Durability and Sustainability of Concrete Structures (DSCS-2018)

Editors:
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38800 Country Club Dr.
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On the cover: The Moscow International Business Centre (MiBC), also known as “Moscow City.”

Printed in the United States of America

Editorial production: Susan K. Esper

Preface

Modern construction is unthinkable without concrete, the world production and consumption of which is about 10 billion m³ per year. Given the steady growth of the world’s population by 2050, it is expected to double this volume, which will undoubtedly be significantly affected on energy consumption and increase global CO₂ emissions.

Concrete is perhaps the most universal building material since the beginning and development of civilization. It is sufficient to recall the Great Wall of China, the palaces and temples of Ancient India, the pyramids of Ancient Egypt, the unique buildings of Romans, made with the use of lime-pozzolanic binders. Universality of concrete is defined by simplicity and convenience of its production, rather low cost, structural integrity and homogeneity, durability and a long service life under various aggressive environments.

However, the concrete image is sometimes not favorable. It is associated with greater labor intensity of construction works and dismantlement, massive structures, a large impact on the environment in connection with the consumption of not renewable natural resources. The same perception is greatly facilitated by the fact that, according to Gigaton Throwdown Initiative, “the cement industry is responsible for about 5 to 7% of total CO₂ emissions, or 2.1 Gt per year.” Indeed, when producing cement clinker about 0.9 t CO₂ / t clinker are produced. Taking into account the annual increase in the production and use of Portland-based cement (more than 4.1 million tons per year) that is the main binder used in the production of concrete, this fact poses a significant threat to humanity as a whole. According to the Intergovernmental Panel on Climate Change (IPCC), actions are necessary to reduce carbon dioxide emissions because in about 30 years CO₂ concentrations is expected to reach 450 ppm – a dangerous point above which irreversible climate change will occur on our planet.

Since concrete will remain the main building material in the future, it is expected that if new ways and mechanisms to reduce the environmental burden by at least 50% will be not found, it is not possible to maintain the existing level of impact.

This problem is so deep and serious that there is hardly a single way to solve it. There is a need for an integrated approach, several complementary activities that provide some synergy.

Until recently, the main efforts were aimed at improving technological processes and reducing the consumption of clinker through the production of blended cements, as well as the creation of new types of binders. Active search for alternative binders has led to the development of sulfoaluminate-based cements; alkali-activated materials and geopolymers (slag, fly ash, metakaolin, etc.), efficient and fairly water-resistant magnesia cements; phosphate cements (ammonium phosphate, silicate phosphate, magnesium phosphate etc.), cements with calcium halogen-aluminate and the so called low water demand binders.

With the advent of high-performance concretes and new technologies, the possibility of a radical increase of the cement factor in conventional concrete due to the use of high-performance superplasticizers and other chemical admixtures, dramatically reducing the water consumption of the concrete mixture; active mineral additives such as micro silica, metakaolin, fly ash, finely ground granulated slag, etc., as well as a variety of inert fillers that can improve the functionality of concrete mixtures, such as fine limestone.
Strictly speaking, “pozzolanic effect” and “filler effect” are easily combined and provide a certain synergy.

The potential for reducing cement consumption in concrete production is still undervalued. This is due to certain fears of decreasing the corrosion resistance of concrete and durability of reinforced concrete structures, since the great bulk of the existing standards is prescriptive and sets the minimum cement content in concrete under specific operating conditions.

Reinforced concrete structures of buildings and constructions, as a rule, initially, shall have the design strength and sufficiently long service life because their construction often requires a significant investment. The durability of these structures, however, is determined by different ageing processes and the influence of external actions, so their life will be limited. As a result, many structures need to be repaired or even replaced in fairly short time periods, resulting in additional costs and environmental impacts. Therefore, there is a need to improve the design principles of structures taking into account the parameters of durability and thus achieving a sufficiently long service life.

Development of the concept of design of structures based on their life cycle, “environmental design”, including a holistic approach that optimizes material and energy resources in the context of operating costs, allow us to completely revise our ideas about structural concrete construction.

It should be noted that many recent developments in the field of life cycle analysis (LCA) are aimed at expanding and deepening traditional approaches and creating a more complete description of the processes with the analysis of sustainable development (LCSA) to cover not only the problems associated mainly with the product (product level), but also complex problems related to the construction sector of the economy (at the sector level) or even the general economic level (economy level).

