



Proceedings  
PRO 70

# Service Life Design for Infrastructure

Proceedings of the  
2nd International Symposium

Edited by K. van Breugel, Guang Ye and Yong Yuan

RILEM Publications S.A.R.L.

Volume 2

Published by RILEM Publications s.a.r.l.

157 rue des Blains F-92220 Bagneux - France

Tel : + 33 1 45 36 10 20 Fax : + 33 1 45 36 63 20

<http://www.rilem.net> E-mail: [dg@rilem.net](mailto:dg@rilem.net)

© 2010 RILEM – Tous droits réservés. ISBN: 978-2-35158-096-7 (set)

ISBN: 978-2-35158-114-8 (Volume 2), e-ISBN: 978-2-35158-097-4

***Publisher's note:** this book has been produced from pdf files provided by the individual contributors. In the absence of some of the original source files, limited editorial adjustments and corrections were possible. The publisher makes no representation, express or implied, with regard to the accuracy of the information contained in this book and cannot accept any legal responsibility or liability for any errors or omissions that may be made.*

*All titles published by RILEM Publications are under copyright protection; said copyrights being the property of their respective holders. All Rights reserved.*

*No part of any book may be reproduced or transmitted in any form or by any means, graphic, electronic, or mechanical, including photocopying, recording, taping, or by any information storage or retrieval system, without the permission in writing from the publisher.*

RILEM, The International Union of Laboratories and Experts in Construction Materials, Systems and Structures, is a non profit-making, non-governmental technical association whose vocation is to contribute to progress in the construction sciences, techniques and industries, essentially by means of the communication it fosters between research and practice. RILEM's activity therefore aims at developing the knowledge of properties of materials and performance of structures, at defining the means for their assessment in laboratory and service conditions and at unifying measurement and testing methods used with this objective.

RILEM was founded in 1947, and has a membership of over 900 in some 70 countries. It forms an institutional framework for co-operation by experts to:

- optimise and harmonise test methods for measuring properties and performance of building and civil engineering materials and structures under laboratory and service environments,
- prepare technical recommendations for testing methods,
- prepare state-of-the-art reports to identify further research needs,
- collaborate with national or international associations in realising these objectives.

RILEM members include the leading building research and testing laboratories around the world, industrial research, manufacturing and contracting interests, as well as a significant number of individual members from industry and universities. RILEM's focus is on construction materials and their use in building and civil engineering structures, covering all phases of the building process from manufacture to use and recycling of materials.

RILEM meets these objectives through the work of its technical committees. Symposia, workshops and seminars are organised to facilitate the exchange of information and dissemination of knowledge. RILEM's primary output consists of technical recommendations. RILEM also publishes the journal *Materials and Structures* which provides a further avenue for reporting the work of its committees. Many other publications, in the form of reports, monographs, symposia and workshop proceedings are produced.

2nd International Symposium on Service Life Design for Infrastructure  
4-6 October 2010, Delft, The Netherlands

**Second International Symposium on  
Service Life Design for Infrastructure**

**Delft, The Netherlands**

4-6 October 2010

**Edited by K. van Breugel, Guang Ye and Yong Yuan**

RILEM Publications S.A.R.L.

