Transportation Literature Search

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Long-Life Concrete Pavements

Prepared for
Wisconsin Highway Research Program
Rigid Pavements Technical Oversight Committee

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Transportation Literature Searches are prepared for WisDOT staff and principal investigators to heighten awareness of completed research in areas of current interest. The citations below are representative, rather than exhaustive, of available English-language studies on the topic. Primary online resources for the literature searches are OCLC's WorldCat and TLCat, U.S. DOT's TRIS Online, the National Transportation Library (NTL), TRB's Research in Progress (RiP) and other academic, engineering and scientific databases as appropriate. Links to online copies of cited literature are noted when available. Hard copies may be obtained through the WisDOT Library at library@dot.state.wi.us or 608-264-8142.

SUMMARY

Long-life concrete pavement documents that addressed expected service lives of 40 years or more were included in our literature search. We found nine citations for documents published in 2000 or later, and one Research in Progress entry.

Two of the citations were published in 2006, three in 2005, two in 2000, and one each in 2004 and 2002. Five of these citations refer to academic articles or conference proceedings. Two originate in state studies (one from California, the other from Alabama), and two others in industry trade news journals.

KEYWORDS

Long life concrete pavement

CITATIONS

Title: Proceedings of the international conference on long-life concrete pavements, Chicago, Illinois, October 25-27, 2006
Author(s): International Conference on Long-Life Concrete Pavements (2006
Date: October 2006
Doc ID/URL: *Proceedings of the International Conference on Long-life Concrete Pavements*, 2006: Chicago, Ill.
Description: 576 pp.
Contents:
Paper Topics:

Regional Practices

- Design and Construction of Extended Life Concrete Pavements in Illinois. Thomas J. Winkelman.
- The Evolution of Long-Life Concrete Pavements in Washington State. Steve Muench, Linda Pierce, Jeff Uhlmeyer, and Keith Anderson.
- Implementation of Proven Portland Cement Concrete Pavement Practices in Colorado. Ahmad Ardani.
- Extended Service Life of Continuously Reinforced Concrete Pavement in California. Chetana Rao, Michael I. Darter, and Tom Pyle.
- U.S. Air Force Perspective on Long-Life Concrete Airfield Pavements. Raymond S. Rollings and James Greene.
- Defining the Attributes of Well-Performing, Long-Lasting, Jointed Portland Cement Concrete Pavements. Halil Ceylan, James Cable, and Kasthurirangan Gopalakrishnan.
- The Dan Ryan Expressway: A Look Back and Forward at the Continuously Reinforced Concrete Pavement That Works. Andrea Talley.
- Long-Life Concrete Pavements: The Florida Perspective. Jamshid Armaghani and Roger Schmitt.

- The Evolution of High-Performance Concrete Pavement Design in Minnesota. Tom Burnham, Bernard Izevbekhai, and Prasada Rao Rangaraju.
- Impact of Construction on the Life of a Jointed Plain Concrete Pavement in Virginia. Shabbir Hossain and Mohamed K. Elfino
- Long-Term Performance of Continuously Reinforced Concrete Pavement in Texas. Moon Won, Dong-Ho Kim, Yoon-Ho Cho, and Cesar Medina-Chavez.
- Long-Term Performance of Prestressed Concrete Pavement on IH-35 in Texas. Cesar Ivan Medina-Chavez and Moon Won.

International Practices
- Australia's Experience With Long-Life, Heavy-Duty Concrete Pavements. George Vorobieff and Justin Moss.
- The Motorway E40 (Formerly E5) From Brussels to Liege. Chris Caestecker.
- The Walloon Motorway, From One Millennium to Another. Vincent Helmus.

Design Practices
- State in Transition: Empirical Designs to Long-Life Designs Based on Mechanistic-Empirical Procedures in California. Venkata Kannekanti, William K. Farnbach, Arron Rambach, Erwin Kohler, and John Harvey.
- Alternative Failure Modes for Long-Life Jointed Plain Concrete Pavements. Jacob E. Hiller and Jeffery R. Roesler.
- Integration of Advanced Material, Numerical, and Failure Models for Long-Life Concrete Pavement. Jeffery R. Roesler, Lev Khazanovich, and Derek Tompkins.
- Use of Mechanistic-Empirical Procedures for Design of Long-Life Concrete Pavements. M. I. Darter, J. Mallela, G. E. Larson, C. Rao, L. Titus-Glover, and L. Khazanovich.
- Structural Design Method of Precast Reinforced Concrete Pavement With Consideration of Concrete and Steel Fatigue. Tatsuo Nishizawa, Kazuo Mizukura,and Kazuhiro Tamura.

