# DEVELOPMENT OF WASTE TYRE RUBBER BASED CONCRETE FOR STRUCTURAL APPLICATIONS

Kuruwita Arachchige Don Venuka Lashan

218086R

Degree of Master of Science

Department of Civil Engineering

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A thesis submitted in partial fulfillment of the requirement for the degree Master of Science in Civil Engineering

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## DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement any materials 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 acknowledgment is made in the text.

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Signature: Date: 29.05.2023

The above candidate has carried our research for the Masters under my supervision

Name of Supervisor: Prof. (Mrs.) J.C.P.H. Gamage

Signature of supervisor: Date: 31.05.2023

# ABSTRACT


## Development of Waste Tyre Rubber Based Concrete for Structural Applications

The drastic expansion in the construction industry has created a scarcity of construction materials. Specifically, the use of natural minerals in concrete production has created sever environmental problems. On the other hand, non-recyclable waste production causes hazardous problems to the environment. Waste rubber tires are one such phenomenon. Hence, the use of waste rubber tires as a partial replacement for aggregate in concrete has been a real concern over the past decade. It is understood that rubberized concrete (RuC) concrete enhances properties of better energy absorption, damping ratio, impact resistance, thermal resistivity, sound resistivity, freeze-thaw resistance, decrease in acid penetrations and chloride penetrations. However, mechanical properties were identified to be poor compared to conventional concrete. Implementation of RuC in structural elements could expand the real benefit of using RuC. Hence, it is crucial to identify and develop the required parameters to improve the mechanical properties of RuC. Investigations were carried out with numerous modifications to the concrete matrix. Despite this, the enhancement in mechanical properties was marginal and inconsistent. The study focused on pretreating the rubber with high reactive graphene oxide (GO) and investigating the micro and macro-level material behavior. The research was conducted in three phases. The optimum mix design was developed, and the concrete properties were investigated in the first phase. Secondly, the material variation of crumb rubber (CR) with respect to GO treatment was investigated. Investigating the optimum CR rubber percentages and their variation with respect to different GO treatment types and identifying the high-strength concrete properties concluded in the third phase. Non-homogenous waste rubber tire aggregate replacement enhances the packing density and thereby improves the mechanical properties. The maximum pretreatment time of 2 hours was identified. The precipitation of GO around CR means to improve the bonding with the cement matrix and a significant strength recovery of 88.18 % resulted. With reference to the three pretreatment methods used, fully air-dried GO-treated CR shows better strength recovery, as a result of the higher percentage of GO precipitation. Yet, 2 g/l was identified to be the optimum GO concentration. With reference to the durability properties, the chloride ion penetration of GO-treated RuC was identified to be very low (100 – 1000 coulombs). However, the water penetration of GO-treated RuC is 35 % greater than the control sample.



Key words: Sustainable construction, Rubberized concrete, Pretreatment, Graphene oxide

# ACKNOWLEDGEMENT

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# LIST OF PUBLICATIONS

## International Journals

1. ***V.L. Kuruwita Arachchi***, J.C.P.H. Gamage 2022 'Waste Rubber Tire for Producing Concrete: A Review on Materials, Methods, Application and Challengers' – European Journal of Environmental and Civil Engineering – Under review.
2. ***V.L. Kuruwita Arachchi***, J.C.P.H. Gamage, Kajanan Selveranjan 2023 'Effect of Graphene Oxide Treatment for Crumb Rubber in Producing Rubberized Concrete with Improved Compressive Strength' – Construction and Building Materials – Submitted.

## International Conferences

1. ***V.L. Kuruwita Arachchi***, J.C.P.H. Gamage, Kajanan Selveranjan 2022 'Investigation of Replacing Aggregate with Non-homogeneous Waste Tire Rubber in Concrete', presented in MERcon 2022 International Research Conference, Moratuwa, Sri Lanka. https://doi.org/10.1109/MERCon55799.2022.9906163

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# LIST OF ABBREVIATIONS

| Abbreviation | Description |
|---|---|
| GO | graphene oxide |
| FA | Fine aggregate |
| CA | Coarse aggregate |
| RuC | Rubberized concrete |
| NaOH | Sodium hydroxide |
| PFA | Pulverized fuel ash |
| SD | Standard deviation |
| SEM | Scanning electron microscopy |
| ITZ | Interfacial transition zone |
| LWC | Light weight concrete |
| NC | Normal concrete |
| HWC | Heavy weight concrete |
| UV | Ultraviolet |
| SCA | Silicon coupling agent |
| CR | Crumb rubber |
| OH | Hydroxyl groups |
| LTP | Low-temperature plasma |
| $SP^2$ | The mix of one S and two P atomic orbitals |
| XRD | X-ray powder diffraction |
| FTIR | Fourier transformed infrared spectroscopy |
| XPS | X-ray photoelectron spectroscopic |
| CR-GO | Treated crumb rubber with graphene oxide |
| IC | Ion chemometric |
| PPM | Parts per million |
| OPC | Ordinary Portland cement |

## LIST OF APPENDICES