## Contents

### Volume 2

#### **THEME 5: CATHODIC PROTECTION / CORROSION AND CORROSION PROTECTION (PART TWO)**

- |    |  |     |
|----|--|-----|
| 67 | <b>A new representation of chloride threshold level for steel corrosion in concrete</b><br>M. S. Jung, H. B. Shim, S-H. Kim and K. Y. Ann                      | 605 |
| 68 | <b>Extension of residual service life by galvanic cathodic protection</b><br>George Sergi  | 613 |
| 69 | <b>Crack initiation and propagation caused by corrosion-product expansion around corroding bars</b><br>Yasuji Shinohara  | 623 |
| 70 | <b>Chloride Binding Behavior of Cement Composition</b><br>In-Seok Yoon   | 631 |
| 71 | <b>On the application of thermodynamics of corrosion for service life design of concrete structures</b><br>André Küter, Mette R. Geiker and Per Møller         | 637 |
| 72 | <b>Corrosion of reinforcing steel and behaviour of reinforced concrete beams under sustained load</b><br>Anongdeth Phetkaysone, Ryoichi Sato and Ryuhei Yamada | 645 |
| 73 | <b>Fluorinated nana-fibres and corrosion</b><br>Pierre van Tonder, D. Kruger and B. Jones  | 655 |
| 74 | <b>Electrochemical behavior of reinforcing steel in modified concrete and cement extract</b><br>D.A. Koleva, K. van Breugel, J.M.C. Mol and J.H.W. de Wit      | 663 |
| 75 | <b>Carbonation and chloride corrosion of steel reinforcement in natural pozzolan-based mortars</b><br>Jose Pacheco, Gerardo J. Fajardo and Pedro L. Valdez     | 673 |

|   |  |            |
|---|--|------------|
| 76  | <b>Effects of blast furnace slag and chemical admixtures on the accuracy of different methods used for the determination of chloride content of Portland cement pastes</b> | <b>681</b> |
|   | D.M. Aleixo, V. A. Quarcioni, S. C. Angulo and W. L. Repette   |            |
| <b>THEME 6: HIGH PERFORMANCE AND ENVIRONMENT-FRIENDLY MATERIALS</b> |  |            |
| 77  | <b>High performance materials and monitoring</b>   | <b>691</b> |
|   | Surendra P. Shah and Jae Hong Kim  |            |
| 78  | <b>Effect of calcium aluminate cement in mitigating the corrosion of steel in concrete</b>   | <b>699</b> |
|   | K. Y. Ann, J. P. Hwang, S-H. Kim and I.L. Jang   |            |
| 79  | <b>Measuring the coefficient of thermal expansion of cement paste at early age</b>   | <b>707</b> |
|   | Roman Loser, Carmelo Di Bella, Beat Münch and Pietro Lura  |            |
| 80  | <b>Side effect of electrochemical desalination in concrete structures</b>  | <b>715</b> |
|   | Y. Tanaka, and Y. Hayamizu   |            |
| 81  | <b>Experimental study on mechanical properties of mortars at ultra low temperature</b>   | <b>723</b> |
|   | Zhengwu Jiang and Xiongying Li   |            |
| 82  | <b>Experimental study to estimate thermal stress caused by heat of cement hydration in massive concrete structures</b>   | <b>733</b> |
|   | Toshiaki Mizobuchi, Yasuro Maki, Ryosuke Inoue   |            |
| 83  | <b>The effect of slag on durability of lightweight concrete</b>  | <b>741</b> |
|   | Hongzhi Cui, T. Y. Lo and Feng Xing  |            |
| 84  | <b>Sintered board materials made from recycled glass in building industry</b>  | <b>749</b> |
|   | T. Melichar and J. Bydžovský   |            |
| 85  | <b>Effect of material constituents on fresh and mechanical properties of SCC designated for precast, prestressed applications</b>  | <b>757</b> |
|   | Wujian Long, Kamal Henri Khayat and Feng Xing  |            |
| 86  | <b>Tensile strength of nano-fibre reinforced concrete repair material</b>  | <b>765</b> |
|   | P. van Tonder, D. Kruger and M. Shihambi   |            |

