

Table of Contents

Preface

Chapter 1: Numerical and Analytical Modeling of Masonry

FRCM/SRG - Masonry Joints: Experimental Investigation and Numerical Modelling L. Ombres, A. Iorfida and S. Verre	3
Numerical Modelling of FRCMs Confined Masonry Column S. Verre, A. Cascardi, M.A. Aiello and L. Ombres	9
Numerical Modelling of the Tensile Behaviour of BFRCM Strips A. Monaco, J. D'Anna, M.C. Oddo, G. Minafò and L. La Mendola	15
Numerical Modelling of FRCM Materials Using Augmented-FEM S. Urso, H.A. Hadad, C. Borsellino, A. Recupero, Q.D. Yang and A. Nanni	23
Numerical Constitutive Models of Low Tensile Strength Materials for the Description of Mechanical Behavior of Rammed Earth Masonry M. Fagone, F. Loccarini, G. Ranocchiai and T. Rotunno	30
Numerical Modelling of the Experimental Response of SRG Systems M. Malena, M. Sangirardi, F. Roscini and G. de Felice	37
Numerical and Theoretical Models for NFRCM-Strengthened Masonry C.B. de Carvalho Bello, D. Baraldi, G. Boscato, A. Cecchi, O. Mazzarella, E. Meroi, I. Aldreggetti, G. Costantini, L. Massaria, V. Scafuri and I. Tofani	44
Assessment of 3D Linear Elastic Masonry-Like Vaulted Structures D. Briccola, M. Bruggi and A. Taliercio	50
A Fe Model for TRM Reinforced Masonry Walls with Interface Effects P. Gulinelli, A. Aprile, R. Rizzoni, Y.H. Grunevald, F. Lebon, R. Lovisetto and S. Tralli	57
Comparison of Different FE Modeling for In-Plane Shear Strengthening of Brittle Masonry with FRCM C. D'Ambra, G.P. Lignola, A. Prota and E. Sacco	65
Numerical Simulation of Geogrid Reinforced Adobe Walls S. Invernizzi	73

Chapter 2: Pultruded Profiles Applied to Masonry

Shape Design Enhancement of Pultruded FRP Profiles for Structures Ancillary to Masonry Constructions G. Boscato, I. Aldreggetti, D. Baraldi, A. Cecchi, G. Costantini, L. Massaria, V. Scafuri and I. Tofani	83
FRP Pultruded Material as Reinforcement for Masonry: Expected Interaction in the Medium and Long Time S. Russo, I. Ippolito and C. Bergamo	89
Half-Scale Tests on Masonry Panels Strengthened with Pultruded FRP Frames F. Sciarretta and S. Russo	95

Chapter 3: Bond Behavior of Composites Applied to Masonry

Bond Mechanism of FRPs Externally Applied to Curved Masonry Structures: Experimental Outcomes and Numerical Modeling F. Fabbrocino, A. Formisano, E. Grande and G. Milani	105
Analytical Modeling of the Bond Behavior between Textile and Mortar Based on Pull-Out Tests A. Dalalbashi, B. Ghiassi and D.V. Oliveira	112
Bond Behavior between Tuff and Fired-Clay Brick Masonry Blocks and SRG Composites G. Baietti, E. Franzoni, G. Quartarone, A. Fregni and C. Carloni	118

Modelling of Bond Behavior of Injected Anchors in Masonry Elements F. Ceroni and T. Celano	126
Experimental Investigation on the Bond Behaviour of Basalt TRM Systems - Influence of Textile Configuration and Multi-Layer Application G. Misseri, G. Stipo, S. Galassi and L. Rovero	134
Some Considerations about the Effects of the Bonding Length on the Effectiveness of Spike Anchors in CFRP Reinforcements of Masonry T. Rotunno, M. Fagone, E. Bertolesi, E. Grande and G. Milani	141
A Bending Test Set-Up for the Investigation of the Bond Properties of FRCM Strengthenings Applied to Masonry Substrates A.S. Calabrese, P. Colombi and T. D'Antino	149

