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MR elastomers for structural control

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MR Elastomers for Structural Control

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Master of Engineering – Research

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CERTIFICATION

I, Yang ZHOU, declare that this thesis, submitted in partial fulfillment of the requirements for the award of Master of Engineering – research, in the School of Civil, Mining and Environmental Engineering, Faculty of Engineering, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Yang ZHOU

18th June 2009

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ABSTRACT

This dissertation focuses on a basic understanding of the behaviour of Magnetorheological elastomers (MREs) and their application as MRE bearings for vibration controlling the structural systems. MREs are an important member of the group of smart materials and as such have attracted increasing interest because their modulus can be controlled by an external magnetic field.

Because MRE based devices usually work in a dynamic mode, the study of MRE properties under these conditions is essential for its practical application. The relationship between the dynamic shear stress and shear strain in various magnetic fields, including different strain amplitudes and frequencies, were measured. The stress-strain data forms elliptical curves which show that MRE behaves as if it possessed linear viscoelastic properties.

Based on these experimental results, a viscoelastic solid model with four parameters was proposed to predict the performance of MRE. In this model a spring element was placed in parallel with a 3-parameter standard viscoelastic solid model. A MATLAB optimization algorithm was used to identify the four parameters under various working conditions (magnetic field, strain amplitude and frequency). A comparison between the experimental results and the model predictions proved that the four-parameter viscoleastic model can accurately predict the performance of MRE.

A building model, three stories high, was constructed using MATLAB SIMULINK to evaluate the performance of an MRE device in structural control. Three controllers, passive on, passive off and bang-bang control strategy were used to compare the response of each storey to displacement and acceleration. In addition, the performance of an MRF damper and an MRE device in structural control, where the resultant peak force was selected as a criterion in the evaluation process, was compared and discussed. The effectiveness of an MRE bearing in structural control was well justified.

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LIST OF TABLE CAPTIONS

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A	test displacement amplitude
B	magnetic flux density
C	damping matrices of structure
c_b	damping coefficient of MREs bearing without control current
c_e	effective viscous damping constant
c_n	viscous damping coefficient for the n^{th} storey
E_{loop}	energy dissipation per cycle of loading
F^+	experimental positive forces
F^-	experimental negative forces
F_{MRE}	control force of MREs bearing
G	pre-yield modulus
G_1	storage modulus
G_2	loss modulus
I	external intensity current inputs
I_{max}	maximum value of the input current
I_{min}	minimum value of the input current
J_p	dipole moment magnitude per unit particle volume
J_s	saturation polarization of the particles
K	stiffness matrices of structure
k_b	stiffness of MREs bearing without control current
k_e	effective stiffness
k_n	elastic stiffness coefficient for the n^{th} storey
M	total mass of the base
m_n	mass of the n^{th} storey
m_b	mass of MRE bearing
M	mass matrices of structure
N	experimental number of one loop

V_i	volume of particle
u_1	relative permeability of the medium
u_0	vacuum permeability
x_0	amplitude of displacement
x_n	displacement of the n^{th} storey
σ	shear stress of MRE sample
ω	angle frequency of shear strain
ε_0	amplitude of shear strain
ε	shear strain of MRE sample
ϕ	phase angle
Δ^+	experimental positive displacement
Δ^-	experimental negative displacement
η	damping loss factor for structure