxide (GO) in mitigating thermal degradation, specifically assessing its effects on residual mechanical characteristics and spalling prevention in heated concrete. Concrete mixes were prepared with 0%, 0.01%, 0.02%, and 0.04% GO as a percentage weight of cement. Samples were grouped and heated to 200°C, 400°C, 600°C, and 700°C, and two cooling methods were used for all the cubes: passive cooling and water quenching. The residual compressive strengths were evaluated, and microstructural observations were examined using Scanning Electron Microscope (SEM). Results revealed that the inclusion of GO refined the pore structure and limited crack propagation, leading to improved residual strength and enhanced spalling resistance up to 700°C. The optimal performance was observed at a GO content of 0.02%. In 0.02% GO mixed specimens at 200^0C shows a 55% improvement over the control specimen. Similarly, at 400^0C, 600^0C and 700^0C temperatures the improvement percentages are 36.8%, 36.32% and 25.85% respectively.

In addition, a Convolutional Neural Network (CNN) model was developed to recognize and classify surface cracks on fire exposed specimens automatically. The CNN model demonstrated high accuracy (Around 0.9) in distinguishing crack patterns based on the GO content and exposed temperature. It provided a quantitative means of assessing damage intensity. The study confirmed that Sri Lankan GO can significantly enhance fire resilience and post fire structural integrity of concrete, highlighting its potential for sustainable and high performance construction applications.

Keywords: Graphene oxide, Fire Performance, Composition, Scanning Electron Microscope, Convolutional Neural Network, Deep Learning

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LIST OF ABBREVIATIONS

Abbreviation	Description
BA	Benzylamine
CBN	Carbon based nanomaterials
CNN	Convolutional Neural Network
DMA	Dimethylacetamide
EG	Expanded Graphite
FGS	Few layer graphene sheet
FTIR	Fourier Transform Infrared Spectroscopy
GIC	Graphite intercalation compound
GO	Graphene Oxide
NG	Natural Graphite
NMP	N-Methyl-2-Pyrrolidone
SEM	Scanning Electron Microscope
XRD	X- ray Diffraction