# CACRCS DAYS 2023

**4th Edition**

www.cte-eventi.com

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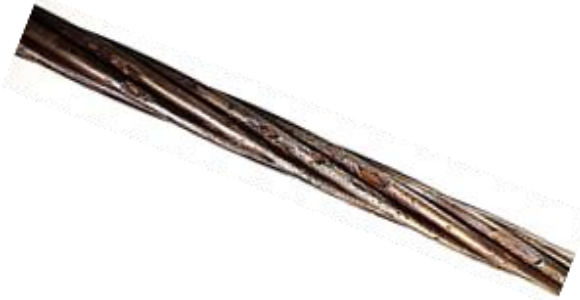
13th -15th September 2023

*Venue*: University of Parma, Parma, Italy

## Capacity Assessment of Corroded Reinforced Concrete Structures: from Research to Daily Engineering Evaluation



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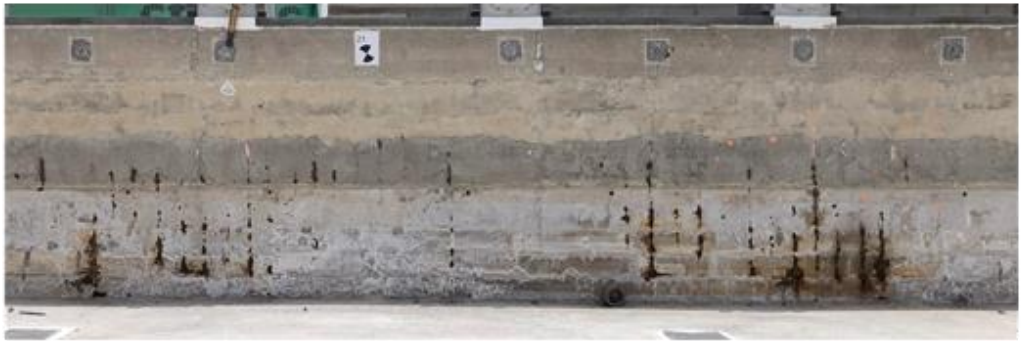

**4th ANNOUNCEMENT**

Collegio dei Tecnici della Industrializzazione Edilizia

Associazione Italiana Calcestruzzo Armato Precompresso

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# CACRCS DAYS 2023

## *Capacity Assessment of Corroded Reinforced Concrete Structures: from Research to Daily Engineering Evaluation*

13 -15 September 2023

Venue: University of Parma, Parma, Italy
Auditorium S. Elisabetta
Via Parco area delle Scienze, 95 Parma

4th Edition

## PROGRAM

**WITH THE SUPPORT OF**

CLUST_ER BUILD Edilizia e Costruzioni

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## CONTACTS

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Secretary of the event
E-mail: cacrcs@cte-eventi.com

For more information about the event, please visit the internet website
www.cte-eventi.com/cacrcs/
www.cte-it.org

## TOPIC

CACRCS DAYS 2023 edition will focus on practical engineering applications achieved with consolidated research on corroded reinforced concrete and prestressed concrete structures. The main line of the workshop starts from the analysis of material characteristics, moves to the evaluation of the structural behaviour of corroded members, ending with the prediction of the remaining service life of corroded structures. Case studies of assessment of deteriorated structures are of great interest.

Since 2019 the Workshop has seen the participation of experts in the capacity assessment of corroded reinforced concrete structures. The workshop is open to young researchers, experts and practitioners.

In the CACRCS DAYS context, professional engineers can find a community of people able to assist in practical problem solving and in decision-making procedures for the assessment and maintenance of existing structures. Moreover, a Round Table will be scheduled to stimulate the debate on the analysis of available codes and guidelines for the evaluation of existing structures and on the gaps and future research fields identified on the basis of the contributions submitted to this workshop.

