NINTH
INTERNATIONAL CONFERENCE ON
CONCRETE PAVEMENTS

The Golden Gate to Tomorrow’s
Concrete Pavements

Organized by:
International Society for Concrete Pavements

August 17-21, 2008
San Francisco, California, USA

Volume 1 of 2
FOREWORD

These are the proceedings for the Ninth International Conference on Concrete Pavements, organized by the International Society for Concrete Pavements (ISCP). This is the ninth in a series of such conferences to bring together experts from all over the world to discuss the state of the art of concrete pavement design, construction, evaluation, performance, and rehabilitation. Additional topics addresses include precast pavements, bases, sealants, joints, and drainage.

The First International Conference on Concrete Pavement Design was held at Purdue University on February 15-17, 1977. The Second International Conference on Concrete Pavement Design was held in Indianapolis, Indiana on April 14-16, 1981. Both of these conferences were planned and organized by Eldon J. Yoder, Professor of Civil Engineering at Purdue University. The Third International Conference, dedicated to his memory and his many contributions to the engineering profession, was held on April 23-25 at Purdue University. The Fourth and Fifth conferences were also held on the Purdue Campus in 1989 and 1993, respectively. The Sixth Conference was held in Indianapolis, Indiana in 1997. The Seventh Conference was held at the Disney Coronado Springs Resort in Orlando, Florida, on September 9-13, 2001. The Eighth Conference was held at Colorado Springs, Colorado. The Ninth Conference was held at San Francisco, California on August 17-21, 2008.

The papers presented in these proceedings were selected through peer review from manuscripts submitted in February 2008. Seventy-two papers were accepted for this conference on the basis of the peer review comments. The papers published in these proceedings have been organized in the same format as that of the general program, as described on page v.

We would like to take this opportunity to thank the authors and the many reviewers who volunteered their time to ensure that the papers that appear in these proceedings are of the highest quality. We wish to thank the members of the conference steering committee and the technical program subcommittee for their tireless efforts in developing the overall conference program and the technical program. We extend special thanks to all of the program cosponsors for their financial support and their guidance in developing the final program. We would like to thank Dr. Neeraj Buch for his assistance with manuscript preparation and coordination of correspondence with the authors and reviewers. Finally, we would like to thank Nona Schaler and her staff at Occasional Events, Inc for all of their efforts in support of planning and organization of the conference.

Neeraj Buch, P.E., Ph.D.
Professor
Michigan State University
East Lansing, MI 48824

Kathleen T. Hall, P.E., Ph.D.
Senior Consultant
Fugro Consultants, Inc.
Mundelein, IL 60060
PROGRAM COMMITTEE MEMBERS

Conference Steering Committee

Jamshid Armaghani, Florida Concrete and Products Association
Kathleen Hall, Conference Co-Chair, and ISCP Vice President - Fugro Consultants, Inc.
Neeraj Buch, Conference Co-Chair, Michigan State University
Jim Grove, Iowa State University
André Jasienski, FEBELCEM
Tom Kazmierowski, Ontario Ministry of Transportation
Mark Snyder, Secretary Treasurer, Consultant
Shiraz D. Tayabji, Past President, Fugro Consultants, Inc.
Sam Tyson, FHWA
George Vorobieff, Head to Head International
Dan Zollinger, President – Texas Transportation Institute

CONFERENCE CO-SPONSORS

The following organizations are official sponsors of the 9th International Conference on Concrete Pavements. The International Society for Concrete Pavements would like to express its gratitude for their financial and technical assistance with this conference.

Federal Highway Administration (US)
American Concrete Pavement Association
ACPA Southwest
CALTRANS
Cement Association of Canada
Concrete and Concrete Institute (South Africa)
Concrete Reinforcing Steel Institute
FEBELCEM (Belgium)
Holcim (US)
Portland Cement Association
University of California Pavement Research Center
Transportation Research Board (US)
INTERNATIONAL SOCIETY FOR CONCRETE PAVEMENTS

Mission- The mission of the society to facilitate the advancement of knowledge and technology related to concrete pavements through education, technology transfer and research at the international level.