The approach to “environmental design” is based on such models and methods of design, which takes into account a set of factors of their impact on the environment, based on the concept of “full life cycle” or models of accounting for total energy consumption and integrated CO$_2$ emission.

All of this could become a basis for the solution of the global problem – to contain the growing burden on the environment, providing a 50% reduction in CO$_2$ emissions and energy consumption in the construction industry. Hence a special sharpness P. K. Mehta's phrase acquires: “...the future of the cement and concrete industry will largely depend on our ability to link their growth for sustainable development...”

The above-mentioned acute and urgent problems form the basis of the agenda of the Second edition of International Workshop on “Durability and Sustainability of Concrete Structures – DSCS-2018,” held in Moscow on 6 – 7 June 2018 under the auspices of the American Concrete Institute, the International Federation on structural concrete and the International Union of experts and laboratories in the field of building materials, systems and structures. The selected papers of this major forum, which brought together more than 150 experts from almost 40 countries of the world, are collected in this ACI SP.

Vyacheslav Falikman and Roberto Realfonzo
Chairs of the Organizing Committee

Luigi Coppola, Petr Hajek and Paolo Riva
Members of the Organizing Committee
TABLE OF CONTENTS

KEYNOTES

SP-326—1
Bio-Inspired, Internally Cured Cellulose Fiber Reinforced Concrete for Next Generation Infrastructure
Authors: N. Banthia, O. Onuaguluchi, and D. Cui

SP-326—2
Design Approach and Properties of a New Generation of Sustainable Structural Concretes
Authors: Harald S. Müller, Michael Haist, Michael Vogel, and Jack S. Moffatt

SP-326—3
Nano-Engineered Meta Cement-Based Materials and Durability
Authors: Surendra P. Shah and Pengkun Hou

SP-326—4
Benchmarking Accelerated Performance Test Methods with Long-Term Testing
Author: R. Doug Hooton

SP-326—5
Considerations of Sustainability in the Mixture Proportioning of Concrete for Strength and Durability
Authors: Ravindra Gettu, Radhakrishna G. Pillai, Jyotiprakash Meena, Anusha S. Basavaraj, Manu Santhanam, and B.S. Dhanya

MINERAL ADDITIVES AND SCM; CHEMICAL ADMIXTURES

SP-326—6
Highly Durable Concrete based on Calcined Clays
Authors: Eugen Kleen and Matthias Gay

SP-326—7
Utilizing Calcined Clay to Enable Aluminum Reinforced Concrete
Author: Harald Justnes

SP-326—8
Characterization and Pore Structure of Rice Husk Ash Cementitious Materials
Authors: Ojedokun Olalekan and P.S. Mangat

SP-326—9
Influence of Synthetic Zeolite on Delayed Ettringite Formation – Preliminary Investigation
Author: Stephen O. Ekolu

SP-326—10
Lignosulfonates in Cementitious Systems Blended with Calcined Clays
Authors: Ricarda Sposito, Isabel Dürr, and Karl-Christian Thienel

SP-326—11
Modification of Mineral Additives when Treating their Suspensions in Different Cavitators
Authors: Gusev, B.V; Bondarenko, I.V.; and Olenich, D.I.

SP-326—12
A Simple Method for Identifying the Saturated-Surface-Dry State of Filler
Author: Ole Mejlhede Jensen
Rheological Behaviour of Cement Pastes with Low Amounts of Polynaphthalene Sulfonate Plasticizer
Authors: Alexander Mezhov, Simon Ulka, Charles. E. Diesendruck, Youri Gendel, and Konstantin Kovler

The Effect of Natural SiO$_2$ Nanoparticles on the Performance of Portland Cement Based Materials
Authors: Konstantin Sobolev, Ismael Flores-Vivian, Rani G.K Pradoto, Marina Kozhukhova, and Vadim Potapov

Hardening of Concrete with Hydrothermal Nanosilica
Authors: Vadim V. Potapov, Yuriy V. Efimenko, Alexander A. Karabtsov, and Denis S. Gorev

Influence of Air Entrainment Content on Strength and Frost Resistance of Concrete
Authors: O. I. Matveeva and G. D. Fedorova

Influence of Self-Healing Stimulated via Crystalline Admixtures on Chloride Penetration
Authors: Estefania Cuenca, Giacomo Cislaghi, Michael Puricelli, and Liberato Ferrara