## ORGANIZING COMMITTEE

Coordinators: **Beatrice Belletti (University of Parma), Dario Coronelli (Politecnico di Milano)**
Anna Magri (*CTE)*
David Fernández-Ordóñez (f*ib Secretary General)*
Luc Taerwe (*Ghent University, Editor-in-Chief Structural Concrete Journal)*
Lorenzo Franceschini, Simone Ravasini, Marco Carlo Rampini, Biagio Calcavecchia, Marta Del Zoppo (*fib Italy Young Members Group)*
Benoit Bissonnette *(CRIB - Laval University)*, Claude Rospars (*University Gustave Eiffel*), Carmen Andrade (*CIMNE - UPC*), Walter Kaufmann *(ETH Zurich)*, Jesus Rodriguez (*UPM*), Joost Walraven (*Em. TU Delft*), Takumi Shimomura (*Nagaoka University of Technology*)

## SCIENTIFIC COMMITTEE

Lucas Adelaide (*University Gustave Eiffel*), Fabio Bolzoni (*Politecnico di Milano*), Joan Ramon Casas (*UPC*), Robby Caspeele *(Ghent University)*, Antoni Cladera *(Universitat de les Illes Balears)*, Edoardo Cosenza *(University of Naples Federico II)*, Pieter Desnerck *(University of Cambridge)*, Marco di Prisco *(Politecnico di Milano*), Michael Fardis *(University of Patras)*, Rade Hajdin *(Infrastructure Management Consultants, Switzerland: IABSE)*, Chris Hendy *(Atkins, University of Cambridge)*, Christopher Higgins *(Oregon State University)*, Raja Rizwan Hussain (*King Saud University*), Stefania Imperatore *("Niccolò Cusano" University of Rome)*, Akio Kasuga *(Sumitomo Mitsui Construction)*, Federica Lollini *(Politecnico di Milano)*, Fausto Minelli (University of Brescia), Boumediene Nedjar (*University Gustave Eiffel*), Camillo Nuti *(Università degli Studi Roma Tre)*, Beatriz Martin- Pérez *(University of Ottawa)*, Antonino Recupero *(University of Messina)*, Peter Tanner *(IETcc-CSIC)*, Francesco Tondolo (*Politecnico di Torino*), (Tamon Ueda *(Shenzhen University),* Weiping Zhang (*Tongji University*)

## CALL FOR ABSTRACTS

The CACRCS DAYS welcome all contributions related to the behaviour of reinforced concrete, fibre reinforced concrete and prestressed concrete structures damaged by corrosion, with both numerical and experimental approaches, and including some recommendations for the daily engineering evaluation of corroded structures.
*You can submit abstracts and papers to the website of the CACRCS event,* www.cte-eventi.com/cacrcs/.

## PAPER SUBMISSION

Authors willing to present their work at the CACRCS DAYS 2023 are invited to kindly submit an abstract in accordance with the sessions of the workshop.
Extended abstracts (4 pages long) will be reviewed and will be included in the Proceedings of the Workshop if they will be accepted. The Authors of selected extended abstracts will be invited to submit a full manuscript to a Special Issue of Structural Concrete. The submission of full manuscripts will undergo the usual peer-review process of Structural Concrete.
In order to promote and facilitate the transfer of knowledge from Research to Daily Engineering Evaluation, the template for extended abstracts contains a paragraph dedicated to a description of the use of the presented results in engineering applications. The template for abstracts and extended abstracts is available on the CACRCS website (www.cte-eventi.com/cacrcs/).

## IMPORTANT DATES

| | |
|---|---|
| abstract submission | 28.11.2022 |
| abstract acceptance notification | 15.01.2023 |
| extended abstract submission | 28.02.2023 |
| extended abstract acceptance | 30.04.2023 |
| **final extended abstract submission** | **30.06.2023** |
| **author's registration** | **30.06.2023** |
| full manuscript submission for a Special Issue of Structural Concrete | 28.02.2024 |

**SPONSORS**

Companies interested in supporting the event can contact us by e-mail to cacrcs@cte-eventi.com.

SPONSOR FEES **€1500+VAT** including

- Conference registration of 1 person.
- Registration of additional attendees at reduced fee of € **300 each**.
- Quoting the logo (in alphabetic order for each sponsoring) on program, and all advertising documents delivered by the conference organizing committee.

**AWARDS**

Awards will be conferred to the most outstanding paper presented by a *fib* young member and to the most excellent paper presented in the workshop.

**REGISTRATION FEES**

are VAT exempted and include participation to the workshop, gala dinner and electronic proceedings.

**Standard fee** **€600,00**
(including CTE membership)
**Reduced fee for Young People** **€530,00**
(valid only for people<30 year and including CTE membership)
**Reduced fee for CTE fib Member** **€500,00**
(valid only for CTE, *fib,* Member 2023)

You will register directly from the CACRCS website (www.cte-eventi.com/cacrcs/) and make the payment by credit card or bank transfer to CTE.