Concrete Materials Practices
- Don't Let ASR Shorten the Life of Your Long-Life Concrete Pavement. Gina Ahlstrom and Jon Mullarky.
- Getting It Right: Achieving Long Life Through Material Selection, Mix Design, and Construction. Thomas Van Dam, Lawrence Sutter, and Karl Peterson.
- Development of a Protocol to Detect Potential Uncontrolled Stiffening and Setting Due to Materials Incompatibility. Peter C. Taylor.
- Laboratory Results of Fast-Setting Concrete Mixes for Long-Life Pavement: Rehabilitation Strategies. Erwin Kohler, John Harvey, and Jeffery Roesler.

Construction Practices
- Analysis of Total Effective Linear Temperature Difference From Concrete Pavement: Field Measurements. Ya Wei, Will Hansen, D. L. Smiley, and E. A. Jensen.
- Use of MIT Scan Data for Improved Dowel Bar Tolerances. Becca Lane and Tom Kazmierowski.
- Construction of Long-Life Concrete Pavement by Using Performance-Related Specification Tools. Michael I. Darter, Lynn K. Evans, and Brian Egan.

Repair and Rehabilitation Practices
- The Early-Age Evaluation of Full-Depth Precast Panels: Canadian and Michigan Experiences. Neeraj Buch, Becca Lane, and Tom Kazmierowski.
- Precast Prestressed Concrete Pavement: A Long-Life Approach for Rapid Repair and Rehabilitation. David K. Merritt and Samuel S. Tyson.
- Using Precast Pavement Slabs in Three Dimensions. Peter J. Smith.
- Productivity Issues and Lessons Learned From Two Long-Life Urban Freeway Concrete: Pavement Rehabilitation Projects in California. Eul-Bum Lee, Kunhee Choi, and John T. Harvey.

Appendix
- Highlights from the 6th International DUT-Workshop on Fundamental Modeling of Design and Performance of Concrete Pavements. L.J.M. Houben.

Title: Optimum design of sustainable concrete pavements
Author(s): Barry P. Hughes
Date: September 2006
Doc ID/URL: *Proceedings of the Institute of Civil Engineers*, Vol. 159 (3), September 2006: 127-132.
Description: 6 pp.
Contents: Optimum design of continuously reinforced concrete pavement (CRCP) can produce low-maintenance sustainable pavements with extremely long service lives. The advantages for roads and highways include low whole-life cost, economic and social benefits from reduced fuel consumption and pollution, reduced man-hour wastage, user frustration and aggravation. Unfortunately, the full potential of CRCP is not realised with conventional pavement design. Furthermore, very few successful structurally enhancing bonded concrete overlays (BCOs) at even lower whole-life cost have actually been achieved. This paper focuses on the essential requirements for a long-life sustainable pavement and outlines the essential shortcomings and deficiencies in conventional CRCP design. Optimum design can only be achieved if both a semi-rigid pavement model and a rigid pavement model are considered jointly. Furthermore, the abysmal failures of many BCOs can also be explained and rectified utilising various concepts outlined in this paper. Optimum combinations of fibre and bar reinforcement are also considered for even further advances in the future when more experimental data, especially field data, become available.

Title: Road science: Trends to watch in 2006
Author(s): Tom Kuennen
Date: December 2005
Doc ID/URL: *Better Roads*, Vol. 75 (12), December 2005: 28-32, 34, 36-37
Description: 8 pp.
Contents: For 2006, some developments are expected to impact how infrastructures will be built. The Integrated Roadside Vegetation Management serves to help road agencies to maintain safe roadsides. A next-generation composite material, the Engineered Cementitious Composites that combine the strength of portland cement concrete with the ductility of metal, offers new options to structural designers and providers of concrete. A demonstration project in Nebraska provides evidence that electrically conductive concrete may help fight snow and ice while preserving bridge deck reinforcing steel. In Montana, laboratory tests show that reclaimed and recycled asphalt pavement (RAP) has a promising future as an additive to crushed angular aggregate or pit-run granular soils. Lastly, a new information from the Federal Highway Administration emphasizes the possibility of constructing future portland cement concrete pavement with optimal smoothness and long life spans.