ALKALI-ACTIVATED BINDERS AND CONCRETES

Alkali-Activated Natural Pozzolan/Slag Concrete: Fresh and Strength Properties
Authors: Meysam Najimi and Nader Ghafoori

Effect of Pre-Conditioning on Durability Indices of Alkali-Activated Concretes
Author: Maxim Kovtun

Geopolymers for Increasing a Durability for Marine Infrastructure
Author: Kinga Korniejenko

Thermal Curing and Environmental Impact of Alkali-Activated Cementitious Materials
Authors: Elien Dejager, Steffen Grünewald, and Geert De Schutter

Behavior of Activated Ternary Binders under Autogenous Condition
Authors: Aveline Darquennes and Farid Benboudjema

Alkaline Activated Slag (AAS): Resistance to Sulfate Attack
Authors: Neusa Aparecida Munhak Beltrame, Mariana Perardt, Caroline Angulski da Luz, José Ilo Pereira Filho, and Cláudia Bernardi Baldin

Chloride Ions Penetration and Carbonation in Alkaline Activated Slag
Authors: Douglas Éverton Cadore, Lucas Ceconi Kretschmer, Carlos Eduardo de Morais Lavandoski, Caroline Angulski da Luz, Marcelo Henrique Farias de Medeiros

Utilization of Steel Furnace Aggregate in Geopolymer Concrete for Wave-Breaker Application
Authors: Arnaud Castel, Mohammad Khan, Aziz Mahmood, and Stephen Foster
SP-326—26
Fly Ash-Based Geopolymer Mortars for Fire Protection
Authors: Lorenza Carabba, Gregor J. G. Gluth, Stephan M. Pirskawetz, Simone Krüger, and Maria Chiara Bignozzi

SULPHOALUMINATE AND SULPHOALUMOFERRITE CEMENTS

SP-326—27
Chemistry Composition and Properties of Sulfated Cements
Authors: Krivoborodov, Yury R.; Samchenko, S.V.; and Kouznetsova, T.V.

SP-326—28
Calcium Sulfoaluminate and Geopolymeric Binders as Alternatives to OPC
Authors: Alessandra Mobili, Alberto Belli, Antonio Telesca, Milena Marroccoli, and Francesca Tittarelli

SP-326—29
Mechanical Performance Comparison between Sulfo-Based and Portland Concretes
Authors: Davide Sirtoli, Paolo Riva, Maurizio Marchi, and Sergio Tortelli

SP-326—30
Drying and Autogenous Shrinkage Evolution of a Blended CSA-Portland Cement Concrete
Authors: Davide Sirtoli, Pietro Lura, Maurizio Marchi, and Sergio Tortelli

SP-326—31
Corrosion-Resistant Cements Based on Sulfated Clinkers
Authors: S.V. Samchenko, O.V. Zemskova, and D.A. Zorin

SP-326—32
Rheological and Physical Performances of Mortars Manufactured with Plain and Ultrafine Fly Ashes
Authors: Luigi Coppola, Denny Coffetti, and Elena Crotti

SP-326—33
Durability of the Concrete Based on a Sulphate-Aluminate Cement
Authors: Panchenko, Alexander I.; Bazhenov, Yuri M.; and Kharchenko, Igor Ya

SP-326—34
Long-Term Behaviour of Concrete Structural Elements varying the Portland Cement-CSA Ratio
Authors: Daniele Colonna, Marianovella Leone, Maria Antonietta Aiello, Maurizio Marchi, Sergio Tortelli, and Salvatore Vendetta

SP-326—35
Performance of Calcium Sulphoaluminate Cement for Fast Concrete Repair: Real-Scale Test Results
Authors: Sergio Tortelli and Maurizio Marchi

SP-326—36
Self-Compacting Concrete (SCC) Made from Supersulfated Cements (SSC)
Authors: Jefferson T. O. Homrich, Letícia Volkweis, Julia Beatriz Milani, Guilherme Holub Camargo, Caroline Anguiski da Luz, and José Ilo Pereira Filho

GREEN CONCRETES

SP-326—37
Suitability of Recycled Aggregate as a Replacement for Natural Aggregate in Construction
Authors: Deb Dulal Tripura, Shubham Raj, Sher Mohammad, and Rima Das