Chapter 4: Durability of Composites

Bond Behaviour of FRCM Composites: Effects of High Temperature A. Iorfida, S. Candamano, F. Crea, L. Ombres, S. Verre and P. de Fazio	161
TRM-to-Masonry Bond under Elevated Temperatures: Lightweight versus Normalweight Matrices P.D. Askouni, C.C.G. Papanicolaou and M.I. Kaffetzakis	167
Freeze-Thaw Durability of Lime Based FRCM Systems for Strengthening Historical Masonry B.Y. Pekmezci, E. Arabaci and C. Ustundag	174
Adhesion between SRP and Masonry: Influence of Moist Condition of Specimens and Presence of Salts in the Substrate Y. Yuan, C. Gentilini, C. Carloni and E. Franzoni	182
Mechanical and Thermal Characterization of FRCM-Matrices F. Longo, A. Cascardi, P. Lassandro, A. Sannino and M.A. Aiello	189
Influence of Alkaline Environments on the Mechanical Properties of FRCM/CRM and their Materials V. Rizzo, A. Bonati, F. Micelli, M. Leone and M.A. Aiello	195

Chapter 5: Masonry Arches and Vaults

NURBS-Based Upper Bound Limit Analysis of FRP Reinforced Masonry Vaults through an Efficient Mesh Adaptation Scheme N. Grillanda, A. Chiozzi, G. Milani and A. Tralli	205
Experimental and Numerical Analysis of FRCM Strengthened Parabolic Tuff Barrel Vault M. Bove, A. Castellano, A. Fraddosio, J. Scacco, G. Milani and M.D. Piccioni	213
Increase in Seismic Resistance for a Full-Scale Dry Stack Masonry Arch Subjected to Hinge Control G. Stockdale, G. Milani and V. Sarhosis	221
Discrete and Finite Element Models for the Analysis of Unreinforced and Partially Reinforced Masonry Arches D. Baraldi, G. Boscato, C.B. de Carvalho Bello, A. Cecchi and E. Reccia	229
Plastic Analysis of Masonry Arches Reinforced with FRCM under Vertical and Horizontal Forces M. Como, S. Coccia and F. di Carlo	236
Strengthening of Masonry Arches with SFRM N. Simoncello, P. Zampieri, J. Gonzalez-Libreros and C. Pellegrino	244
Strengthening of Masonry Arches with FRCM Composites: A Review P. Zampieri, J. Gonzalez-Libreros, N. Simoncello and C. Pellegrino	251
Finite Hinge Stiffness and its Effect on the Capacity of a Dry-Stack Masonry Arch Subjected to Hinge Control G. Stockdale, V. Sarhosis and G. Milani	259
Defining the Structurally Compatible Uses of Ancient Vaults: A Comparison between Traditional and Modern Modelling Approaches E. Coïsson, D. Ferretti, C. Boni and A. Tasora	267

On Collapse Behavior of Reinforced Masonry Domes under Seismic Loads N. Grillanda, A. Chiozzi, G. Milani and A. Tralli	275
--	-----

Chapter 6: Seismic Stability and Dynamic Behavior of Masonry

Dynamic Response of FRCM Reinforced Masonry Arches A. Castellano, A. Fraddosio, J. Scacco, G. Milani and M.D. Piccioni	285
Retrofit of Masonry Buildings through Seismic Dampers B. Jafarzad Eslami and A. Del Grosso	293
First-Aid and Provisional Devices in Historical Structures with Collapse Risk after Seismic Shock L. Ferrari	301
Advanced Seismic Analyses of “Apennine Churches” Struck by the Central Italy Earthquakes of 2016 by the Non-Smooth Contact Dynamics Method A. Ferrante, E. Ribilotta, E. Giordano, F. Clementi and S. Lenci	309
Masonry Spires: 3D Models to Understand their Seismic Vulnerability E. Zanazzi, E. Coisson, D. Ferretti and A. Lorenzelli	317
Reducing Seismic out of Plane Vulnerability of Masonry Church Facades through Optimization of Capacity Spectrum by Tie Rods S. Baraccani, G. Dan, A. Di Tommaso and T. Trombetti	325
Tracking Modal Parameter Evolution of Different Cultural Heritage Structure Damaged by Central Italy Earthquake of 2016 E. Ribilotta, E. Giordano, A. Ferrante, F. Clementi and S. Lenci	334
Shake Table Tests on a Masonry Structure Retrofitted with Composite Reinforced Mortar S. de Santis, G. de Felice, G.L. Di Noia, P. Meriggi and M. Volpe	342
The Generalized Density Evolution Equation for the Dynamic Analysis of Slender Masonry Structures M. Lucchesi, B. Pintucchi and N. Zani	350

