1 INTRODUCTION

The infrastructure heights are increasing rapidly with time. Due to the limited land availability the tall buildings are becoming popular. Rapid construction, low weight to strength ratio and many other benefits of steel attracts it as a construction material for tall buildings. The recent expansion of telecommunication sector has increased the use of tall steel towers and masts to support antennas. However these tall steel structures are subjected to dynamic loading such as wind and earthquake induced loading in their lifespan. The wind induced loadings are very significant at greater heights. . These tall steel structures are often slender and hence sensitive to dynamic loading. Therefore dynamic stresses on structural elements of those structures are significant.

A material can fail well below its monotonic strengths when it is subjected to repeated loading. This phenomenon is known as fatigue. Fatigue can happen progressively, even when the applied loads are individually too small to cause failure. In the 19th century, it was considered mysterious that a fatigue fracture did not show visible plastic deformation and this lead to a false belief that fatigue was merely an engineering problem.

A structure may fail with lower number of cycles when it is subjected to higher amplitudes of vibration (low-cycle fatigue) or the same structure may fail with higher number of cycles but under lesser amplitude of vibration (high-cycle fatigue).

Fatigue damage estimation methods given in most codes of practices are for simple structural shapes. On the other hand experimental testing of large structural components for fatigue is costly. Australian code AS-4100:1990 defines a concept called the detailed category (f_{rn}) for different components. Detail category takes in to account many fatigue inducing properties to estimate the appropriate endurance curve. However there are still a number of unidentified potential problems in fatigue design specifications given in codes of practices (Mendis & Dean, 2000). Therefore fatigue modelling through computer software is becoming popular. These finite element software use damage estimating algorithms to estimate the damage initiation and propagation. All fatigue inducing properties such as surface finish, temperature, stress concentrations can be included for accurate estimations.

But Idealizations of loading, material properties, boundary conditions, interactions with other elements that are in the actual event must be done carefully to get numerical results which are closer to actual results.

This thesis presents a simulation technique focusing on accurate prediction of fatigue life of steel structures. First part of the thesis attempts to simulate two experimental tests found in literature for successful verification of simulation results. Finally the verified simulation technique is applied to a selected case study to predict the fatigue endurance.

In this thesis, Chapter 2 explains the literature survey done on fatigue and fatigue simulations. Chapter 3 gives a technical introduction to the software that were used for the analysis. Chapter 4 verifies the simulation techniques against the experimental results available in literature. Chapter 5 presents the case study performed on a selected tall steel mast.

