INVESTIGATING THE PERFORMANCE OF LAMINATED GLASS PANELS UNDER WINDBORNE DEBRIS IMPACT

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228001N

Master of Science (Major Component of Research)

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Thesis submitted in partial fulfilment of the requirements for the degree

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DECLARATION

I declare that this is my own work and this thesis 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).

Signature: UOM Verified Signature Date: 30/12/2023

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

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Signature of the Main Supervisor: UOM Verified Signature Date: 30/12/2023

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Signature of the Co-Supervisor: UOM Verified Signature Date: 30/12/2023

DEDICATION

In profound appreciation, I dedicate this thesis to my cherished parents.

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ABSTRACT

Glass façades, a prominent feature in modern buildings, have garnered widespread popularity despite the inherent brittleness of glass due to its non-crystalline molecular structure. While glass is commonly utilised as a structural material following quality and performance enhancement measures, its susceptibility to extreme loads, particularly impact loads, is higher compared to other structural elements. Past investigations into windstorms have revealed that the generation of various debris poses a significant threat to glass façades during extreme wind conditions. This research addresses the imperative need to comprehensively study the response of Laminated Glass (LG) panels to windborne debris impact, emphasising the potential consequences of damage during windstorms. LG, known for its safety features and higher post-crack load carrying capacity, is employed in buildings. The study focuses on fully framed LG window panels and employs a finite element (FE) based numerical modelling approach to assess their impact performance. The FE models are validated using results from past experiments, and subsequent examinations explore the impact performance of LG panels and their constituent components under various critical impact locations. Key findings suggest that support conditions and impact locations significantly influence the LG panel's impact performance. The Polyvinyl Butyral (PVB) interlayer plays a crucial role in resisting penetration by absorbing substantial impact energy. The study advocates purposeful design of LG window panels as sacrificial elements to enhance impact resistance, rather than relying solely on thicker glass panes. Energy absorption is found to be highest for mid-impacts, diminishing for long-span mid-impacts, short-span mid-impacts, and corner impacts, respectively. The research highlights the importance of an iterative design process for impact-resistant glazing, emphasising the need for designers to propose suitable layer thicknesses and configurations. Failure to do so may result in additional material costs without achieving satisfactory impact resistance. Hence, the findings of this research encourage manufacturers to create innovative materials with strong energy absorption, enabling engineers to implement impact-resistant glazing for safe, optimised, and aesthetically pleasing glass façades in cyclone-prone areas.

Keywords: Windborne debris impact; Impact-resistant glazing; Laminated glass; Finite element modelling; Material failure

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

Abbreviation	Description
AITHM	Australian Institute of Tropical Health and Medicine
ASCE	American Society of Civil Engineers
AS	Australian Standard
ASTM	American Society for Testing and Materials
AS/NZS	Australian/New Zealand Standard
CST	Central Standard Time
CTS	Cyclone Testing Station
FE	Finite Element
IDL	International Date Line
IMOC	Integrated Marine Operations Centre
LG	Laminated Glass
PDMS	Polydimethylsiloxane
PVB	Polyvinyl Butyral
SAA	Standard Association of Australia
SG	SentryGlas®
SGP	SentryGlas® Plus
SHPB	Split Hopkinson Pressure Bar
SLS	Serviceability Limit State
TPU	Thermoplastic polyurethane
TR 440	Technical Record 440
ULS	Ultimate Limit State
UTC	Coordinated Universal Time