Chapter 7: Experimental Assessment of Masonry

Shear Behavior of Multi Leaf Masonry Panels with Transversal Connections A. Cascardi, M. Leone and M.A. Aiello	359
An Alternative Approach for FRCM Matrix Tensile Strength Evaluation A. Bellini, M. Bovo, A. Incerti and C. Mazzotti	365
Preliminary Results on the Tensile Capacity of Steel Anchors in Brick Units of Different Materials P.Z. Chen, F. Finelli, E. Franzoni, C. Gentilini and G. Sansone	371
On the Use of Digital Image Correlation (DIC) for Evaluating the Tensile Behaviour of BFRM Strips J. D'Anna, G. Amato, J.F. Chen, G. Minafò and L. La Mendola	377
Composite Materials with Natural Fiber NFRC on Inorganic Matrix for Seismic Reinforcement of Masonry Structures A. La Tegola and W. Mera	385
Confinement of Masonry Columns with PBO and Basalt FRCM Composites L. Ombres, A. Iorfida and S. Verre	392
Discontinuous CFRP-Jacketing of Masonry Columns M. Lerna, F. Micelli, A. Cascardi and M.A. Aiello	398
Experimental Investigation on Masonry with Textile Reinforcement in Thin Bed Joints D. Saenger and M. Raupach	404
Structural Repointing of Masonry Structures J. Gonzalez-Libreros, T. D'Antino, F. Focacci, C. Carloni and C. Pellegrino	412
An Experimental Investigation on Pull-Off Tests Conducted on FRP Composites Applied to Brick Units M. Ghaemi, A. Di Tommaso and C. Gentilini	421
Mechanical Behaviour of Masonry Panels Strengthened by Flax TRM Systems G. Ferrara, C. Caggegi, A. Gabor and E. Martinelli	427

Can Textile Reinforced Mortar (TRM) Systems Be Really Effective to Increase Compressive Strength of Masonry Panels?	
J. Donnini, G. Maracchini, G. Chiappini, V. Corinaldesi, E. Quagliarini and S. Lenci	435
The Effects of Strengthening the AAC Walls Using Glass Mesh Arranged in Different Configurations	
M. Kałuža and J. Kubica	442
Local FRP-Reinforcement of Clay Hollow Block Panels under Shear Loading	
A. Borri, M. Corradi, R. Sisti, A. Molinari and C. Quintaliani	450
Mechanical Characterization of SRG Composites According to AC434	
D. Campanini, H.A. Hadad, C. Carloni, C. Mazzotti and A. Nanni	458
Mechanical Behavior and Failure Modes of Two Different Steel-FRCM Systems on Masonry Substrate: Experimental Investigation	
F. Bencardino, M. Nisticò, L. Ombres and S. Verre	466
Structural Behavior of Small-Scale Masonry Panel with Fiber Reinforced Mortar under Compressive Load	
F. Bencardino, A. Cecchi, M. Franceschi, M. Nisticò, L. Ombres and S. Verre	472
Influence of Matrix Properties on FRCM-CRM Strengthening Systems	
A.R. Tilocca, A. Incerti, A. Bellini and M. Savoia	478
Shear Capacity of Masonry Panels Reinforced with Inorganic Strengthening Systems	
M. Del Zoppo, G. Maddaloni, A. Balsamo, M. di Ludovico and A. Prota	486
On the Lateral Capacity of Reinforced Masonry Members Using Combined Retrofitting Methods	
A. Borri, R. Sisti and M. Corradi	493
Strengthening of Masonry Structures: Current National and International Approaches for Qualification and Design	
A. Bonati, A. Franco, O. Coppola and G. de Luca	501
Experimental Assessment of Geopolymer Grouts for Stone Masonry Strengthening	
L.G. Baltazar, F.M.A. Henriques, D. Temporão and M.T. Cidade	507
First Results of a 3D Pull-Out Model of Steel Anchors in Fired-Clay Bricks	
F. Finelli, A. Di Tommaso and C. Gentilini	514
Stress Redistribution in Glass Fibers of G-FRCM Composites	
T. D'Antino and C. Poggi	520
Diagonal Compression of Masonry Walls Strengthened with Composite Reinforced Mortar	
T. D'Antino, F.G. Carozzi and C. Poggi	528
Reinforced Jacketing of Wall Panels: A Comparative Experimental Investigation	
R. Sisti, A. Borri, M. Corradi and A. Dudine	536
Experimental Shear Behaviour of Rammed Earth Strengthened with a TRM-Based Compatible Technique	
A. Romanazzi, M. Van Gorp, D.V. Oliveira, R.A. Silva and E. Verstrynge	544
Grout Injection Effect on the Shear Behavior of FRCM Strengthened Stone Masonry Panels	
F. Ferretti, A. Incerti, A.R. Tilocca and C. Mazzotti	552