|    |   |     |
|----|---|-----|
| 87 | <b>On improving the infrastructure service life using ECC to mitigate rebar corrosion</b><br>Mo Li, Ravi Ranade, Lili Kan and Victor C. Li  | 773 |
| 88 | <b>Numerical simulation of the behaviour of high performance fibre reinforced mortar with conventional reinforcing bars in concentric tension</b><br>Ryosuke Shionaga, Withit Pansuk, Yasuhiko Sato and Joost C. Walraven | 783 |
| 89 | <b>Microstructural analysis and global performance of mortar with tailored nano aggregates</b><br>Jie Hu, D. A. Koleva and K. van Breugel   | 791 |
| 90 | <b>Effect of temperature on the healing rates of asphalt mastic</b><br>Alvaro García  | 799 |
| 91 | <b>Review of recent progress in structural applications of ductile fiber reinforced cementitious composites</b><br>Mohamed Maalej   | 807 |
| 92 | <b>Influencing factors of air-void characteristics</b><br>Yan Shang, Changwen Miao, Jiaping Liu and Qianping Ran  | 817 |
| 93 | <b>Self-healing of Cracks in Bacterial Concrete</b><br>Virginie Wiktor and Henk M. Jonkers  | 825 |
| 94 | <b>Bacteria mediated remediation of concrete structures</b><br>Henk M. Jonkers and Arjan Thijssen   | 833 |
| 95 | <b>Improving Service life of Concrete by using RHA</b><br>Nguyen van Tuan, Guang Ye, Klaas van Breugel and Bui Danh Dai   | 841 |
| 96 | <b>Super absorbent polymers to simulate self healing in ECC</b><br>J. S. Kim and E. Schlangen   | 849 |
| 97 | <b>Effect of fly ash on effective alkali in matrix and at different depth of reactive aggregates</b><br>Chunxiang Qian, Wen Xu and Yuan Zhuang  | 859 |
| 98 | <b>Water Security Problems of Shanghai Expo 2010 and Countermeasures</b><br>Shuguang Liu, Haoyun Wu, Cuiping Kuang and Guihui Zhong   | 867 |
| 99 | <b>Chloride Penetration into the cracked tensile zone of reinforced concrete structures before and after water repellent treatment</b><br>Fuxiang Jiang, Folker H. Wittmann, Tiejun Zhao, Furu Li and Song Gao            | 875 |

- 100 **Determination of activation energy of cement hydration by electrical resistivity measurement** 883  
Xiaosheng Wei and Lianzhen Xiao

**THEME 7: TRANSITION FROM EARLY-AGE PROPERTIES TO SERVICEABILITY**

- 101 **On the variability of temperature fields in massive concrete structures at early age** 993  
J. M. Torrenti and L. Buffo-Lacarriere
- 102 **Early age properties of green concrete containing high mineral additions** 901  
Muhammad Irfan Ahmad Khokhar and Stéphanie Staquet
- 103 **Autogenous deformation of slag cement concretes under free condition at early age** 911  
A. Darquennes , S. Staquet and B. Espion
- 104 **The Effect of curing on the microstructure and chloride penetration resistance of concrete** 919  
W. Jeannette Bouwmeester – van den Bos, Rob B. Polder and Federica Lollini

**THEME 8: INSPECTION, ASSESSMENT AND MONITORING**

- 105 **Service states of an operating tunnel: view from a structural engineer** 929  
Yong Yuan
- 106 **Structural and durability assessment of the bridges across the low-rhine** 937  
Michel M.R. Boutz, Rob P.H. Vergoossen and Cor Kuilboer
- 107 **Benchmark test on load-carrying behavior of RC member with reinforcing steel corroded by using common experimental procedure** 945  
Takashi Yamamoto, Michiaki Oyado, Yasuhiro Mikata and Takumi Shimomura
- 108 **Investigation on variability of cross sectional area of electrically corroded reinforcing bar** 953  
M. Oyado, T. Yamamoto and T. Shimomura
- 109 **Risk inventory serviceability hydraulic structures in the Netherlands** 961  
Dirk Jan Kiljan and Hans Janssen