The Society will gather and disseminate information for the concrete pavement community. The Society’s efforts will promote technological advancements and competence of its members, leading to improved concrete pavement performance.

Executive Officers

President: Dan Zollinger, Texas Transportation Institute
Vice President: Kathleen Hall, Senior Consultant, Fugro Consultants, Inc., Mundelein IL 60060
Secretary/Treasurer: Mark Snyder, Consultant, Bridgeville, Pennsylvania, USA
Past President: Shiraz Tayabji, Columbia, Maryland, USA

Board of Directors (As of September 1, 2007)

Directors:
Jamshid Armaghani, Florida Concrete and Products Assn. (USA)
Neeraj Buch, Michigan State University (USA)
George Vorobieff, Head to Head International (Australia)
Leif Wathne, American Concrete Pavement Association (USA)
José Balboa University of São Paolo (Brazil)
Anna-Carin Brink, Stewart Scott, International (South Africa)
Jean-Pierre Christory, LROP (France)
Juan Pablo Covarrubias, Consultant (Chile)
Michael I. Darter, Applied Research Associates (USA)
Jim Grove, Iowa State University (USA)
André Jasienski, FEBELCEM (Belgium)
Timothy J. Smith, Cement Association of Canada (Canada)
Jacob Hiller, Michigan Technological Institute (USA)
Bryan Perrie, Cement and Concrete Institute (USA)

Note: In addition to the elected board members, several liaison members from non-US countries regularly attend the board meetings. The Society encourages international liaison membership to the board to ensure that the Society continues to maintain global representation.
<table>
<thead>
<tr>
<th>Time</th>
<th>Sunday</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>August 17</td>
<td>August 18</td>
<td>August 19</td>
<td>August 20</td>
<td>August 21</td>
</tr>
<tr>
<td>7:00 AM</td>
<td>Registration</td>
<td>Registration</td>
<td>Registration</td>
<td>Registration</td>
<td></td>
</tr>
<tr>
<td>7:30 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8:30 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9:30 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:00 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:30 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11:30 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12:30 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:30 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2:30 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3:00 PM</td>
<td>Break</td>
<td>Break</td>
<td>Break</td>
<td>Break</td>
<td></td>
</tr>
<tr>
<td>3:30 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3:30 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5:30 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Session 7a:** Low-Volume Road Design and Performance
- **Session 11a:** Fiber-Reinforced Concrete Pavements
- **Session 15:** Topics in Pavement Materials
- **Session 16:** Thin Concrete Paving
- **Session 17:** Design Methods and Considerations
- **Session 18:** Innovations in CRCP Design and Construction

**Conference Ends 12:30 PM**
Volume I

Session 1: Pavement Research Programs, Initiatives and Policies
Moderator: Amir Hanna, National Cooperative Highway Research Program, USA
Decision Support Model for Road Pavements Based on Whole Lift Costing, Life Cycle Assessment and Multi-Criteria Analysis
Adrian J. van Leest, Steef B. van Hartskamp and Joep P.R. Meijer ................................................1
Precast Concrete Pavements: Current Technology and Future Directions
Shiraz Tayabji, Neeraj Buch and Erwin Kohler .................................................................17
Concrete Pavement – Initiatives in India
R.K. Jain and Ashutosh Gautam .......................................................................................... 37

Session 2: CRCP Design, Practice and International Experiences
Moderator: David Lippert, Illinois Department of Transportation, USA
CRCP on the Ben Schoeman Freeway- No Alternative
Anna-Carin Brink and Kevin Pickard .....................................................................................54
RN61-Mons-Tournai Road-Bury Braffe Section: A Modest Renovation Becoming a Long Life Pavement
Raymond Debroux and André Jasienski ...........................................................................70
Unique Aspects of the Design and Construction of the Bristol Motor Speedway
CRC Pavement
Stephen Swift, D. Zollinger, A. Bhasin, E. Masad and Anol Mukhopadhyay ......................79
Behavior and Performance of Continuously Reinforced Concrete Pavement
Moon C. Won, Seongcheol Choi and Jeonghee Nam .........................................................94