Title: Framework for design and construction of long-life concrete pavements
Author(s): Shiraz Tayabji
Date: 2005
Doc ID/URL: *Proceedings of the Eighth International Conference on Concrete Pavements*, 2005: 208-220.
Description: 13 pp.
Contents: In the past, concrete pavements were routinely designed and constructed to provide low-maintenance service life of 20 to 25 years. In fact, the majority of the United States (U.S.) interstate and the primary system were designed on the basis of the 20 to 25 year initial service life. Experience has shown that pavements in high volume traffic corridors need to be designed and constructed to provide longer service life because of the difficulties in performing effective repair and rehabilitation activities along these high volume highway corridors. In addition, the public is no longer tolerant of frequent extended lane closures to perform repair activities. It is becoming an established practice in the U.S. to require that concrete pavements provide low-maintenance service life of 40 plus years. Portland cement concrete (PCC) pavements can meet this specific requirement if proper considerations are incorporated in the design and good construction practices, including use of sound concrete making materials, are followed. This paper provides an overview of current U.S. practices and efforts at optimizing pavement design features and construction practices to minimize early age failures and provide long-term low-maintenance service in excess of 40 plus years. The paper also provides a framework for ensuring that the critical design and construction features that impact long-term service are recognized and accounted for. The design and construction features discussed include features that improve slab cracking and deflection responses, features that minimize maintenance operations, and construction features that assure long-life pavement.

Title: Alternative dowel bars for load transfer in jointed concrete pavements
Author(s): Roger M. Larson, Kurt D. Smith
Date: 2005
Doc ID/URL: *Proceedings of the Eighth International Conference on Concrete Pavements*, 2005: 415-439.
Description: 25 pp.
Contents: Concerns over the long-term effectiveness of epoxy coatings of dowel bars have motivated some agencies to investigate the use of alternative dowel bar materials. Alternative dowel bars are either constructed of a non-corrodible material or contain a non-corrodible cladding for protection against corrosion. The need for a long-lasting dowel bar design has become even more acute as many highway agencies are exploring the development of long-life portland cement concrete (PCC) pavements, ones that are capable of providing service lives of 40, 50, or even 60 years. Under Test and Evaluation Project 30 (TE-30), High Performance Concrete Pavements (HPCP), the Federal Highway Administration (FHWA) is exploring the applicability of innovative PCC pavement design and construction concepts, including the use of alternative dowel bars. Several projects incorporating alternative dowel bars have been constructed under that program, and interest in these projects is high. At the same time, the Highway Innovative Technology Evaluation Center (HITEC) is sponsoring an evaluation the HPCP projects that specifically compare the performance of 38-mm (1.5-in.) diameter fiber reinforced polymer (FRP) composite or Type 304 solid or concrete-filled tubes to standard epoxy-coated steel dowels. This paper summarizes some of the types of alternative dowel bars currently available for use in jointed concrete pavement (JCP) construction, describes some of their advantages and disadvantages, and reviews some of the recent field projects constructed under the TE-30 or related programs that incorporate alternative dowel bars. In addition, a brief summary of related laboratory or accelerated pavement testing.

Title: America's quest for premium aggregates
Author(s): Tom Kuennen
Date: August 2004
Doc ID/URL: *Better Roads*, Vol. 74 (8), August 2004: 24-34.
Description: 11 pp.
Contents: The United States' road management establishment pursues long-life pavements with high performance characteristics. Focus is now on aggregate properties, dimensions, and quality as on the binder properties of cement and liquid asphalt. Two important mix designs, Superpave and High-Performance Concrete Pavement mix, put emphasis on the quality of aggregates used. Current research is also addressing ways where Reclaimed asphalt pavement (RAP) and demolition concrete will work best in pavements and bases.