SP-326—38
Efficient Recycling and Reuse of Waste Concrete on a Construction Site
Authors: Daguang Han, Yupeng, Yang, Chunli Ying, Zeger Sierens, Hongbo Fan, and Jiabin Li
SP-326—39
Mechanical Properties of Concrete with Recycled Aggregate at Early Ages
Authors: Zeger Sierens and Jiabin Li

SP-326—40
Macro-Mechanical Models for Evaluation of the Elastic Modulus of Recycled Aggregate Concrete
Authors: A. Ghani Razaqpur and Gholamreza Fathifazl

SP-326—41
Short- and Long-Term Properties of Concretes with Secondary Raw Materials
Authors: Nicola Buratti, Anna Lisa Vinciguerra, Andrea Incerti, Stefania Manzi, Elisa Rambaldi, Maria Chiara Bignozzi, and Claudio Mazzotti

SP-326—42
Permeation Properties of Recycled Concretes Containing Recovered Aggregates
Author: Stephen O. Ekolu

SP-326—43
Recycled Aggregates Effect on Concrete Mechanical Performance Subjected to High Temperatures
Authors: Jéssica Beatriz da Silva, Marco Pepe, and Romildo Dias Toledo Filho

SP-326—44
Shear Behavior of Reinforced Concrete Beams made with Recycled Concrete Aggregates
Authors: Nariman Khalil, Chelsea Tamer, and Fidel Abdo

SP-326—45
Durability of Thermal Plasters made with Recycled Materials
Author: Maurizio Nicolella

SP-326—46
New Sustainable Binders Based on Waste Valorization for Civil Engineering Applications
Authors: Anna Lisa Vinciguerra, Andrea Incerti, Nicola Buratti, Stefania Manzi, Elisa Rambaldi, Claudio Mazzotti, and Maria Chiara Bignozzi

SP-326—47
The Use of Vanadium Production Waste to Produce Alumina Cement
Authors: Kouznetsova, T.V.; Burlov, I.Y.; and Krivoborodov, Y.R.

SP-326—48
High-Effective Artificial Porous Gravel from Metallurgical Industry Waste
Authors: Huseyn Mammadov and Malik Mirzayev

SP-326—49
Experimental Study on Properties of Mortar Containing Molten Slag as Fine Aggregate
Authors: Yuto Yamanaka, Hiromi Fujiwara, Masanori Maruoka, and Ryosuke Otsuka

SP-326—50
Leaching Behaviors of Heavy Metals from Mortar in Various Types of Solutions
Authors: Shaojun Zhou, Takumi Nishiwaki, Yuko Ogawa, and Kenji Kawai

SP-326—51
Environmentally Friendly Concretes Manufactured with CSA Cement
Authors: Luigi Coppola, Denny Coffetti, and Elena Crotti

SP-326—52
Concretes with Low Paste and Low Cement Content: Durability and Sustainability
Authors: Edgardo Becker, Patricio Corallo, Juan Domínguez, Cristian Ríos, Ismael Gea, and Javier Cañari
SP-326—53
Study of Environmentally Friendly Mortars Prepared with Recycled Concrete Aggregates and Biomass Ash
Authors: Valeria Corinaldesi, Jacopo Donnini, and Glauco Merlonetti

NONMETALLIC REINFORCEMENT

SP-326—54
Durability of Structures Made of or Strengthened using Textile Reinforced Concrete
Author: Viktor Mechtcherine

SP-326—55
Testing Concept for the Investigation of the Long-Term Durability of Textile Reinforced Concrete (TRC)
Authors: Arne Spelter, Sergej Rempel, Norbert Will, and Josef Hegger

SP-326—56
GFRP-Reinforced Concrete Columns Subjected to Seismic Loads
Authors: Shamim Sheikh and Zahra Kharal

SP-326—57
GFRP Reinforced Foundation Slab Design for 15 Story Residential Building
Authors: Vladimir Kakusha, Oleg Kornev, Mikhail Kovalev, Andrey Lapshinov, and Egor Litvinov

FRC

SP-326—58
Next Generation UHPFRC for Sustainable Structural Applications
Authors: Amir Hajiesmaeili and Emmanuel Denarié

