OPTIMIZING ENERGY PERFORMANCE AND INDOOR ENVIRONMENTAL QUALITY OF BUILDINGS USING ENERGY SIMULATION, GENERIC OPTIMIZATION AND COMPUTATIONAL FLUID DYNAMICS

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DEDICATION

I dedicate this thesis to my beloved late father, Mr. R M Navaratne Bandara (1943-2016), who had been the live wire throughout my life. Without his never ending support and encouragement, I would not have come this far.

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Abstract

A building is a complex system with multiple interacting physical processes taking place simultaneously. Various aspects influence the performance of buildings and the building envelope is one of the major contributors in this regard. Building orientation, Aspect ratio, Window to wall ratio, Location and types of fenestration, Envelope materials and their characteristics etc. can have a major impact on the energy consumption and life cycle cost of buildings. However, the best combination of the said envelope elements for optimizing the performance of buildings is difficult to determine and is not known. Whole building simulation tools are often used in making building performance predictions. Building energy simulation is generally used on a scenario-by-scenario basis, with the designer generating a solution and subsequently having the computer evaluating it. This is however, a slow and a tedious process and only a few cases are evaluated in a large range of scenarios, possibly leading to sub-optimal envelope designs. By coupling a generic optimization tool with a whole building energy simulation tool, it is possible to optimize the performance of buildings by determining the best combination of envelope elements, subject to predefined constraints. First part of the thesis explains optimization of energy performance and life cycle cost of buildings through this methodology. Secondly, drawbacks of whole building simulation tools that lead to issues in energy performance predictions of buildings are discussed in detail. The issues have been addressed by coupling the whole building simulation tool with a computational fluid dynamics tool on a complementary data exchange platform. It is observed that with this approach more reliable building performance predictions can be made. Final section of the thesis discusses on optimizing indoor environmental quality using computational fluid dynamics with respect to identified mechanical ventilation configurations. Model predictions have been validated using a detailed experimental design where computational model predictions closely agree with the actual measurements.

Keywords: Performance, Envelope, Simulation, Optimization, Computational Fluid Dynamics

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