Session 3: M-E Pavement Design Procedures – Evaluation and Comparisons
Moderator: Jeff Uhlmeyer, Washington State Department of Transportation, USA
Evaluation of M-E PDG for Rigid Pavements – Incorporating the State-of-the-Practice in Michigan
Syed Waqar Haider, Neeraj Buch and Karim Chatti ..........................................................111
Prediction of Spalling and Roughness in the Mechanistic-Empirical Pavement Design Guide
Kathleen T. Hall ................................................................................................................134
Effect of the MEPDG Hierarchal Levels on the Predicted Performance of a Jointed Plain Concrete Pavement
Jennifer K. McCracken, Julie M. Vandenbossche and Rania E. Asbahan ............................153
Comparison of Mechanistic-Empirical Thickness Design Methods and Predicted Critical Fatigue Locations
Jacob E. Hiller and Jeffrey R. Roesler ..................................................................................171

Session 4: Pervious Concrete Pavements
Moderator: Denis Thébeau, Québec Ministry of Transportation, USA
Water Pervious Concrete Pavement Blocks: Durable Structures for an Integrated Water Policy
Anne Beeldens and L. Vijverman .........................................................................................189
Experimental Study on Pervious Concrete
Bing Chen, Juanyu Liu and Peng Li .................................................................202

Field Performance Evaluation of Pervious Concrete Pavements in Freeze-Thaw Environments
Norbert Delatte, Daniel Ian Miller and Aleksandar Mrkajic ..................................................212

Design and Construction of a Pervious Concrete Pavement in Ontario, Canada
Chris Raymond, Becca Lane, Maria Bianchin, Stephen Senior and Melissa Titherington ........226

Session 5: Analysis of PCC Pavement Response
Moderator: Johan Silfwerbrand, Swedish Cement and Concrete Research Institute, Sweden
Data Analysis on Residual Stresses Measured in Concrete Beams
Edward H. Guo, Frank Pecht, Lia Ricalde, Donald Barbafallo and Xinkai Li ..........................243
Moisture Warping in Jointed Plain Concrete Pavements
Will Hansen, Ya Wei and Erik Schlangen .............................................................................258
Experimental Analysis of Strains on Welded Wires in Thin Reinforced Concrete Pavement
José T. Balbo and Valeria J.F. Ganassali .................................................................................267

Session 6: Admixtures and Concrete
Moderator: Rico Fung, Cement Association of Canada, Canada
Optimization of Fly Ash and Slag Binder Systems for Pavement Concrete Mixtures in Indiana
Adam Rudy, Jan Olek, Tommy Nantung and Richard M. Newell ...........................................283
Monitoring of Strength Development in Portland Cement Concrete With High Fly-Ash Content at the FAA’s National Airport Pavement Test Facility
Navneet Garg and Lia Ricalde ..............................................................................................300
Identification of Concrete Incompatibilities Using Dynamic Shear Rheometer (DSR)
Sehoon Jang, Anal Mukhopadhyay and Dan G. Zollinger ......................................................315

Session 7a: Low-Volume Road Design and Performance
Moderator: Anna-Carin Brink, UWP Consulting, South Africa
Lessons Learned from Mn/ROAD (1992-2007): Five-Inch Concrete Pavement Study
Mark B. Snyder ...................................................................................................................330
Lessons from Michigan’s Oldest Concrete Pavement – Still Serving After 100 Years
Lawrence Mailloux, Karl Peterson, Thomas Van Dam and Kyle Ellis ....................................346
Lessons Learned from Mn/ROAD (1992-2007): Low-Volume Road Concrete Pavement Design and Performance
Mark B. Snyder ...................................................................................................................364

Session 7b: Permeable Bases
Moderator: Anna-Carin Brink, UWP Consulting, South Africa
Problems with and Alternatives to Permeable (Open-Graded) Subbases for Use in Jointed Plain Concrete Pavement Structures
Robert A. Rodden and Gerald F. Voight ...............................................................................384
Mixture Ratio Design Method for Porous Concrete Permeable Base
Mulian Zheng, Shauanfa Chen and Binggang Wang ...........................................................395
Session 8: PCC in Airfield Applications
Moderator: Navneet Garg, Federal Aviation Administration USA

