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

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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 showing 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°C shows a 55% improvement over the control specimen. Similarly, at 400°C, 600°C and 700°C 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

TABLE OF CONTENTS

DECLARATION	i
DEDICATION	ii
ACKNOWLEDGEMENT	iii
ABSTRACT	iv
TABLE OF CONTENTS	v
LIST OF FIGURES	viii
LIST OF TABLES	x
LIST OF ABBREVIATIONS	xi
Chapter 1	1
INTRODUCTION	1
1.1 Background	1
1.2 Problem Statement	3
1.3 Aim	3
1.4 Objectives	4
1.5 Scope of Study	4
1.6 Thesis Structure	4
Chapter 2	6
LITREATURE REVEIW	6
2.1 Introduction	6
2.2 Production of Graphene and Graphene Oxide	7
2.3 Graphene and Graphene Oxide: Structure and Properties	9
2.4 Effect of GO on cement Hydration and Microstructure	15
2.5 Mechanical and Durability Properties of GO Concrete	16
2.6 Fire Performance of Concrete with GO	18
2.7 Residual Strength and microstructural Changes of Concrete after Fire Exposure	19
2.8 Mechanisms and Factors Influencing Concrete Spalling and Incorporation of GO on Concrete Spalling	20
2.9 Use of AI and CNN Models for Crack Detection and Crack Classification in Concrete	21
2.10 Research Gap	22
Chapter 3	24
METHODOLOGY	24

3.1	Overview of Research Design	24
3.2	Materials	25
3.2.1	Preparation of GO suspension	27
3.3	Mix Design and Preparation	28
3.3.1	Mix Design and Preparation	28
3.3.2	Mix Proportions	29
3.3.3	Mixing Procedure	29
3.4	Specimen Preparation	30
3.5	Exposure to Elevated Temperatures	32
3.6	Testing Procedures	33
3.7	CNN Based Crack Detection	36
3.8	Data Analysis	37
3.9	Research Flow Diagram	38
Chapter 4		39
RESULTS AND DISCUSSION		39
4.1	Ambient Compressive Strength and Graphene Oxide Optimization	39
4.1.1	Effect of GO Content on $f_{c,0}$	39
4.1.2	Mechanism of GO Reinforcement and Over-Dosage Effect	39
4.2	Residual Compressive Strength and Thermal Degradation	41
4.2.1	Absolute Residual Compressive Strength ($f_{c,T}$)	41
4.2.2	Residual Strength Ratio (R_c) Analysis	42
4.3	Spalling Behavior Comparison	43
4.4	Effect of Cooling Methods (Thermal Shock Resistance)	43
4.5	Microstructural Observations (SEM) and Correlation	45
4.5.1	Microstructural Observations (SEM)	45
4.5.2	Ambient Microstructure and Nano reinforcement Quality	45
4.5.3	Microstructure of Thermal Shock Resistance (200°C Quenched vs 200°C Air-Cooled)	48
4.6	Optimum GO Percentage for Fire Resistance	49
4.7	Integrated Discussion and Correlation with Literature	49
4.7.1	Correlation of Strength Enhancement Mechanisms	50
4.7.2	Advancements in Thermal Shock Resistance	51
4.7.3	Future Research Directions	51
4.8	Crack Pattern Analysis using CNN model	52
4.8.1	Image Preprocessing Workflow	52

4.8.2	Data Acquisition from Concrete Crack Images	53
4.8.3	CNN Model Development and Performance Evaluation	53
Chapter 5		55
CONCLUSION AND RECOMMENDATIONS		55
5.1	Summary of Findings	55
5.2	Conclusions	56
5.3	Recommendations for Future Work	56
REFERENCES		59

LIST OF FIGURES

Figure	Description	Page
Figure 2.1	Typical scheme for production of screened graphite oxide (GO) [1]	8
Figure 2.2	Schematic illustration of the graphene exfoliation process [2]	9
Figure 2.3	2D building material for other dimension carbon materials [3]	10
Figure 2.4	Structure of graphene. a–c Schematics of crystal structure [3]	10
Figure 2.5	Structure of GO sheets. a) Structural model, b) 3D view of GO	11
Figure 2.6	Measurements of thermal conductivities of graphene	13
Figure 2.7	a) SEM image of a graphene sheet spanning an array of circular holes (scale bar = 3 mm). b) Schematic of nanoindentation on suspended graphene [4]	14
Figure 2.8	Stress–strain curve of graphene sheets containing a row of Stone Wales defects along with morphological changes with increasing strain [5]	15
Figure 2.9	Chemical bonding between GO and cement hydration products (C-SH and C-H)	16
Figure 2.10	The formation of densified microstructure in GO-added concrete [6]	17
Figure 2.11	High strength specimens after the exposure to high temperatures, particularly with respect to the torsions, (a) GHS after 800 after) the HS after spalling at (350–400) °C [7]	21
Figure 3.1	FTIR spectrum of GO	27
Figure 3.2	(a) GO dispersion using high-speed mixer and (b) GO-PS suspension [8]	28
Figure 3.3	Cube specimens preparation	30
Figure 3.4	Calibration of thermocouples	31
Figure 3.5	(a) Demoulded specimens (b) Curing the specimens	32
Figure 3.6	Thermal exposure of the samples	33
Figure 3.7	Monitoring the internal temperature of the specimens	34
Figure 3.8	Possible surface crack patterns due to the thermal loads	34
Figure 3.9	Edge damages due to the thermal loads	35
Figure 3.10	ADR Touch SOLO 1500 Compression Machine	35
Figure 3.11	EVO 18 scanning electron microscope	35
Figure 3.12	SEM images	37
Figure 3.13	Methodology	38
Figure 4.1	Bar chart illustrating the Ambient Compressive Strength ($f_{c,0}$) for all GO contents.	40
Figure 4.2	SEM micrograph illustrating the dense microstructure of the 0.02% GO concrete at ambient conditions (25°C), showing visual evidence of GO sheets integrated within the C-S-H matrix.	40

Figure 4.3	Absolute Residual Compressive Strength ($f_{c,r}$) versus Temperature for all GO contents (Passive Air-Cooled).	42
Figure 4.3	Residual Strength Ratio (R_c) versus Temperature for all GO contents (Passive Air Cooled)	43
Figure 4.5	Crack mesh observed on control specimens at 700 °C temperature	44
Figure 4.6	Comparison of (a) Air-Cooled and (b) water Quenched, Residual Strength for all GO contents	45
Figure 4.7	SEM of CH and CSH, Mix 50	46
Figure 4.8	Flaky GO sheets	46
Figure 4.9	Interfacial van der Waals bonds	47
Figure 4.10	Inactive clusters	48
Figure 4.11	Comparison of microstructure with 1000X Magnification (a) Air cooled, (b) Quenched	49
Figure 4.12	Image preprocessing workflow	52
Figure 4.13	CNN Architecture	53

LIST OF TABLES

Table	Description	Page
Table 2.1	Comparison of Electrical properties of ristine graphene and GO	12
Table 2.2	Thermal conductivities of graphene, GO, and GO papers in comparison at room temperature	13
Table 3.1	Chemical composition of OPC cement	26
Table 3.2	Mix proportions for grade 50 concrete with different GO contents	29
Table 4.1	Ambient compressive strength ($f_{c,0}$) results	39
Table 4.2	Absolute residual compressive strength ($f_{c,t}$) for passive air cooled specimens (MPa)	41
Table 4.3	Residual strength ratio (r_c) for air cooled specimens	42
Table 4.4	Residual compressive strength comparison ($f_{c,200}$) between air-cooled and quenched specimens (Mpa)	44

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