SP-326—59
Ductility Index and Durability in Fiber-Reinforced Concrete
Authors: Andrea Gorino, Alessandro P. Fantilli, Bernardino Chiaia, Davide Zampini, Alexandre Guerini, and Giovanni Volpatti

SP-326—60
Properties of Ultra-High-Strength Self-Compacting Fiber-Reinforced Concrete
Authors: Simon S. Kaprielov, Andrey V. Sheynfeld, Igor A. Chilin, and Igor M. Bezgodov

SP-326—61
Aging Behavior of High-Performance Fiber-Reinforced Concrete
Authors: Giuseppe Di Nunzio, Andrea Consiglio, Giovanni Muciaccia, and Gianpaolo Rosati

SP-326—62
Influence of Fiber Content on the Conductivity of Steel Fiber-Reinforced Concrete
Authors: Valeriy Dorf, Rostislav Krasnovskiy, Dmitriy Kapustin, Patimat Sultygova, and Nina Umnyakova

SP-326—63
Stress-Strain Behavior (SSB) of Steel Fiber Concrete
Authors: Dmitriy Kapustin, Leis Zeid Kiliani, and Rostislav Krasnovskiy

SP-326—64
Post-Cracking Response of Hybrid Recycled/Industrial Steel Fiber-Reinforced Concrete
Authors: Enzo Martinelli, Carmine Lima, Marco Pepe, Antonio Caggiano, and Ciro Faella

SP-326—65
High Temperature Effect on Stress-Strain Properties of High-Strength Steel Fiber Concrete
Authors: Valery Dorf, Rostislav Krasnovskiy, Dmitriy Kapustin, and Patimat Sultygova
SP-326—66
Performance of Fiber-Reinforced Concrete with Expanding Component and Glass-Polymer Composite Fiber
Authors: Vadim Solovyov, Yury Bazhenov, Vyacheslav Falikman, and Marsel Nurtdinov

SP-326—67
Enhanced Seismic Response of a Bridge Pier Strengthened with UHPFRC
Authors: Adriano Reggia, Alessandro Morbi, and Giovanni A. Plizzari

SUSTAINABLE CONSTRUCTION

SP-326—68
Innovations and Value Engineering contribute to Sustainable Structures
Author: Milan Kalny

SP-326—69
Advanced Concrete Structures for the Sustainable and Resilient Built Environment
Authors: Petr Hajek and Ctislav Fiala

SP-326—70
Sustainability-Oriented Innovation of a Multilayered Cement-Based Roof Element
Authors: Adriana Angelotti, Sonia Leva, Giulio Zani, and Marco di Prisco

SP-326—71
Concrete vs Asphalt: Pavement and Lighting Costs in Italian Road Tunnels
Authors: Paola Di Mascio and Laura Moretti

SP-326—72
CARES Sustainable Constructional Steel Certification Scheme
Authors: Lee Brankley BP, Ayhan Tugrul Nebosh IGC, Ladin Camci, and Dave Knight

EXTREME CONDITIONS

SP-326—73
Seismic Performance of Reinforced Concrete Columns from an Existing Building Constructed in 1963
Author: Hideo Araki

SP-326—74
Fire Performance of Reinforced Concrete Columns Based on Eurocode 2
Authors: Lijie Wang, Robby Caspeele, and Luc Taerwe

SP-326—75
Hydroabrasive Exposure and Concrete Resistance against Abrasion Erosion
Author: Frank Spörel

SP-326—76
TRC Sandwich Panel for Energy Retrofitting Exposed to Environmental Thermal Actions
Authors: Isabella G. Colombo, Matteo Colombo, Marco di Prisco, Graziano Salvalai, and Marta M. Sesana

SP-326—77
Reversible Creep of Building Materials under Constant and Repeated Loading
Authors: M.M. Lordkipanidze, L.I. Minkin, and N.K.Chakhvashvili

SP-326—78
Methodology of Long-Term Concrete Tests for Bending
Authors: Petr Arleninov, Sergey Krylov, and Dmitry Kuzevanov
CONCRETE DURABILITY ASPECTS

SP-326—79
Forecasting Durability of Reinforced Concrete Structures under Weathering
Authors: Gusev Boris Vladimirovich and Fayvusovich Alexander Solomonovich

SP-326—80
Corrosion-Induced Cracking in Concrete Exposed to a South Africa Inland Environment
Author: Jacob Olumuyiwa Ikotun

