

CONTENTS

摘要.....	I
ABSTRACT.....	II
CONTENTS.....	III
CHAPTER 1.....	1
INTRODUCTION.....	1
1.1 Structural Testing Methods.....	1
1.2 Motivation.....	3
1.3 Research Objectives.....	3
1.4 Organization of Dissertation.....	4
CHAPTER 2.....	7
LITERATURE REVIEW OF REAL-TIME HYBRID TESTING.....	7
2.1 Researches on Integration Algorithm.....	7
2.1.1 Nakashima and Masaoka.....	7
2.1.2 Wu <i>et al.</i>	7
2.1.3 Bonnet <i>et al.</i>	8
2.1.4 Zhang <i>et al.</i>	8
2.1.5 Chen and Ricles.....	8
2.1.6 Bursi <i>et al.</i>	8
2.1.7 Other Researches.....	9
2.2 Researches on Actuator Compensation.....	9
2.2.1 Horiuchi <i>et al.</i>	9
2.2.2 Stoten <i>et al.</i>	9
2.2.3 Ahmadizadeh <i>et al.</i>	10
2.2.4 Chen and Ricles.....	10
2.2.5 Other Researches.....	10
2.3 Researches on Stability Analysis.....	11
2.3.1 Wallace <i>et al.</i>	11
2.3.2 Mercan and Ricles.....	11
CHAPTER 3.....	12
FUNDAMENTALS OF CONTROL THEORY.....	12
3.1 Classical Control.....	12
3.1.1 Transfer Function.....	12
3.1.2 Bode Plot.....	13
3.1.3 Poles and Zeros.....	13
3.1.4 Stability Criteria.....	14

3.1.4.1 Routh Criterion.....	14
3.1.4.2 Root Locus	14
3.1.4.3 Nyquist Stability Criterion	15
3.1.5 PID Control	15
3.2 Modern Control.....	17
3.2.1 State-Space Representation	17
3.2.2 Lyapunov Stability Theorem	18
3.2.3. State Feedback Control	18
3.2.4 Gain Scheduling Control.....	19
3.2.5 Sliding Mode Control.....	20
3.2.6 Adaptive Control	20
3.2.7 Robust Control	21
CHAPTER 4.....	27
OUTER-LOOP CONTROL OF THE TEST SYSTEMS.....	27
4.1 Hardware Facilities at NCREE	27
4.2 Case Study 1: Cyclic Test of a Coupled Steel Plate Shear Wall Substructure	28
4.3 Case Study 2: Design and Control of a Uni-axial Shaking Table	29
CHAPTER 5.....	54
REAL-TIME HYBRID TESTING FOR RATE-INDEPENDENT SPECIMENS.....	54
5.1 Critical Time Delay	54
5.1.1 Pseudodelay Technique	54
5.1.2 Effect of Time Delay and Amplitude Error	56
5.2. Phase Lead Compensator	57
5.2.1. Dynamics of Servo-Hydraulic Systems	57
5.2.2 Simplified Model for Servo-Hydraulic Systems.....	58
5.2.3 Inverse Model.....	60
5.2.4 Delay Estimator.....	61
5.2.4.1 Static Parametric Model (SPM)	62
5.2.4.2 Parameter Identification	63
5.2.4.3 Stability and Parameter Convergence	63
5.2.4.4 Discrete Time Representation	64
5.2.5 Numerical Simulation	65
5.3 Restoring Force Compensator.....	66
5.3.1 Error Propagation	67
5.3.2 Force Compensation.....	67
5.3.3 Moving-Averaged Tangent Stiffness.....	68
5.3.4 Numerical Simulation	69
5.3.4.1 Elastic Structures.....	69

5.3.4.2 Inelastic Structures	70
5.4 Experimental Validation	71
5.4.1 Experimental Setup	71
5.4.2 Design of PLC	72
5.4.3 Real-time Hybrid Testing	72
CHAPTER 6.....	85
REAL-TIME HYBRID TESTING FOR RATE-DEPENDENT SPECIMENS.....	85
6.1 Smart Base-isolated Building.....	85
6.1.1 System Identification.....	86
6.1.2 MR Damper Control Algorithms.....	87
6.1.2.1 Linear-quadratic Control.....	87
6.1.2.2 Fuzzy-logic Control.....	90
6.1.3 Numerical Simulation	91
6.1.4 Experimental Validation.....	92
6.2 Adaptive Model-based Tracking Control	96
6.2.1 Feedforward and Feedback Controllers	96
6.2.2 Adaptive Control Implementation.....	98
6.2.2.1 Stability Constraint.....	98
6.2.2.2 Gradient Adaptive Law	98
6.2.2.3 Parameter Projection	99
6.2.3 Numerical Simulation	100
6.3 Experimental Validation	102
6.3.1 Hardware Facilities	102
6.3.2 System Identification Tests	103
6.3.3 Tracking Performance Testing.....	104
6.3.4 Real-time Hybrid Testing.....	104
CHAPTER 7.....	128
SUMMARY AND CONCLUSIONS	128
7.1 Summary	128
7.2 Conclusions	130
7.3 Future Works	132
REFERENCE	133