For Bank Transfer please indicate
Name Surname – CACRCS 2023
CTE – Bank Intesa San Paolo
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It is necessary to register **no later than June 30, 2023.**

**PROFESSIONAL CREDITS - CFP**

3+3+3 CFP will be requested to CNI only to Italian Engineering

**PRELIMINARY PROGRAM**

Special sessions are organised during the workshop. Authors are invited to kindly select the session at which they will present their papers. Each session will include both research and engineering applications focussing on what is needed for the evaluation of corroded structures.
CACRCS DAYS 2023 includes a Round table to promote discussions.
The workshop offers didactic material for engineers, practitioners, scientists, concrete technologists, researchers, and academics to further knowledge about corrosion of reinforced concrete structures.

# Wednesday 13 September

8:30 (*CET) OPENING OF THE WORKSHOP
*Centre European Time

## Welcome & Introduction

8:45 **B. Belletti, D. Coronelli**, Event Coordinators
9.00 **Fornari R.**, Vice Rector with responsibility for Research – University of Parma
9:15 **Enrico Nusiner**, CTE President
9:30 **David Fernández-Ordóñez**, *fib* Secretary General
9:45 **Luc Taerwe**, Editor-in-Chief of Structural Concrete

OPENING KEY-NOTE LECTURES

10:00 **Rodríguez J.**, UPM, Chairman of the Spanish Mirror Group Eurocode 2, Spain
*New version of Eurocode 2: what is covered for the corroded concrete structures and how to be enlarged for an appropriate structural evaluation*

10:30 **Gennari Santori A.**, ANAS S.p.a. - Centro Sperimentale Stradale di Cesano, Italy
*Special inspections on bridge decks with post-tensioned concrete elements*

*11:00-11:30 Coffee Break*

## A1) Derivation of reliable material models for the analysis of corroded structures

KEY-NOTE LECTURE

11:30 **Verstrynge E.*, Martens C., Caspeele R.**, *KU Leuven University, Belgium
*Experimental datasets and model uncertainty of empirical relations for rebar corrosion assessment*

PRESENTED PAPERS

12:00 **Rebolledo N., Torres J.E., Silva A., Sanchez J.**
*Monitoring of reinforced concrete durability: weather effect*

12:15 **Cassiani J.D., Valcacel J.M.L., Kraenkel T., Gehlen C., Keßler S.**
*Challenges of stochastic assessment of concrete degradation due to chloride-induced corrosion: the importance of the corrosion rate*

12:30 **Proverbio E., Scionti G., Calabrese L.**
*Issues in damage severity assessment by Acoustic Emission technique in highly emissive reinforced concrete beams under cyclic loading*

12:45 **Russo N., Gastaldi M., Lollini F.**
*Effect of cracks on corrosion propagation of carbonated reinforced concrete*

*13:00-14:00 LUNCH*

KEY-NOTE LECTURE

14:00 **Bouteiller V.*, Chaussadent T., Adelaide L., Martin R.P., Chauveau E., Mai-Nhu J., Marie-Victoire E., Bouichou M., Turcry P., Cussigh F., Chanut S.**
*Université Gustave Eiffel, France
*Corrosion of reinforced concrete: results obtained from accelerated tests and from natural environments*

PRESENTED PAPERS

14:30 **Freddi F., Mingazzi L.**
*A multi-physics predictive model for corrosion in concrete*

14:45 **Alrazak M. A., Benedetti A.**
*Experimental correlation of the concrete resistivity with damage level of reinforced concrete beams*

15:00 **van de Velde M., Vandecruys E., Verstrynge E., Reynders E., Lombaert G.**
*Experimental investigation of the effects of corrosion damage on the modal characteristics of reinforced concrete beams*

## A2) Models for deteriorated materials: constitutive relationships to be implemented in structural models

KEY-NOTE LECTURES

15:15 **Tanaka Y.*, Shimomura T.**, *Kanazawa Institute of Technology, Japan
*An experimental and numerical study on remaining strength of corroded prestressed concrete girder*

PRESENTED PAPERS

15:45 **Franceschini L., Ravasini S., Belletti B.**
*SCPS-model Validation Based on a Database of Naturally Corroded Prestressing Strands*

16:00 **Maura J.M., Murcia-Delso J., Ribas C., Buades J.M., Ruiz-Pinilla J., Cladera A.**
*Bond strength deterioration between corroded steel and concrete: an analysis using AI techniques*

16:15 **Coronelli D., Lundgren K., Zandi K.**
*Evaluation of anchorage capacity and bond models in Model Code 2020*

