

CONTENTS

LIST OF BASIC SYMBOLS.....	7
1. INTRODUCTION	11
2. MOTIVATION AND MAIN ASSUMPTIONS.....	14
2.1. Motivation	14
2.2. Objectives	15
2.3. Statements of the thesis	15
2.4. Scope.....	16
3. EVALUATION OF THE STATE OF KNOWLEDGE	17
3.1. Standard arrangements for stiffening masonry walls	17
3.1.1. Regulations in the Eurocode 6	17
3.1.2. Regulations in the polish standard for masonry structures PN-B-03002:2007...	21
3.1.3. Standard regulations in other European countries	29
3.1.4. Other standards and recommendations	32
3.2. Selected experimental and numerical studies of stiffening walls.....	43
3.3. Computational models of stiffening walls.....	52
3.4. Numerical methods of modelling masonry structures.....	65
3.4.1. Classification of homogenization methods	66
3.4.2. Macro-modelling.....	68
3.4.3. Micro-modelling	69
3.4.4. Meso-modelling	71
3.5. Concluding remarks	72
4. EXPERIMENTAL RESEARCH.....	74
4.1. Assumptions	74
4.2. Research campaign – models and research program.....	75
4.2.1. Construction of the bottom ring beam	77
4.2.2. Construction of the masonry walls.....	80
4.2.3. Construction of the reinforced concrete slab	81
4.2.4. Construction of steel supporting structure	86
4.2.5. Construction phases of subsequent models.....	86
4.3. Test stand.....	87
4.4. Measuring methods	91
4.4.1. Measurement of displacements with LVDT sensors.....	91
4.4.2. Measurement of displacements, strains, deformations and crack propagation using a digital image correlation system (DIC).....	98
4.4.3. Measurement of horizontal force	106
4.4.4. Additional methods	106
5. BEHAVIOR OF MASONRY STIFFENING WALLS.....	107
5.1. Behavior phases.....	107
5.1.1. Results for models with door opening in stiffening wall A – type I models.....	107

5.1.2. Results for models with door opening in stiffening wall A and windows opening in perpendicular wall 1 – type II models	111
5.1.3. Results for models with a window opening in stiffening wall A and door opening in stiffening wall B – type III models	114
5.1.4. Results for reference model – type IV models	117
5.2. Analysis of test results	119
5.2.1. The proposition of an Empirical Method of Load Distribution on Stiffening Walls	119
5.2.2. Determination of internal forces by the analytical method	124
5.3. The procedure for calculations of the coordinates of the rotation center	130
6. CRACK MORPHOLOGY	141
6.1. Digital image correlation results	141
6.1.1. Results for MB-AAC-010/1 model	141
6.1.2. Results for MB-AAC-010/2 model	144
6.1.3. Results for MB-AAC-010/4 model	148
6.1.4. Results for MB-AAC-010/5 model	150
6.1.5. Results for MB-AAC-010/6 model	152
6.1.6. Results for MB-AAC-010/7 model	155
6.1.7. Results for MB-AAC-010/8 model	158
6.2. Crack patterns of tested buildings	160
7. NUMERICAL ANALYSIS	169
7.1. Empirical homogenization of the elasto-plastic model	169
7.1.1. Assumptions	169
7.1.2. Properties of masonry components	170
7.1.3. Masonry models used in the validation procedure	170
7.1.4. Material models	172
7.1.5. Strategy for calibrating mechanical parameters	179
7.1.6. Results of the validation of parameters for the homogeneous finite element model	181
7.2. Full-scale nonlinear analysis	199
7.2.1. First calculation approach	203
7.2.2. Second calculation approach	207
7.2.3. Third calculation approach	209
7.2.4. Fourth calculation approach	211
8. DISCUSSION	214
9. CONCLUSIONS	226
BIBLIOGRAPHY	230
APPENDIX – SUPPLEMENTARY MATERIALS	247
Abstract	263