Chapter 8: Monitoring of Masonry

AE Characterization of Brick Masonry Walls Mechanical Behavior: The Case-Study of Alessandria and Boves Barracks	
N. Viale, F. Accornero, G. Lacidogna and G. Ventura	563
Diagnosis and Structural Assessment of the Assumption of the Virgin Mary Chapel in Prague (CZ)	
F. Monni, E. Quagliarini, R. di Nisio and A. Benedetti	571
AE Damage Assessment in the Bell Tower of the Turin Cathedral	
A. Manuello, D. Masera and A. Carpinteri	579
Health Monitoring of Medieval Masonry Towers by an Acoustic Emission Approach	
G. Lacidogna, G. Niccolini and A. Carpinteri	586
Fatigue Analysis of FRP Strengthened Masonry by Acoustic Emission Monitoring	
A. Grazzini and G. Lacidogna	594

Chapter 9: Special Case Studies

Influence of Long-Time Work of 19th Century Modern-Type Roof Construction on Technical Condition of Vaults of Gothic Church K. Ałykow and M. Napiórkowska-Ałykow	605
Analysis of the Condition of Damaged Vaults after a Construction Disaster in a Historic Church Ł. Bednarz, P. Opalka, A. Górski and G. Wojciechowska	613
Structural Behaviour of Masonry Vaulted Staircases Using Limit Analysis: The Case Study of the Bell Tower of Santa Maria Delle Vigne B. di Napoli, C. Calderini, M. Rossi, R. Vecchiattini, F. Portioli, L. Cascini and C. Battini	621
Damage Assessment of San Francesco Church in Amandola Hit by Central Italy 2016-2017 Seismic Event E. Giordano, A. Ferrante, E. Ribilotta, F. Clementi and S. Lenci	627
Post-Cracking B-FRCM Strengthening of a Traditional Anti-Seismic Construction Technique (<i>Casa baraccata</i>): Extensive Experimental Investigations S. Tiberti, C. Scuro, S. Porzio, G. Milani and R.S. Olivito	634
Annular Post-Compression by FRP inside Mortar Joints and Vertical Post-Compression by Stainless Steel, for Seismic and Wind Retrofitting of Historical Masonry Chimney A. Viskovic, L. Antonelli and F. Morgante	642
Modeling and Design of the Restoration and Seismic Strengthening of the Sanctuary of Santa Maria Delle Grazie at Forno under New Italian Rules NTC 2018 A. Custodi and N. Santopuoli	650
Dynamic Characterization of Nepali Masonry Temples Hit by 2015 Earthquake S. Russo and E. Spoldi	659
Problems with Maintaining in Required Technical Condition and Revitalization of Medieval Defense Fortries D. Bajno, A. Grzybowska and J. Gajewski	665
Structural Reinforcement of a Masonry Building G. Cerretini and G. Giacomini	673