*16:30-17:00 Coffee Break*

KEY-NOTE LECTURES

17:00 **Meda A.*, Rinaldi Z., Saetta A.**, *University Tor Vergata
*Design relationships for corroded steel bars*

PRESENTED PAPERS

17:30 **Andrade C., Munoz J.J., Bernabeu A., Gonzalez A.**
*Calculation of residual mechanical factors based in the residual uniform area of corroded bars of an old building*

17:45 **Caprili S., Mattei F., Salvatore W., Agostini M.**
*Analysis of corrosion effects on strands of prestressed concrete bridges with post-tensioned cables*

18:00 **Calcavecchia B., Belletti B., Franceschini L., Ravasini S., Rinaldi Z., Di Carlo F., Moialoni F.**
*Numerical and analytical approaches to evaluate the load bearing capacity of RC dapped-end-beams subjected to corrosion*

18:15 **Haefliger S., Thoma K., Kaufmann W.**
*Influence of the pit geometry on the load-deformation behaviour of locally corroded reinforcing bars*

18:30 **Coronelli D., Fernandez I.**
*Models of corroded reinforcements cross-section for resistance verification*

18:45 **Imperatore S., Ferracuti B.**
*Mechanical behaviour of naturally corroded steel reinforcement: a state of art*

19:00 **Prieto M., Turner P., Andrade C.**
*Experimental study of bond strength and measurement of steel strains along bonded length of corroded steel bars with FBG sensors*

19:15 **Koulouris K., Basdeki M., Apostolopoulos C.**
*Degradation aspects in the assessment of corroded Reinforced Concrete elements*

19:30 (*CET) CLOSING OF THE 1st DAY

# Thursday 14 September

8:30 (*CET) OPENING OF THE 2nd DAY

## B1) Analytical models of the capacity assessment of corroded members

KEY-NOTE LECTURES

8:30 **Ye Z., Zhang W.*, Liu X., Li C.**, *Tongji University, China
*Assessment of fatigue behaviour of corroded prestressed concrete beams*

PRESENTED PAPERS

9:00 **Ferracuti B., Imperatore S., Lignola G.P.**
*Corrosion effect on flexural behaviour of RC members*

9:15 **Berto L., Di Carlo F., Meda A., Rinaldi Z., Saetta A., Stella A., Talledo D.A.**
*Experimental and numerical study for the analysis of structural performance in flexure of corroded reinforced concrete beams*

9:30 **Di Stefano N., Minelli F.**
*Experimental and numerical study on artificially corroded reinforced concrete beams*

9:45 **Castelli S., Belleri A., Persico M., Rota L., Riva P., Azzola P., Cardaci A.**
*Preliminary structural assessment of a corroded RC beam in a Maillart bridge*

10:00 **Haefliger S., Kaufmann W.**
*Modelling the load-deformation behaviour of locally corroded cantilever retaining walls*

10:15 **Giriraju R., Sengupta A.K., Pillai R.G.**
*Ductile-to-brittle transition of Flexural behaviour of pre-tensioned concrete girders subjected to chloride induced corrosion of strands*

10:30 **Belletti B., Caspeele R., Botte W., Franceschini L., Ravasini S., Sandrini S.**
*Probabilistic assessment of the moment-curvature response of PC beams subjected to corrosion*

10:45 **Barbagallo F., Bosco M., Licciardello E., Marino E.M., Rossi P.P.**
*Impact of corrosion on seismic fragility of existing buildings with RC framed structures*

*11:00-11:20 Coffee Break*

KEY-NOTE LECTURES

11:20 **Kaufmann W.**, ETH, Switzerland
*Capturing the global structural impact of local corrosion*

PRESENTED PAPERS

11:45 **De Domenico D., Mazzeo M., Messina M., Recupero A.**
*Safety assessment of corroded PC half-joint bridges through an advanced mechanochemical finite element model*

12:00 **Di Carlo F., Isabella P., Moialoni F., Meda A., Rinaldi Z.**
*Influence of corrosion on the experimental behaviour of corroded Gerber half-joints*

12:15 **Granata M.F., La Mendola L., Messina D., Recupero A.**
*Effects of transverse beams on the behaviour of damaged Gerber saddles of bridge girders*

12:30 **Di Stefano N., Minelli F.**
*Experimental and numerical study on naturally corroded r.c. beams*

