



# CONCRETE SOLUTIONS 2022

8th INTERNATIONAL CONFERENCE ON CONCRETE REPAIR  
DURABILITY AND TECHNOLOGY



Hilton Leeds City Hotel, UK  
11<sup>th</sup> to 13<sup>th</sup> July 2022



# CONCRETE SOLUTIONS SINCE 2003

*2003 SAINT-MALO (FRANCE)*

*2006 SAINT-MALO (FRANCE)*

*2009 PADUA (ITALY)*

*2011 DRESDEN (GERMANY)*

*2014 BELFAST (NORTHERN  
IRELAND)*

*2016 THESSALONIKI (GREECE)*

*2019 CLUJ-NAPOCA (ROMANIA)*

*2022 LEEDS (UNITED KINGDOM)*



Institute of  
Concrete Technology

The Proceedings of all conferences are available either from Concrete Solutions or the Publisher  
Please enquire if interested.

## SPONSORS

***CORRPRE***  
Special Anodes Manufacturing



**Germann Instruments**

## Introduction

The Eighth International Conference on Concrete Repair, Durability and Technology (ICCR2022) was held in Leeds in the United Kingdom, from the 11<sup>th</sup> to the 13<sup>th</sup> July 2022. The Conference was the latest in a sequence of ICCR International Conferences (St. Malo, 2003 and 2006; Padova, 2009; Dresden 2011; Belfast 2014; Thessaloniki 2016 and Cluj-Napoca, 2019). The organization was a collaborative venture between GR Technologie Ltd (Concrete Solutions) Leeds University and Mr Raman Mangabhai (Past President of the Institute of Concrete Technology).

The estimated cost to repair reinforced concrete structures has been said to be some €175 per square meter of exposed surface. In the United States alone, the annual direct cost of corrosion in highway bridges alone is roughly €7.3 billion, including maintenance, repair, replacement, and the cost of capital. Indirect costs, including traffic delays and lost productivity, may run 10 times that number.

But corrosion is more than an economic issue. In June 1983, a 100-foot section dropped out of the Mianus River Bridge in Greenwich, Connecticut, U.S.A., killing three motorists and critically injuring three others. The steel pins that joined sections of the bridge had decayed. In May 2000, in Concord, North Carolina, U.S.A., more than 100 people were injured when steel strands corroded in a pre-stressed concrete pedestrian bridge and the structure collapsed onto the highway below. In 2006, The De La Concorde Overpass near Montreal collapsed. The collapsed section crushed two vehicles under it, killing five people and seriously injuring six others who went over the edge while travelling on the overpass. More recently in Italy in August 2018, a partial collapse of the Ponte Morandi Bridge in Genova was blamed on corrosion in the cable stays and killed 43 people who were crossing the bridge at the time. The disaster caused a major political controversy about the poor state of infrastructure in Italy and raised wider questions about the condition of bridges across Europe.

In 2022, Europe is faced with a man-made problem with the war in Ukraine. This has resulted in massive damage to infrastructure, buildings and bridges that will all require assessment and repair or replacement! So, the problems of dealing with maintenance and repair of structures are not just financial, they affect people's lives too!

Concrete Solutions has historically developed a name as a conference that brings together researchers from the Academic world with Engineers and Scientists who are practitioners in the field of concrete repair. These vary from Owners and Specifiers, to Engineers and Technicians, but include Architects and those engaged in preserving historic structures. COVID has had a massive impact on conferences world wide. Despite this, the conference has received excellent support by researchers and practitioners from around the world, with authors being drawn from numerous research and industrial organisations from 17 countries for this 8th Conference. These Proceedings contain papers presented at the conference, classified into a total of 7 themes:

*Case Studies - Assessment*

*Case Studies – Durability*

*Case Studies – Electrochemical Repair*

*Performance Evaluation for Patch Repairs in Historic Structures (PEPS)*

*Concrete and Admixture Technology*

*Durability Performance of Concrete*

*Performance Evaluation*

Only original contributions were considered for inclusion in the conference proceedings and all papers submitted were subjected to a full process of peer review. The review of manuscripts was undertaken by members of the International Scientific Advisory Board and other identified leading experts, acting independently on one or more assigned manuscripts. This invaluable assistance, which has greatly enhanced the quality of the Proceedings, is gratefully acknowledged. The full conference papers are published by MATEC Web of Conferences, a provider of open-access proceedings in Materials Science, Engineering and Chemistry. This was done in order to give the papers better accessibility in the international research and industry communities. This hard copy of the proceedings contains abstracts of all accepted papers, in order to provide an overview on the topics covered and to guide conference participants in selecting technical sessions that are of most interest to them.