1.1 Objectives

1.1.1 Overall Objective

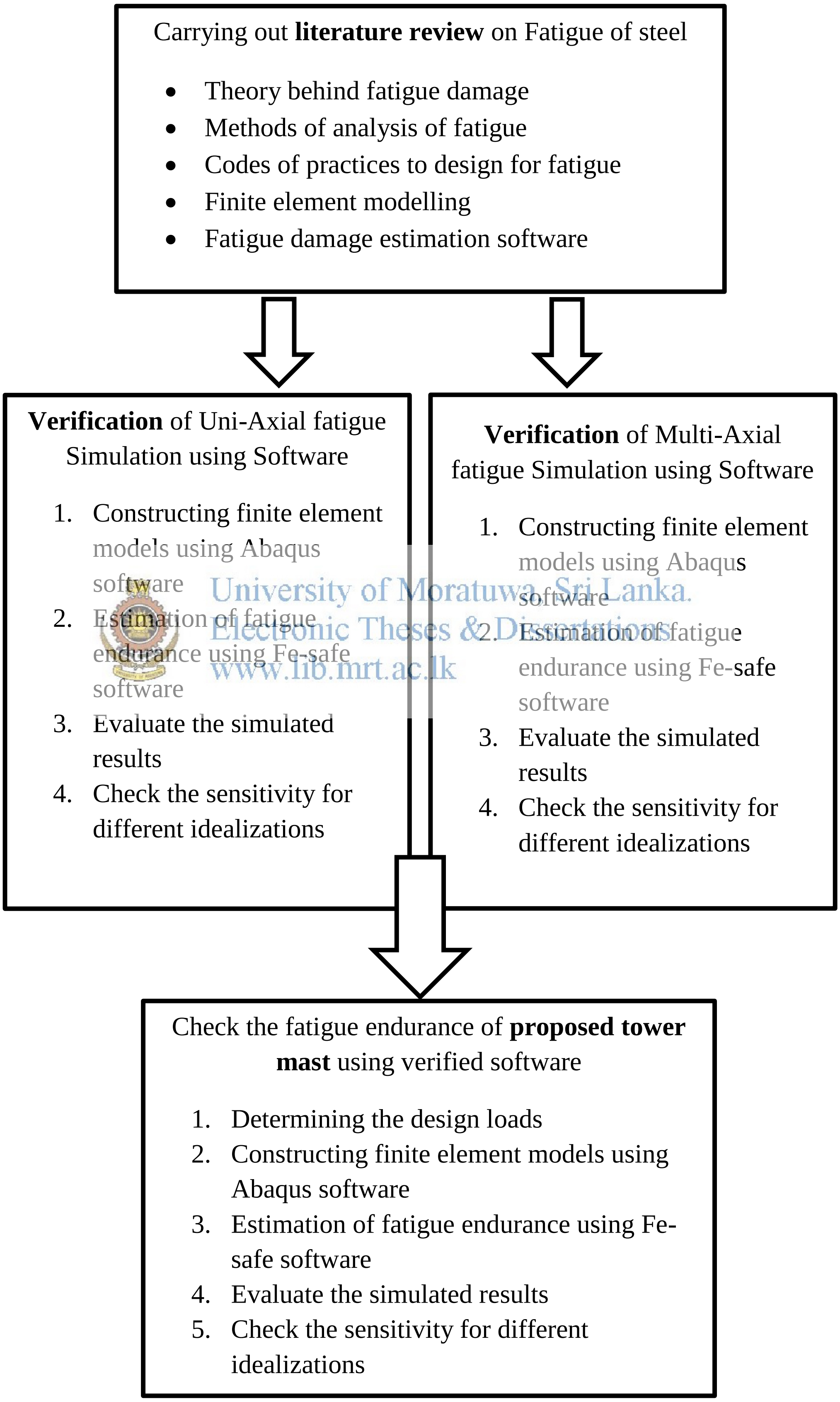
The main objective of this research is to develop a simulation technique that can predict the fatigue life of tall steel structures. This will facilitate design improvement of future steel structures as well as suggest remedial measures for existing structures.

1.1.2 Specific Objectives

- Study the concept behind the fatigue damage
- Study on fatigue inducing loading and how to determine those loading.
- Study finite element modelling with ABAQUS commercial software and couple FE-safe commercial software for fatigue simulations
- Study sensitivity of fatigue inducing parameters such as surface roughness and shape of structure on fatigue endurance of a material.
- Study sensitivity of various fatigue simulation techniques on fatigue endurance of a material.
- Study appropriate material models
- Validate simulated results against physical experiments
- Evaluate vulnerability of a real structure for fatigue damage

1.2 Methodology

1.2.1 Methodology flowchart



1.2.2 Description of methodology

Initially literature review was done on fatigue and fatigue simulation using finite element software to get the basic understanding and to determine the exact methodology of research. Literature was done as given below.

- Study on the theories behind fatigue and what other researchers have found on the area.
- Study on the methods of analysis for fatigue.
- Find out the codes of practices that can be used to design for fatigue and the research done on issues of codes of practices.
- Study on finite element modelling using Abaqus FEA software. Different material property, loading and boundary condition idealizations are studied.
- Study on fe-safe simulation techniques and study on other research done using the software.

Then both uniaxial and multi-axial fatigue were simulated as given below.

- Find experiments conducted by other researchers which provide all necessary properties and dimensions.
- Construct finite element models for the experiments chosen from the literature and run the analysis to find out the stress and strain datasets.
- Import the datasets to fe-safe software and perform fatigue analysis.
- Evaluate the simulated results against the results given in the experimental tests chosen.
- Study the sensitivity of different idealizations for fatigue endurance.

Use verified technique to estimate the fatigue endurance of the steel mast of a proposed tower.

- Determine the design wind induced loading.
- Construct a finite element model of the steel mast using Abaqus software and perform analysis to get stress strain datasets.
- Estimate the fatigue endurance of the mast using fe-safe software.
- Check the sensitivity of opening shape and plate thickness for fatigue endurance.