

Contents

Contents	I
Abstract.....	V
Zusammenfassung	VII
Acknowledgments	IX
1 Introduction	1
1.1 Research motivation.....	1
1.2 Research objective	3
1.3 Research approach	4
1.4 Research significance.....	6
1.5 Thesis outline	6
2 Literature review	8
2.1 Introduction.....	8
2.2 Pure friction seismic isolation systems for URM structures.....	8
2.3 Unreinforced masonry with a soft layer in bed joint	14
3 Experimental investigation.....	19
3.1 Introduction.....	19
3.2 Monotonic and static-cyclic in-plane shear tests on masonry triplets with multi-layer bed joints	22
3.2.1 Test programme and masonry materials.....	22
3.2.2 Test set-up, testing procedure and measurements	24
3.2.3 Test results and specimen behavior	26
3.2.3.1 Shear load-deformation characteristics: monotonic tests.....	29
3.2.3.2 Shear load-deformation characteristics: static-cyclic tests.....	30
3.2.3.3 Behavior at ultimate load	32

3.2.4	Discussion	33
3.2.4.1	Load-deformation characteristics: monotonic vs. static-cyclic loading..	33
3.2.4.2	Shear stress-normal stress relationship	35
3.2.4.3	Influence of the pre-compression level	37
3.2.4.4	Soft layer degradation	37
3.2.4.5	Influence of the loading speed	40
3.3	Compression tests of URM wallettes with a multi-layer bottom bed joint	42
3.3.1	Test programme and masonry materials	42
3.3.2	Test set-up, testing procedure and measurements	43
3.3.3	Test results and specimen behavior	45
3.3.4	Discussion	48
3.3.4.1	Influence of the multi-layer bed joint	48
3.3.4.2	Degradation of elastomer and core soft layers	48
3.4	URM walls with a multi-layer bottom bed joint subjected to in-plane static-cyclic shear load	50
3.4.1	Test programme and masonry materials	50
3.4.2	Test set-up, testing procedure and measurements	53
3.4.3	Test results and specimen behavior	57
3.4.3.1	Preliminary testing phase	59
3.4.3.2	Main testing phase	61
3.4.4	Discussion	63
3.4.4.1	Horizontal force resistance and the wall size effect	63
3.4.4.2	Horizontal force-displacement response stiffness	65
3.4.4.3	Horizontal displacement capacity	72
3.4.4.4	Horizontal force-displacement response idealization	72

3.4.4.5	Influence of the pre-compression level	74
3.4.4.6	Influence of the aspect ratio	75
3.4.4.7	Influence of the core soft layer type	76
3.4.4.8	Soft layer degradation	77
3.4.5	Vertical tensile cracks at the bottom block course of the walls	78
3.5	Monotonic in-plane shear and relaxation tests on masonry triplets with a rubber granulate core soft layer in multi-layer bed joints	84
3.5.1	Test programme and masonry materials	84
3.5.2	Test set-up, testing procedure and measurements	85
3.5.3	Test results and specimen behavior	87
3.5.4	Discussion	89
3.5.4.1	Load-deformation characteristics	89
3.5.4.2	Shear stress-normal stress relationship	89
3.5.4.3	Deformation of the multi-layer bed joint	91
3.5.4.4	Degradation of elastomer and core soft layers	92
3.6	Summary and conclusions	93
4	Analytical Modelling	97
4.1	Model description	97
4.2	Model parameters	101
4.3	Model extension and validation	105
4.4	Summary and conclusions	112
5	Supplementary investigation: I-shaped unreinforced masonry wallettes with a rubber granulate soft layer in the bottom bed joint	113
5.1	Test programme and masonry materials	114
5.2	Test set-up, testing procedure and measurements	117
5.3	Test results and specimen behavior	120

5.3.1	First test series (I-shaped wallettes with soft layers tested under cantilever boundary conditions).....	123
5.3.2	Second test series (I-shaped wallettes with soft layers with the shear span of $1.75 h_w$).....	127
5.4	Horizontal force-displacement response characterization and discussion.....	128
5.4.1	Load-deformation response characteristics and their idealization	129
5.4.2	Influence of the pre-compression level	137
5.4.3	Influence of the flanges	137
5.4.4	Influence of the shear span	143
5.4.5	Influence of the soft layer and its thickness	143
5.4.6	Soft layer degradation	144
5.5	Summary and conclusions	145
6	Summary and recommendations for future research	148
6.1	Summary.....	148
6.2	Recommendations for future research	152
Appendix A1	Monotonic and static cyclic shear tests on masonry triplets with multi-layer bed joints.....	153
Appendix A2	Static cyclic shear tests on URM walls with a multi-layer bottom bed joint.....	182
Appendix A3	Static cyclic shear tests on I-shaped URM wallettes with a rubber granulate soft layer in the bottom bed joint.....	192
	List of symbols	199
	References	204
	Curriculum vitae	