Concrete Solutions and Leeds University are pleased to acknowledge the support and sponsorship of the following organisations:-

## **SPONSORS**

Corr Pre Special Anodes Manufacturing  
Germann Instruments

## **INTERNATIONAL SUPPORTERS**

The American Concrete Institute (ACI) – Co Sponsor  
RILEM – Co Sponsor  
Concrete Society UK  
The Institute of Concrete Technology  
INCD URBAN INCERC Romania

Finally, the editors wish to give special thanks to the authors for their efforts at producing and delivering some excellent and thought-provoking papers of a very high standard. We are sure that these Proceedings will be used by many working in this critical field, and that the papers and the discussions at the Conference will form a suitable base for discussion and provide suggestions for future development and research.

## ***Editors***

Michael Grantham  
P.A.M. Basheer  
Raman Mangabhai

## **Scientific Committee and Advisory Board**

Dr Chris Atkins, Mott McDonald, UK  
Dr Atef Badr, MTC, Sultanate of Oman  
Prof. Yun Bai - University College London, UK  
Prof. M. Basheer, University of Leeds, UK  
Dr. Piotr Berkowski, Wroclaw University of Science & Technology, Poland  
Dr. Hans Beushausen, University of Cape Town, S Africa  
Dr Véronique Bouteiller, IFSTTAR, France  
Dr John Broomfield - Corrosion Consultant - UK  
Mr David Corbett—Proceq SA, Switzerland.  
Mr. Richard Day, The Concrete Society, UK  
Prof. Frank Dehn - MFPA Leipzig  
Dr. Ted Donchev - Kingston University, UK  
Mr John Drewett - Concrete Repairs Ltd., UK  
Ass. Prof. Raafat El-Hacha- University of Calgary, Canada  
Prof. Dr. Vyatcheslav R. Falikman, Structural Concrete Association, NIIZHB, Russia  
Prof. Nader Ghafoori, University of Nevada, USA  
Prof. Dr. Chris Goodier - Loughborough University, UK  
Prof. Michael Grantham - Concrete Solutions & Sandberg LLP  
Ass. Prof. Oguz Gunes, Istanbul Technical University, Turkey  
Prof. Peter Hewlett, University of Dundee and the David Ball Group  
Prof. Dr Iqbal Khan, King Saud University, S. Arabia  
Prof. Minoru Kunieda, Nagoya University, Japan  
Dr. Bryan Magee - University of Ulster, Jordanstown, N. Ireland, UK  
Dr. Elisabeth Marie-Victoire Laboratoire de Recherche des Monuments Historique, France  
Mr Raman Mangabhai – Cement and Concrete Science, Wembley, UK  
Prof. Dr. Viktor Mechtcherine - TU Dresden  
Prof. Dr Carlos Jurado Cabañes, Polytechnic University of Madrid and Ingecal Ingenieros S.L. Spain  
Prof. Christophe Lanos - IUT Rennes, France  
Dr. David Law - RMIT University, Australia  
Prof. Dr. Calin GR Mircea - Technical University of Cluj-Napoca Romania  
Dr-Ing Ioan Popenar, ICECON, Romania  
Prof. Rob Polder, RPCP Consultants, Netherlands  
Prof. Peter Robery - Robery Forensics and Leeds University  
Dr Ioannis Sfikas, Jacobs UK Ltd.  
Dr. Ulrich Schneck -Citec GmbH - Dresden  
Dr. Wolfgang Schwarz—Composite Anode Systems GmbH, Austria  
Prof. Kosmas Sideris - Democritus University of Thrace, Greece