SP-326—81
Carbonation of Mortar with Alkali-Silica Reactions
Authors: Chun-Tao Chen, Wei-Cheng Yang, and Chin-Wei Hsu

SP-326—82
Effect of Hardening Conditions on the Structure of Cement
Authors: katerina Potapova, Sergey Sivkov, and Ivan Korchunov

SP-326—83
The Influence of the Different Factors on the Stability of the AFt and AFm Phases
Authors: Svetlana Samchenko and Evgeny Makarov

SP-326—84
Site Air-Permeability of HPSFR and Conventional Concretes
Authors: Roberto Torrent, Marco di Prisco, Verónica Bueno, and Fabio Sibaud

SP-326—85
Influence of Negative Temperatures on Water Permeability of Concrete
Authors: Vovk Anatoly and Irina Vovk

SP-326—86
Effects of Gel-Polymerized Superabsorbent Polymers on Freeze-Thaw Resistance of Concrete
Authors: Sung-Gul Hong, Min-soo Kim, and Ju-Hyuck Moon

SP-326—87
Steam Curing of Precast Concrete Containing Limestone Filler – Evaluation of Early Age Strength
Authors: Daman K. Panesar and Duo Zhan

SP-326—88
Analytical Modelling of RC Members Subjected to Rebar Corrosion and Buckling
Authors: Fabio Di Carlo, Alberto Meda, and Zila Rinaldi

SP-326—89
Constant Chloride Flux Model to Predict Airborne-Chloride Penetration in Concrete
Author: Johanna H.M. Visser

SP-326—90
Durability of RC Structures made with Chloride-Contaminated Raw Materials
Authors: Federica Lollini, Maddalena Carsana, Matteo Gastaldi, Elena Redaelli, and Forood Torabian Isfahani

SP-326—91
Flexural Behavior of Corroded RC Beams
Authors: Giuseppe Campione, Francesco Cannella, Piero Colajanni, and Maurizio Papia

SP-326—92
An Improved Method for the Calculation of Crack Spacing and Width in RC beams
Author: Maurizio Taliano
SP-326—93
Improving of Methods of Evaluating the Crack Resistance of Concrete Structures
Authors: Nikolay N. Trekin, Emil N. Kodysh, Aleksander N. Mamin, Dmitry N. Trekin, and Justine Onana

SP-326—94
Laser Shearography Applications in Concrete Durability Studies
Authors: Amde M. Amde, Richard A. Livingston, and John W. Newman

CASE STUDIES

SP-326—95
Deterioration Survey of Structural Concrete at the Rogun Hydro after its Conservation
Authors: Vyacheslav Falikman, Komron Safarov, and Valentina Stepanova

SP-326—96
Refurbishment of a Cooling Tower in Opole, Poland
Author: Reinhard Martin

SP-326—97
Scientific Assistance of Hazardous Construction in Russian Arctic Region
Authors: Lyudmila Elshina, Vyacheslav Yarmakovskiy, Igor Kirillov, and Viktor Panteleev

SP-326—98
Preserving Concrete Thin Shells: The Case of Deitingen South Station by Heinz Isler (1968-1969)
Authors: Francesca Albani and Carlo Dusi

SP-326—99
Buildings with Open Plan Floors and Integrated Load-Bearing Structures
Authors: Viktor V. Granev, Nikolay G. Kelasiev, Emil N. Kodysh, Nikolay N. Trekin, and Ivan A. Terekhov

SP-326—100
Seismic Analysis of RC Buildings by Modeling Floor Deformability and Infill Walls
Authors: Sergio Ruggieri, Francesco Porco, Domenico Raffaele, and Giuseppina Uva

REPAIR AND STRENGTHENING

SP-326—101
An Overview of the Design Approach to Strengthen Existing Reinforced Concrete Structures with SRG
Authors: Christian Carlonia, Francesco Ascioneb, Guido Camatac, Gianmarco de Feliced, Stefano De Santisd, Marco Lambertib, Annalisa Napoli, Roberto Realfonzob, Mattia Santandreaa, Elena Stievanine, Elvis Cescattie, and Maria Rosa Valluzzie

SP-326—102
State of the Art of Steel Reinforced Grout Applications to Strengthen Masonry Structures
Authors: Gianmarco de Felice, Stefano De Santos, Roberto Realfonzo, Annalisa Napoli, Francesco Ascione, Elena Stievanin, Elvis Cescatti, Maria Rosa Valluzzi, Christian Carloni, Mattia Santandrea, and Guido Camata