Proposed Specification for Construction of Airfield Concrete Pavements
Shiraz Tayabji, John Anderson and Jim Lafrenz .................................................................403

Early Age Spalling on USAF Airfield Pavements
Raymond S. Rollings, Toy S. Poole, Craig Rutland and Marian P. Rollings .........................420

Is Top-Down Cracking Critical on Airfield Rigid Pavements?
Francisco Evangelista Jr. and Jeffrey R. Roesler .................................................................434

Session 9a: Pavement Scanning Equipment
Moderator: Thomas Yu, Federal Highway Administration, USA

Magnetic Imaging Tools Scanner (MIT Scan-2) Application in North America: Five Years After
Kyle Hoegh, Thomas Yu and Lev Khazanovich ..................................................................450

Measurement of Concrete Thickness and Detection of Defects Using Ultrasound Methods
Ed Pristov, Wayne Dalton and Garland Likins ..................................................................463

Session 9b: Dowel Bar Alignment
Moderator: Thomas Yu, Federal highway Administration, USA

Revised Dowel Bar Tolerances for Ontario Concrete Pavements
Becca Lane and Tom Kazmierowski ..................................................................................476

Effect of Dowel Bar Embedment Length on Joint Load Transfer Efficiency of MnROAD Concrete Pavement Test Cells
Thomas R. Burnham ........................................................................................................487
Volume II

Session 10: Concrete Pavement Rehabilitation and Restoration
CPR Techniques in Canada – 18 Years of Performance Experience
Tom Kazmierowski, Susanne Chan and Ludomir Uzarowski
Evaluation of Rigid Pavement Rehabilitation Methods on I-86
Luis Julián Bendaña, Joel Ambrosino and Shad Sargand
Case Study on US 75: Assessment of Full Depth Repair Effectiveness
Youn su Jung, Tom J. Freeman, Dan G. Zollinger and Andrew J. Wimsatt
Experiences with Dowel Bar Retrofit in California
Erwin Kohler, John T. Harvey and Bruce Steven

Session 11a: Construction
Moderator: Peter Deem, Holcim, Inc., USA
Construction of Cement Concrete Pavement-A Case Study
Akhil Gupta

Session 11b: Fiber-reinforced Concrete Pavements
Moderator: Peter Deem, Holcim, Inc., USA
Behavior of Concrete Mixtures in Ultra-Thin Whitetopping Composite Pavements
Amanda Bordelon and Jeffrey R. Roesler
Fibre Concrete Mixes in Road Pavements: In Between Plain and Reinforced Concrete?
C. René Braam, Adrian J. van Leest, Steef B. van Hartskamp, George Jurriaans, Corné A. van der Steen and Marc J.A. Stet
Development of a Long-Term, Durable Cementitious Wearing Course for Pavements
George Vorobieff and François de Larrard

Session 12: Pavement Analysis and Performance Prediction
Moderator: Jacob Hiller, Michigan Technological University, USA
Study of Features of Numerical Simulation of Falling Weight Tests on Rigid Pavements
Chen-Ming Kuo and Yi-Chen Lai
Numerical Analysis of Concrete Overlays on Flexible Pavements
Fereidoon Moghaddas Nejad and Sepehr Ghafari
Correlation between Properties of Axle Load Distribution and Rigid Pavement Performance Measures
Syed Waqar Haider and Ronald S. Harichandran

Session 13: Pavement Ride Quality and Safety
Moderator: Susan Tighe, University of Waterloo, Canada
A Simple Diagnosis Tool for Detecting Localized Roughness Features
Karim Chatti, Imen Zaabar and Hyung Suk Lee
Use of Profile Data to Detect Concrete Paving Problems
Starr D. Kohn, Rohan W. Perera, James K. Cable, Steven M. Karamihas and Mark Swanlund
Ride Quality Measurements and User Ratings—Initial Assessment of Improved Techniques
Hans Prem, Ziming Tu and Geoff Ayton ................................................................. 704

A Safe Highway Driving Surface Using Open-Graded Concrete
George Vorobieff and Gavin Donald..................................................................... 720