Title: Case study of urban concrete pavement reconstruction in Interstate 10
Author(s): Eul-Bum Lee, Jeff Roesler, John T. Harvey, C. William Ibbs
Date: January 2002
Doc ID/URL: *Journal of Construction Engineering and Management*, Vol. 128 (1), January/February 2002: 49-56.
Description: 8 pp.
Contents: Many urban concrete pavements in California need to be reconstructed, as they have exceeded their design lives and require frequent maintenance and repair. Information is needed to determine which methodologies for pavement design, materials selection, traffic management, and reconstruction strategies are most suitable to achieve the objectives of California Department of Transportation's (Caltrans) long-life pavement rehabilitation strategies (LLPRS) program. To develop construction productivity information for several construction windows, a case study was performed on a Caltrans concrete rehabilitation demonstration project near Los Angeles on Interstate-10, where 20 lane-km was successfully rebuilt using fast setting hydraulic cement concrete (FSHCC) with one weekend closure for 2.8 lane-km and repeated 7- and 10-h nighttime closures for the remaining distance. The concrete delivery and discharge controlled the overall progress. In terms of the number of slabs replaced per hour, the 55-h weekend closure was 54% faster than the average nighttime closure. An excellent traffic management strategy helped to reduce the volume of traffic during the weekend closure and minimize the traffic delay through the construction zone.

Title: Concrete pavement performance in the southeastern United States
Author(s): N.J. Delatte, M. Safarjalani, N. B. Zinger
Date: September 2000
Doc ID/URL: UTCA Report 99247, Final Report; http://utca.eng.ua.edu/projects/final_reports/99247report.pdf
Description: 31 pp.
Contents: This report documents an in-depth study of the performance of concrete pavements in the southeastern United States. Information from the Strategic Highway Research Program (SHRP) Long Term Pavement Performance (LTPP) database was investigated. Analysis of 36 sections in Alabama, Florida, Georgia, Mississippi,

and North and South Carolina showed that the majority of these pavements are providing excellent service well beyond their original design lives. This has important implications for new pavement construction, as well as maintenance and rehabilitation of existing pavements. For new pavement construction, the results of this study suggest that life cycle cost models should assume better performance and longer service life than existing AASHTO predictions for these pavements. Thus, the economic benefits of constructing concrete pavements where heavy traffic is anticipated or long life is desired may be considerable. The implication for maintenance and rehabilitation of existing pavements is that concrete pavements may have considerably more remaining structural capacity than time in service or traffic applied to the pavement would suggest. For this reason, expensive and time-consuming reconstruction efforts or thick overlays should not be used unless the evaluation of pavement condition indicates it is warranted. If the pavement is in good structural condition, diamond grinding and other rapid, low cost Concrete Pavement Restoration (CPR) alternatives may extend pavement life considerably and improve serviceability.

Title: Investigation of Design and Construction Issues for Long Life Concrete Pavement Strategies
Author(s): Jeffery R. Roesler, John T. Harvey, Jennifer Farver, Fenella Long
Date: February 2000
Doc ID/URL: FHWA/CA/OR-200/04,
http://www.its.berkeley.edu/pavementresearch/PDF/Investigation%20of%20Design.pdf
Description: 71 pp.
Contents: This report addresses design and construction issues as they pertain to long-life rigid pavement strategies. The design and construction issues are discussed with the goal of determining the boundaries of existing technology and approaches to rigid pavement design and construction. Design issues addressed include limitations of existing design procedures and the load equivalency concept. Construction topics covered in this report are paving train productivity, concrete fast tracking, and concrete opening strength. In addition, this report includes a brief study on the formation of longitudinal cracks in existing concrete pavements.

RESEARCH IN PROGRESS

Title: Determination of the Mechanical Properties of Materials Used in the WAY-30 Test Pavement
Principal Investigator(s): Sang-Soo Kim, Ohio University, 740-593-1463, kim@ohio.edu
Start Date: 1/1/2004
RIP URL: http://rip.trb.org/browse/dproject.asp?n=9324
Sponsor Organization: Ohio Department of Transportation
Contents: The objectives of the proposed research are to determine the mechanical properties of the pavement materials used in WAY-30 test pavements during construction and in-service; and to provide data to calibrate the long life pavement design procedures. Results of this research will provide data to be used for the validation and calibration of long lasting pavement design procedures. Long lasting asphalt and concrete pavements will reduce traffic congestion, user delays, and life-cycle costs.