SP-326—103
Evaluation of Performance of Backfilling Mortar for Repairing Sewage Pipes
Authors: Ken Ogasawara, Hiromi Fujiwara, and Masanori Maruoka

SP-326—104
Repairing and Upgrading of a Heavy-Duty RC Slab
Authors: Pietro G. Gambarova, Francesco Lo Monte, Seyed M.S. Mousavi, Pietro L. Torregiani, and Mattia Zecchillo
SP-326—105
Beam-Column Joints Strengthened with Steel FRP and Steel FRCM: Experimental Investigations
Authors: Annalisa Napoli and Roberto Realfonzo

SP-326—106
Experimental Evaluation of the Efficiency of FRCM-U-Wrap Joist Tech for Flexural Improvement of RC Beam
Author: Laura Anania

SP-326—107
Using Fiber-Reinforced High Performance HPFRC Micro-Concretes in Structural Restoring
Authors: Marco Bressan, Alessandro Pasqualini, and Felice Marco Liberatore

SP-326—108
Predictive Strain Debonding in RC BeamsExternally Strengthened with S-FRCM
Authors: Francesco Bencardino and Mattia Nisticò

SP-326—109
Adhesion Testing Between Concrete and Reinforcement by Acoustic Emission Method
Authors: Alexandr Sagaydak, Dmitriy Zimnukhov, Sergey Krylov, Shevlyakov Konstantin, and Vladimir Bardakov

SP-326—110
SRP/SRG Strips Bonded to Concrete Substrate: Experimental Characterization
Authors: Francesco Ascione, Marco Lamberti, Annalisa Napoli, and Roberto Realfonzo

SP-326—111
The Bond Strength of Repairing Systems Applied to Concrete Elements: Analysis of Historical Data
Authors: A. Bonati, I. Capasso, O. Coppola, E. Grasso, and L. Schiavi

SP-326—112
Marine Environmental Condition effect on FRP Sheets Durability and Bond Strength to Concrete
Authors: Amin Kashi, Ali Akbar Ramezanianpour, Faramarz Moodi, and Mohsen Kheirandish

SP-326—113
Study of Green FRCM Systems made of Lime-Based Matrix and Hemp Fibers
Authors: Jacopo Donnini and Valeria Corinaldesi

SP-326—114
Towards an Integrated Approach to Seismic and Energy Retrofitting of Existing RC Frame Buildings
Authors: Carmine Lima, Enzo Martinelli, Marco Pepe, and Ciro Faella

NEW OR NOVEL CONCRETES AND CONSTRUCTION TECHNOLOGIES

SP-326—115
Performance-Based Concrete Mixtures for Durable, Long-Life Bridges
Authors: Julie K. Buffenbarger, Mary E. Vancura, and Kevin A. MacDonald

SP-326—116
Early Structure Formation in Concrete with Water-to-Cement Ratio 0.2
Authors: Ivan Sitnikov and Vasily Sitnikov

SP-326—117
Kinetics of UHPC Strength Gain at Subfreezing Temperatures
Authors: Vasily Sitnikov and Ivan Sitnikov
SP-326—118
Evaluation of Mechanical and Durability Properties of Sulfur Concrete
Authors: Renata Kotynia, Radoslaw Walendziak, and Michal Lewandowski

SP-326—119
Production of Sustainable Concrete Materials through Innovative Uses of CO₂
Authors: Caijun Shi, Bao Lu, Zhenjun Tu, and Xiaoying Pan

SP-326—120
Studies on Some Factors Affecting CO₂ Mixing or CO₂ Curing of Cement Concrete
Authors: Ming-Gin Lee, Yung-Chih Wang, Yu-Min Su, and Yishuo Huang

SP-326—121
Energy Selection and Consumption of Cold Region Concrete Production
Author: Satoshi Fujimoto

SP-326—122
The Influence of Mixed Cement Filler Dispersity to the Concrete Properties
Author: Olga Kononova

SP-326—123
Influence of the Emulsions to the Interface Formwork/Concrete
Authors: Laurent Libessart, Amine Lahlou, Chafika Djelal, Yannick Vanhove, and Sandrine Mateo

SP-326—124
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