## List of Figures

Figure 3.1: Rapid instrumental intensity map for the Parkfield earthquake	
(CSMIP 2006).	18
Figure 3.2: Contour map of near-fault peak ground accelerations (CSMIP;	
Shakal, et al. 2005; Graphic generated by Pete Roffers at	
CSMIP).	19
Figure 3.3: Particle displacement motions of Parkfield Earthquake of 28 Sep	
2004 (CSMIP 2006).	20
Figure 3.4: Location and photograph of the Parkfield school building strong	
motion station.	21
Figure 3.5: Instrumentation layout of the Parkfield school building.	22
Figure 3.6: Elevation views of the Parkfield school building (CSMIP).	23
Figure 3.7: Acceleration strong motion time histories (East/West direction)	
of the Parkfield school building.	24
Figure 3.8: Acceleration strong motion time histories (North/South	
direction) of the Parkfield school building.	25
Figure 3.9: Location and photograph of the Templeton hospital.	26
Figure 3.10: Instrumentation layout of the Templeton hospital.	27
Figure 3.11: Acceleration strong motion time histories (East/West direction)	
of the Templeton hospital during the 2003 San Simeon	
Earthquake.	28
Figure 3.12: Acceleration strong motion time histories (North/South	
direction) of the Templeton hospital during the 2003 San	
Simeon Earthquake.	29
Figure 4.1: First three modeshapes of the Parkfield school building	
generated from the 2004 Parkfield Earthquake.	40

Figure 4.2: One-mode model for the 1993 Parkfield school records.	43
Figure 4.3: Two-mode model for the 1993 Parkfield school records.	44
Figure 4.4: Three-mode model for the 1993 Parkfield school records.	45
Figure 4.5: One-mode model for the 1994 Parkfield school records.	46
Figure 4.6: Two-mode model for the 1994 Parkfield school records.	47
Figure 4.7: Three-mode model for the 1994 Parkfield school records.	48
Figure 4.8: One-mode model for the 2004 Parkfield school records.	49
Figure 4.9: Two-mode model for the 2004 Parkfield school records.	50
Figure 4.10: Three-mode model for the 2004 Parkfield school records.	51
Figure 4.11: Amplitude dependence of the E-W and N-S mode frequency	
estimates for the Parkfield school building. The window	
analysis is performed on the 2004 Parkfield Earthquake.	54
Figure 4.12: Amplitude dependence of the E-W and N-S mode damping	
estimates for the Parkfield school building. The window	
analysis is performed on the 2004 Parkfield Earthquake.	54
Figure 4.13: Amplitude dependence of the E-W and N-S mode frequency	
estimates for the Parkfield school building. The window	
analysis is performed on the 1993 Parkfield Earthquake.	55
Figure 4.14: Amplitude dependence of the E-W and N-S mode damping	
estimates for the Parkfield school building. The window	
analysis is performed on the 1993 Parkfield Earthquake.	55
Figure 4.15: Amplitude dependence of the E-W and N-S mode frequency	
estimates for the Parkfield school building. The window	
analysis is performed on the 1994 Parkfield Earthquake.	56
Figure 4.16: Amplitude dependence of the E-W and N-S mode damping	
estimates for the Parkfield school building. The window	
analysis is performed on the 1994 Parkfield Earthquake.	56
Figure 4.17: First three modeshapes of the Templeton hospital building	
generated from the 2003 San Simeon Earthquake.	59

Figure 4.18: One-mode model for the 2003 Templeton hospital records.	60
Figure 4.19: Two-mode model for the 2003 Templeton hospital records.	61
Figure 4.20: Three-mode model for the 2003 Templeton hospital records.	62
Figure 4.21: Amplitude dependence of the west wing and north wing	
frequency estimates for Templeton hospital building. The	
window analysis is performed on the 2003 San Simeon	
Earthquake.	64
Figure 4.22: Amplitude dependence of the west wing and north wing mode	
damping estimates for Templeton hospital building. The	
window analysis is performed on the 2003 San Simeon	
Earthquake.	64
Figure 4.23: Amplitude dependence of the west wing and north wing	
frequency estimates for Templeton hospital building. The	
window analysis is performed on the 2004 San Simeon	
aftershock.	65
Figure 4.24: Amplitude dependence of the west wing and north wing mode	
damping estimates for Templeton hospital building. The	
window analysis is performed on the 2004 San Simeon	
aftershock.	65
Figure 5.1: Illustration of the nailed sheathing connection and pinching	
hysteresis curve (Judd 2005).	68
Figure 5.2: Illustrative example of the free body diagram concept to	
calculate a hystersis curve.	72
Figure 5.3: Hysteresis curves of the east wall.	74
Figure 5.4: Hysteresis curves of the diaphragm.	74
Figure 5.5: Hysteresis curves of the south wall.	75
Figure 5.6: Hysteresis curves of the south shear wall.	75
Figure 5.7: Corrected hysteresis curves of non wood-frame structures	
(Cifuentes 1984).	77