12:45 **Amini S. N., Raiput A. S.**
*Experimental and numerical evaluation of corrosion influence on seismic response of RC columns*

*13:00-13:45 LUNCH*

KEY-NOTE LECTURES

13:45 **Francois R.*, El-Fatmi R., Garcia D., Ringot E.**, *LMDC, INSA, UPS, Université de Toulouse, France,
*Mechanical re-calculation of reinforced concrete structures taking into account load-redistribution due to both load-induced cracks and corrosion of reinforcements*

PRESENTED PAPERS

14:10 **Terao S., Arai T., Toishi K., Tanaka Y.**
*Loading test of long span prestressed concrete bridge degraded by salt attack*

14:25 **Belluco S., Pelligrino C., Faleschini F.**
*Challenges in bond modelling of corroded pre-tensioned concrete structures*

14:40 **Belletti B., Ferretti D., Pagliari F., Sirico A.**
*Combined effect of corrosion and defectiveness on the bond behaviour of post tensioned prestressing steel strands*

14:55 **Casprini E., Passoni C., Marini A., Bartoli G.**
*Considerations on corrosion patterns in naturally corroded bars*

15:10 **Marcucci A., Martignoni F., Nicolò M., Ferrara L.**
*Influence of steel and concrete degradation mechanisms on the seismic behaviour of reinforced concrete structures through a durability-based design*

## B2) NLFE models for the capacity assessment of corroded members

KEY-NOTE LECTURES

15:25 **Martín-Pérez B.**, University of Ottawa, Canada
*Numerical modelling of structural concrete members subjected to reinforcement corrosion*

15:50 **Ožbolt J.**, University of Stuttgart, Germany
*Corrosion of steel reinforcement in concrete: 3D FE modelling & on situ structural measurements*

*16:20-16:40 Coffee Break*

16:40 **Nakamura H.**, Nagoya University, Japan
*Advanced nonlinear analysis model, Rigid Body Spring method - Simulation from corrosion crack to bond and structural performance with corroded rebar*

17:05 **Allaix D.**, TNO, The Netherlands
*Data-informed and NLFEM-based assessment of concrete structures with corroded reinforcement: challenges and perspective for future standardisation*

PRESENTED PAPERS

17:30 **Anghileri M., Fabio Biondini**
*Validation of Nonlinear Finite Element Analysis of RC/PC Corroded Structures based on Experimental Results*

17:45 **Messina D., Recupero A., Rossi P.P., Spinella N.**
*Modeling of Corroded-affected-shear-critical reinforced concrete beams*

18:00 **Reckinger N., Haefliger S., Thoma K., Kaufmann W.**
*Non-linear finite element analyses to study the effects of pitting corrosion on reinforced concrete plates and shells*

18:15 **Bernardini D., Ruta D., Di Re P., Cardone D., Paolone A.**
*Fiber-based modelling of reinforced concrete bridges piers subjected to spatially non-uniform corrosion patters*

18:30 **Galano S., Ravasini S., Franceschini L., Losanno D., Belletti B., Parisi F., Aida Safabakhsh**
*Numerical simulations of a benchmark reduced-scale post-tensioned concrete bridge girder with corroded strands*

18:45 **Abou-Eid J., Adelaide L., Bouteiller V., Yvonnet J.**
*Modeling, numerical simulation and measurements of cracking in the corrosion process of the steel/concrete interface*

19:00 (*CET) CLOSING OF THE 2st DAY

**19:15 GALA DINNER**
(Antica Corte Pallavicina, strada del Palazzo Due Torri 3, Polesine Parmense, Parma, 43016, Italia)

# Friday 15 September

8:30 (*CET) OPENING OF THE 3rd DAY

## C1) Long-term behaviour of corroded concrete structures and determination of the residual service life

KEY-NOTE LECTURES

8:30 **Kessler S.**, Helmut-Schmidt-University, Germany
*Reliability of corrosion detection and its effect on service life prediction*

9:00 **Frangopol D. M. *, Akiyama M.**, *Lehigh University, Pennsylvania, USA,
*Life-cycle performance assessment of corroded RC structures using machine learning, experimental evidence, probabilistic analysis and finite element method*

PRESENTED PAPERS

9:30 **Leporace-Guimil B., Conforti A., Plizzari G.**
*Residual capacity of fiber-reinforced concrete elements exposed to chloride-rich environment*

9:45 **Alegre V., Casas J.R., Comellas J.**
*Residual service life of a deteriorated retaining wall near the Terrassa railway station based on evidence*

