

**DETECTION AND ESTIMATION OF DAMAGE IN
FRAMED STRUCTURES USING EXPERIMENTAL
MODAL DATA**

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Degree of Master of Science

Department of Civil Engineering

University of Moratuwa

Sri Lanka

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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.

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

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Prof. M. T. R. Jayasinghe

ABSTRACT

The inevitable ageing and degradation of buildings and the structural failures that follow, have ignited a need for early prognosis of probable structural failures so that proactive measures can be undertaken. Hence, one of the important steps of structural health monitoring (SHM) process is the detection of damage and estimation of damage severity. Modal data can be effectively used for this purpose owing to their sole dependency on mechanical characteristics of a structure. However, the focus of mode shape-based damage detection techniques has concentrated only on symmetric structures whereas the existing buildings are typically asymmetric. This study presents a damage detection methodology using the behaviour of mode shape derivatives such as mode shape slope and mode shape curvature for a symmetric framed structure applied on an experimental model tested using a shaking table, and a calibrated finite element model. Furthermore, an extended parametric analysis has been performed to investigate damage localization and quantify severity. Finally, the models have been modified to incorporate the irregularity effects and damage detection possibility has been explored. The study enables to provide key conclusions for damage detection with respect to localization and severity in the steel frame model. Damage detection method using the mode shape curvature is identified to be more sensitive as opposed to mode shape slope method. And the effect of mass irregularity on the detection methods were identified.

Key words: structural health monitoring, modal based damage detection, damage localization, damage severity, frame structure, shaking table, finite element model, irregularity

DEDICATION

To my loving parents and sisters for encouraging me throughout the milestones of my life and my supervisor, Dr. C. S. Lewangamage and co-supervisor Prof. M.T.R. Jayasinghe for the unwavering motivation and mentorship they provided.

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LIST OF ABBREVIATIONS

Abbreviation	Description
SHM	Structural Health Monitoring
NDT	Non-destructive testing
VBDD	Vibration based detection
MSS	Mode shape slope
MSC	Mode shape curvature
DOF	Degrees of freedom
DMSS	Difference of mode shape slope
DMSC	Difference of mode shape curvature
CDM	Central difference method