Figure 5.8: Comparison of the pre- and post-processed hysteresis curves	
from the east wall.	80
Figure 5.9: Comparison of the pre- and post-processed hysteresis curves	
from the diaphragm.	80
Figure 5.10: Comparison of the pre- and post-processed hysteresis curves	
from the south wall.	81
Figure 5.11: Comparison of the pre- and post-processed hysteresis curves	
from the south shear wall.	81
Figure 5.12: Comparison between hysteresis loops derived from measured	
displacements and double-integrated accelerations. Seismic	
Level 1 (5% g).	83
Figure 5.13: Comparison between hysteresis loops derived from measured	
displacements and double-integrated accelerations. Seismic	
Level 2 (20% g).	83
Figure 5.14: Comparison between hysteresis loops derived from measured	
displacements and double-integrated accelerations. Seismic	
Level 3 (50% g).	84
Figure 5.15: Comparison between hysteresis loops derived from measured	
displacements and double-integrated accelerations. Seismic	
Level 4 (80% g).	84
Figure 5.16: Comparison between hysteresis loops derived from measured	
displacements and double-integrated accelerations. Seismic	
Level 5 (100% g).	85
Figure 5.17: Fourier transform of the acceleration time histories from the	
east wall and diaphragm.	91
Figure 5.18: Fourier transform of the acceleration time histories from the	
south wall and south shear wall.	91
Figure 5.19: STFT of the Parkfield school building with 4 second time	
intervals.	92

Figure 5.20: Wigner-Ville spectrums of the east wall.	93
Figure 5.21: Wigner-Ville spectrums of the south wall.	94
Figure 5.22: Forced vibration results with low level shaking force on the	
three-Story Del Mar apartment (Camelo 2003).	98
Figure 5.23: Forced vibration results with low level shaking force on the	
three-Story Del Mar apartment (Camelo 2003).	98
Figure 5.24: Hysteresis loop and damping estimate of the three-story Del	
Mar apartment building at low level shaking forces.	99
Figure 5.25: Hysteresis loop and damping estimate of the three-story Del	
Mar apartment building at middle level shaking forces.	99
Figure 5.26: Hysteresis loop of the three-story Del Mar apartment building	
at high level shaking forces.	100
Figure 5.27: Comparison of modal parameter estimates from UCSD and	
MODE-ID analyses on the same test structure.	102
Figure 5.28: Variations in the damping estimate through time. Hysteresis	
curves are from Test Phase 9 at seismic level 4.	105
Figure 5.29: Variations in the damping estimate through time. Hysteresis	
curves are from Test Phase 10 at seismic level 4.	105
Figure 5.30: Variations in the damping estimate through time. Hysteresis	
curves are from Test Phase 10 at seismic level 5.	106
Figure 6.1: Geometry of the plane stress element.	110
Figure 6.2: Hysteresis behavior with pinching. F is a generalized action and	
e is a generalized deflection. Required parameters are F <sub>y</sub> , F <sub>u</sub> , k,	
$\alpha$ , $\beta$ , and $\rho$ where y = yield and u = ultimate. An illustrative	
history follows the path 0-1-2-3-4-5-6-7-8-10-11-12-13-14.	111
Figure 6.3: Sample of the different types of model discretizations used	
(south-west point of view).	113
Figure 6.4: Black elements show the windows and door openings in the	
structure. The procedure models these as openings.	113

Figure 6.5: (From left to right) Model 1. Walls and diaphragm have same	
set of parameters. Model 2. Walls and diaphragm have different	
set of parameters. Model 3. East-West walls, North-South	
walls, and diaphragm have different set of parameters.	114
Figure 6.6: Parkfield Earthquake Input – Linear Model a) No horizontal	
ground motion b) No horizontal ground motion but with	
adjusted displacement time c) With horizontal ground motion	
and obtained from an east wall sensor location d) With	
horizontal ground motion and obtained from Parkfield sensor	
locations e) Add viscous damping in the model and obtained	
from an east wall sensor location f) Add viscous damping in the	
model and obtained from Parkfield sensor locations.	117
Figure 6.7: Earthquake Ground Motion Input - Nonlinear Model. a) No	
horizontal ground motion b) With horizontal ground motion c)	
Add 10% viscous damping in the model and obtained from an	
east wall sensor location f) Add viscous damping in the model	
and obtained from Parkfield sensor locations.	118
Figure 6.8: Data misfit surface between shear modulus and shear yield	
strength. Axes values are relative to the nominal values of the	
parameters.	121
Figure 6.9: Data misfit surface between shear modulus and shear ultimate	
strength. Axes values are relative to the nominal values of the	
parameters.	122
Figure 6.10: Data fit of the Parkfield school record from SPSA identified	
parameters.	127
Figure 6.11: Hysteresis curves obtained from the SPSA identified numerical	
model.	128
Figure 6.12: Samples from both prior (green) and posterior (black) PDF.	133

Figure 6.13: Posterior samples for different pairs of uncertain parameters in	
Model 1. X marks the mean of the posterior PDF. This	
illustrates the difficulty in identifying hysteretic structures.	134
Figure 6.14: Data fit of Model 3 predicted by the most probable model from	
Bayesian updating and model selection.	137
Figure 6.15: Extracted hysteresis loop from east wall. Model chosen by	
Bayesian model selection.	139
Figure 6.16: Extracted hysteresis loop from diaphragm. Model chosen by	
Bayesian model selection.	140
Figure 6.17: Extracted hysteresis loop from south wall. Model chosen by	
Bayesian model selection.	140
Figure 6.18: (Top) Structural deformations up to the first 2 seconds of	
seismic record. (Bottom) Structural deformations up to the first	
3 seconds of the seismic record.	142
Figure 6.19: (Top) Structural deformations up to the first 5 seconds of	
seismic record. (Bottom) Structural deformations up to the first	
6 seconds of the seismic record.	143
Figure 6.20: Structural deformations up to the first 8 seconds of the seismic	
record.	144
Figure 6.21: Displacement particle motion of instrumented stations during	
the Parkfield Earthquake. The Parkfield school building is	
located in the middle of the figure (CSMIP 2006).	144
Figure 6.22: Energy dissipation in the east-west motion. 10% damping can	
be seen at the top left and bottom right corners.	146
Figure 6.23: Energy dissipation in the north-south motion. More than 20%	
damping can be seen at east and west walls.	146