10:00 **Zani G., Rampini M.C., Russo N., Lollini F., di Prisco M.**
*Effect of the environmental exposure on the behaviour of cement-based multi-layered roof elements*

10:15 **Lenticchia E., Matteini I., Sorrentino G., Ceravolo R., Tondolo F.**
*Experimental study on ferrocement specimens subjected to corrosive environment*

*10:30-11:00 Coffee Break*

11:00 **Plaza P., Sirico A., Palii O., Belletti B., Bernardi P., Medina C., Sanchez J.**
*Chloride migration for concrete containing recycled aggregate and supplementary cementitious material*

11:15 **Frontera A., Cladera A., Ruiz-Pinilla J., Ribas C.**
*Time-dependent shear strength of RC beams under chloride-induced corrosion*

11:30 **Gino D., Miceli E., Amendola G., Castaldo P., Mori M., Mariscotti M., Garozzo M., Deiana M., Magri B., Giordano L., Mancini G.**
*Experimental investigation of ultimate behaviour of a RC bridge beam after 60 years of working life*

11:45 **Holý M., Mezera A., Čítek D., Řeháček S., Kolisko J., Ryjacek P.**
*Prestressed railways bridges in the Czech Republic- types and failures*

12:00 **Tawil D., Martin-Perez B., Sanchez L.F.M., Noel M.**
*Detailed visual inspection of grouted post-tensioning tendons embedded in concrete deck slabs of a decommissioned bridge*

12:15 **Rehacek S., Citek D., Holy M., Krystov M., Citek A.**
*Evaluation of the condition of prefabricated pretensioned prestressed beam forming the load bearing structure of bridges after about 60 years of use*

12:30 **Proverbio E., Recupero A., Giglio M., Messina D.**
*Issues in estimating corrosion rate of steel wires for remaining service life prediction in post-tensioned concrete structures*

12:45 **Contento A., Aloisio A., Xue J., Quaranta G., Brisighella B., Gardoni P.**
*Effects of chloride-induced corrosion on post-tensioned integral abutment bridges*

*13:00-14:00 LUNCH*

## C2) Upgrading of deteriorated structures by reactive and proactive interventions

KEY-NOTE LECTURES

14:00 **Shimomura T.**, Nagaoka University of Technology, Japan
*Research and practice in Japan on evaluation of performance of existing concrete structures before and after intervention*

14:30 **Biondini F.*, Ghosn M.,** *Politecnico di Milano, Italy
*Effect of Climate Change on Life-Cycle Performance, Safety, Reliability, and Risk of Structures and Infrastructure Systems: A SEI/ASCE Project*

PRESENTED PAPERS

15:00 **Quaranta G., Giaccu G.F, Briseghella B., Nuti C.**
*Probabilistic analysis of the corrosion hazard for reinforced concrete bridges exposed to marine atmosphere*

15:15 **Tawil D., Martin-Perez B., Sanchez L.F.M., Noel M.**
*Current strengths and limitations of non-destructive techniques for the corrosion assessment of post-tensioned concrete*

15:30 **Bolzoni F., Brenna A., Beretta S., Diamanti M.V., Ormellese M., Pedeferri M.P.**
*Long term performance of corrosion inhibitors in concrete*

15:45 **Messina D., Recupero A., Rossi P.P., Spinella N.**
*Experimental application of italian guidelines for the safety evaluation of existing bridges*

16.00 **Becerra-Mosquera J., Carro-López d., Herrador-Barrios M.F**.
*Evaluation of different bridge interventions and the effect in the investment/life cycle ratio*

16.15 **Tondolo F., Biondini F.**
*Bridge|50 research project: an overview*

*16:30-17:00 Coffee Break*

## Round table on identifying the technical gaps for the structural evaluation of corroded concrete structures for future guidelines and code on short and long-term assessment of corroded structures

17:00 CHAIR: **Walraven J.**, Em. TU Delft

Since the main objective of this workshop is to move from research to daily engineering evaluation, this final Round Table aims to exchange some views and comments on the pending technical gaps for the structural evaluation of corroded concrete structures, in spite of the contributions to this workshop, in order to promote some guidelines and codes.

## CLOSING CEREMONY

18:00 (*CET)

- AWARDS
- Conclusion of the Workshop with Beatrice Belletti and Dario Coronelli

18:30 (*CET) CLOSING OF THE WORKSHOP
*Centre European Time