Session 14: Pavement Behavior and Modeling
Moderator: José Balbo, University of São Paulo, Brazil
Evaluation of Thermal Stress in Airport Concrete Pavement Slab by 3D-FEM Analysis
Taizo Shimomura, Tatsuo Nishizawa and Takato Ozeki..................................... 740
Effective Initial Crack Depth in Exposed Concrete Surfaces
Matthew A. Beyer and Jeffrey R. Roesler........................................................... 755
Composite Computational Model for Portland Cement Concrete Pavement
Bo Tian and Kai-min Nu....................................................................................... 768

Session 15: Topics in Pavement Materials
Moderator: James Grove, Federal Highway Administration, USA
Pavement Flexural Fatigue Capacity, and the Influence of Mix Charging Sequence
Justin Moss........................................................................................................... 786
Internal Curing of Concrete Pavements and Overlays
Norbert Delatte and John Cleary....................................................................... 810
Influence of Air-Void System Parameters on Freeze-Thaw Resistance of Pavement
Concrete—Lessons Learned from Field and Laboratory Observations
Mateusz Radlinski, Jan Olek, Maria del Mar Arribas, Adam Rudy, Tommy Nantung and Mike Byers.................................................................................... 824
Fresh and Hardened Properties of Paving Concrete with Steel Slag Aggregate
Paul Bosela, Norbert Delatte, Richard Obratil and Ashish Patel.......................... 836
Moving Towards an Environmentally Sustainable Concrete Pavement Using Recycled Concrete Aggregate
James T. Smith and Susan L. Tighe..................................................................... 854

Session 16: Thin Concrete Paving
Moderator: Bryan Perrie, Cement and Concrete Institute, South Africa
Thin Whitetopping Overlay Over a Deformed Asphalt Pavement of a Highly Trafficked Urban Intersection
László Gáspár, Katalin Karsai and Tibor Bors...................................................... 869
Influence of Bond Conditions on the Performance of Ultra-Thin Whitetopping (Bonded Concrete Resurfacing)
Scott A. Newbolds and Jan Olek....................................................................... 878
Mechanical Design of Ultra-Thin White-Topping with High Strength Concrete Panel
Tatsuo Nishizawa, Hiroyuki Obata and Iwao Sasaki............................................ 894
"TCP Design“ for Thin Concrete Pavement
Juan Pablo Covarrubias T and Juan Pablo Covarrubia V..................................... 905
Durable and Sustainable Overlay with ECC
Shunzhi Qian, Victor C. Li, Han Zhang and Gregory A. Keoleian......................... 918
Session 17: Design Methods and Considerations
Moderator: Craig Hennings, Southwest Chapter, American Concrete Pavement Association, USA
New Swedish Design Method for Concrete Pavements
J. Silfwerbrand, A.A. Farhang and J. Söderqvist ................................................................. 934
Best Practices for Transition Design of Concrete Pavement Intersections and Related Transitions
Youn su Jung, Dan G. Zollinger and Shiraz D. Tayabji ......................................................... 947
Concrete Pavements for Railway Tracks
Bernhard Lechner .................................................................................................................. 964
15-Year Performance of SPS-2 Project in Kansas
Taslima Khanum, Mustaque Hossain, Andrew J. Gisi and Daba S. Gedafa ......................... 976

Session 18: Innovations in CRCP Design and Construction
Moderator: Emmanuel Diependaele, Technum, Belgium
Ultra Thin CRCP Development in South Africa
Kannemeyer, Perrie, Strauss, and Plessis ........................................................................... 995
A Double-Layered CRCP: Experiences on the E34 near Antwerp (Belgium)
Luc Rens, Henk Keymeulen and Ilse Van Wijnendaele ....................................................... 1019
Continuously Reinforced Concrete Pavement with SMA Coating – The Composite Structure For the Challenges of the Future
Stefen Höller ......................................................................................................................... 1030
Use of Glass FRP Reinforcing Bars Instead of Steel Bars in CRCP in Quebec
Denis Thébeau, Mohamed Eisa and Brahim Benmokrane ................................................... 1048

Performance of Permeable Bases
Allen R. Long and Anastasios M. Ioannides ................................................................. 1064