# DEVELOPMENT OF A BIOLOGICALLY ACTIVE MOSS WALL SYSTEM AS A SUSTAINABLE EXTERIOR BUILDING ENVELOPE

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Master of Science in Structural Engineering

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Thesis/Dissertation submitted in partial fulfillment of the requirements for the degree Master of Science in Structural Engineering

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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).

Signature: Date:

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:

Signature of the Supervisor: Date:

# DEDICATION

I dedicate this thesis to my beloved parents, husband and family, whose unwavering support, encouragement, and sacrifices have shaped the foundation of my academic and personal journey.

I also extend this dedication to my teachers, mentors, and colleagues, whose guidance has inspired me to pursue excellence in my field. To all those committed to fostering a more sustainable and resilient built environment, I hope this work serves as a meaningful contribution to that shared vision.

# ACKNOWLEDGEMENT

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# ABSTRACT

The integration of sustainable systems into the built environment is a critical response to the growing impacts of climate change, particularly in tropical regions. This research investigates the development and evaluation of a biologically active moss wall system as a sustainable exterior building envelope, with specific emphasis on structural feasibility, thermal performance, cost and environmental sustainability within the context of Sri Lanka's tropical climate.

A prototype moss wall system was designed using lightweight steel framing, moisture-retentive substrate layers, recirculating irrigation system and moss species adapted to local climatic conditions. Structural performance was analysed via analytical modelling and manual calculations to determine load-bearing capacity, wind resistance, and overall stability. Thermal performance was assessed through experimental monitoring by constructing four models using brick masonry, cement block masonry, plywood model with moss and double-layer configuration with moss. In addition, a computer simulation using DEROB-LTH, and as the results deviated from the actual measurements, a parametric study was carried out varying the factors relevant to solar radiation, thermal conductivity, specific heat, density, solar absorptance, and thermal emittance. Cost analysis was conducted for both conceptual and detailed designs, while sustainability evaluation was benchmarked against Sri Lanka Green Building Council (SLGBC, 2017) criteria.

The actual measurement results indicated that moss-integrated walls particularly double-layer configurations, maintained lower indoor temperatures and higher relative humidity than masonry and cement block walls, indicating enhanced microclimatic stability and passive regulation of temperature and humidity. Although discrepancies were observed between measured results and DEROB-LTH simulations, parametric sensitivity analysis confirmed consistently improved thermal performance for moss walls. Structurally, the system meets design standards and allows flexibility in configuration, while the passive irrigation system maintains adequate moss hydration with minimal water consumption. Environmental benefits include improved air quality and potential mitigation of urban heat island effects.

This study concludes that biologically active moss wall systems constitute a structurally viable, thermally efficient, and environmentally sustainable building envelope solution for tropical climates. The integration of such systems offers potential for reducing energy demand, enhancing occupant comfort, and contributing to urban sustainability. Further research is recommended to explore full-scale applications, design optimization, comprehensive lifecycle assessment and integration with smart building technologies.



**Keywords**: Biologically active moss wall, Sustainable building envelope, Thermal performance, Optimized structural configurations, Tropical climate.

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# LIST OF ABBREVIATIONS

| Abbreviation | Description |
|---|---|
| ACP | Aluminium Composite Panel |
| BIM | Building Information Modelling |
| BS | British Standard |
| BSR | Building Schedule of Rates |
| CABS | Climate-Adaptive Building Shells |
| CMU | Concrete Masonry Units/ Cement Block Units |
| CIDA | Construction Industry Development Authority |
| EA | Energy and Atmosphere |
| EN | European Norm (European Standards) |
| HVAC | Heating, Ventilation, and Air Conditioning |
| ICF | Insulated Concrete Forms |
| ICMU | Insulated Concrete Masonry Units |
| ICTAD | Institute for Construction Training and Development |
| ID | Innovation in Design |
| IEQ | Indoor Environmental Quality |
| LCA | Life Cycle Assessment |
| MCDM | Multi-Criteria Decision Making |
| MR | Materials and Resources |
| OSB | Oriented Strand Board |
| PVC | Polyvinyl chloride |
| RH | Relative Humidity |
| SHS | Square Hollow Section |
| SIP | Structural Insulated Panels |
| SLGBC | Sri Lanka Green Building Council |
| UHI | Urban Heat Island |
| WE | Water Efficiency |

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