|     |  |      |
|-----|--|------|
| 110 | <b>The assessment method of vertical cracks influence on cooling towers shell</b><br>Zdeněk Šnirch, Amos Dufka and Martin Lukavec                                | 969  |
| 111 | <b>Investigation of dynamic and static elastic modulus based on in-situ concrete cores</b><br>SangHun Han and WooSun Park  | 977  |
| 112 | <b>Design verification using corrosion monitoring systems indicating time-to-corrosion</b><br>Michael Raupach and Joost Gulikers                                 | 985  |
| 113 | <b>A laboratory and on-site test method for air permeability of concrete</b><br>P. Paulini   | 995  |
| 114 | <b>The use of NDT methods in the evaluation of structures</b><br>Michael Grantham  | 1103 |
| 115 | <b>GPR an effective tool inside the inspectors' tool box</b><br>Sherif A. Yehia  | 1013 |
| 116 | <b>NMR inspection on concrete-coatings</b><br>Jeanette Orłowsky  | 1019 |
| 117 | <b>Error effect analysis in shape measurement of bridge pier model by laser transducer</b><br>Xianfeng Wang, Feng Xing, Yoshiaki Goto and Makoto Obata           | 1027 |
| 118 | <b>Fracture behavior of concrete pavement material in bending under monotonic and cyclic loading</b><br>Erik Denneman, R. Wu and John Harvey                     | 1035 |
| 119 | <b>Study of methods of testing used to prevent the RAA</b><br>C.F.C. Silva , E.C.B. Monteiro and A.D. Gusmão   | 1043 |
| 120 | <b>Appearance defects on lining structure of tunnel</b><br>Rulu Wang, Shuai Fan and Yong Yuan  | 1051 |
| 121 | <b>Classifying inspection of tunnel structures</b><br>Yuan Yong and Xian Liu   | 1059 |
| 122 | <b>The challenge of a perpetual service life: conservation of concrete heritage</b><br>Herdis A. Heinemann, Rob P.J. van Hees, Timo G. Nijl and Hielkje Zijlstra | 1067 |



**THEME 9: MAINTENANCE, REPAIR AND STRENGTHENING STRATEGIES**

- 123 **Experimental analysis of the durability of RC beams strengthened by FRP laminates under the penetration of chloride ions** 1077  
A. A. Ramezani pour and A. Gharachorlou
- 124 **The use of polymer cement mortar in the rehabilitation of service stairs in Lisbon, Portugal** 1085  
M. S. Ribeiro
- 125 **Preliminary study of Electrochemical lithium migration into cementitious mortar** 1093  
Jose Pacheco and Rob B. Polder
- 126 **The muiderbrug - extending the life time by strengthening the structure** 1011  
Hans Dorsman
- 127 **Anticipation of degradation in concrete buildings' facade and balcony structures** 1111  
A. Köliö and J. Lahdensivu
- 128 **Durability and service life of concrete repairs in the presence of cracks** 1121  
Jian Zhou, Guang Ye and Klaas van Breugel
- 129 **Performance analysis and causes of concrete pavements imperfections (CPI): a case study** 1131  
Muhieddin S. Tughar
- 130 **Stray current increased by underground space extension and underground space structure service life** 1139  
Yongjing Tang and Koujun Wei
- 131 **Research for durability of common used hinged joints in hollow slab bridge** 1149  
Pei Li, Jun Wei, Rongzhen Dong, Zhiwu Yu, Yue Xu and Xia Ban
- 132 **Bridge performance asset management** 1163  
E.A.B. Koenders, J. Kok, C. Bosma and B. Obladen
- 133 **Verify Operating Conditions of Tunnel Structure** 1171  
Yang Chi, Yong Yuan and Xian Liu

**THEME 10: ASSET MANAGEMENT: ECONOMICALLY EFFICIENT  
EXPLOITATION OF INFRASTRUCTURE; CONTROL OF RISK OF SAFETY  
AND DURABILITY; CHANGING DEMANDS OF SOCIETY**

- |     |  |             |
|-----|--|-------------|
| 134 | <b>Towards a new business model for asset management in water sector</b><br>H. Ehrenburg and J.B.G. Bruinsma   | <b>1181</b> |
| 135 | <b>System risk management for the maintenance of infrastructure facilities</b><br>Hans de Jonge, Marc Lasne and Linda Docters van Leeuwen            | <b>1191</b> |
| 136 | <b>Asset management of road infrastructure in the Netherlands: a framework<br/>for an integrated life cycle model</b><br>Rupin Soti and Harry Habing | <b>1199</b> |
| 137 | <b>Infrastructural transport networks value asset management</b><br>A.R.M. Wolfert and E.A.B. Koenders   | <b>1209</b> |