RESEARCH AND TECHNOLOGY

REVIEW

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RESEARCH BULLETIN

Product Evaluation Synthesis Topic

The Research Division was successful in having a synthesis topic funded under the NCHRP Project 20-5 "Synthesis of Information Related to Highway Problems." The topic is 33-03 "State Product Evaluation Programs."

This synthesis will summarize state DOT practices for product evaluation, including program structure, evaluation procedures, and the implementation of evaluation results. Items to be considered, include, but are not limited to:

1. Product evaluation program organization, funding, and procedures;
2. Types of products evaluated;
3. Product acceptance criteria, e.g., state specifications, laboratory and field testing results, or national product testing center results such as NTPEP (National Transportation Product Evaluation Program), APEL (AASHTO Product Evaluation Listing), and HITEC (Highway Innovative Technology Evaluation Center);
4. Acceptance options, e.g., approval based on a certification of compliance with existing state specifications, conditional approval on a project-by project basis, reciprocity with other states/regional collaborations, and general approval for all applicable projects; and
5. Product-approval implementation, i.e., the use of a qualified products list (QPL), and the method in which the QPL is incorporated into contract specifications.

The synthesis series attempts to report on the various state DOT practices, making some recommendations where appropriate in terms of what could be considered best management practices. In NDOT's case, the Research Division will use the final report to improve and update its product evaluation program. Hopefully, our contribution to the synthesis in the form of current product evaluation practices will be used likewise by other states. **?**

Early Age Shrinkage and Cracking of Nevada Concrete Bridge Decks

Throughout the state of Nevada, newly cast bridge decks are being affected by early age cracking problems. These cracks occur shortly after casting the deck. In order to investigate this problem and propose solutions, NDOT sponsored

Photo 1. Extensive cracks in the mid-section of the deck.

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a research project at the University of Nevada, Reno. The project was under the direction of David Sanders, an Associate Professor of Civil Engineering. Graduate student Heinere Ah-Sha and Professor M. Saiid Saiidi also worked on the project.

As part of the project, a comprehensive literature review of the existing knowledge and practices related to early shrinkage and cracking of concrete bridge decks was done. Evaluations of existing concrete bridge decks were conducted in both northern and southern Nevada. Specific mix designs and deck-curing methods were developed that had low concrete shrinkage values and minimized/eliminated cracking. A series of concrete mix designs incorporating the usage of commercially available shrinkage reducing admixtures (SRA) and compensating cement or additive (SCC/SCA) were developed and evaluated for their suitability in concrete bridge decks. A total of 27 mix designs were prepared using SRA, SCC/SCA, fly ash, and various combinations of these admixtures. The evaluation program consisted of tests for compressive strength, drying shrinkage, cracking strength, chloride ion penetration, cracking tendency, temperature evolution, and the hardened air-void system.

As a result of the project, certain guiding principles with regards to early-age shrinkage and cracking were determined. These principles include the importance of well-graded aggregates, the implementation of a low water-cementitious (W/C) ratio, the utilization of superplasticizers, adequate curing time, and careful use of shrinkage-reducing or shrinkage-compensating admixtures. The results of the project show that low shrinkage and limited/no crack concrete is possible. Instead of developing detailed mix-design rules, the preferred method is to specify the desired performance (see Table 1). The results of this study showed that there are a number of tools available for producing durable concrete with low shrinkage and low chloride penetration. Both SRA and SCC/SCA were effective at reducing shrinkage. The addition of fly ash in mix designs incorporating the SCC/SCA or the SRA improved workability, drying and thermal shrinkage performance of the concrete. Fly ash also significantly improved the resistance of concrete to chloride-ion penetration.

The study showed that regardless of the time of year and the location, Nevada weather produces an environment that encourages high evaporation rates of concrete and therefore increases the chances for early-age cracking. The study further showed that the placement time could assist in minimizing the effects of ambient conditions. In the trial runs,

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Table 1 Sample of Suggested Concrete Performance Grades for NDOT

Performance Parameter	Test Method	Concrete Performance Grade			
		0	1	2	3
Freeze-Thaw Durability (x = relative dynamic modulus of elasticity	ASTM C 666	NA	60% ? x < 80%	80% ? x < 90%	x ? 90%
Chloride Penetration (x = coulombs)	ASTM C 1202	NA	4000 ? x > 2000	2000 ? x < 1000	1000 ? x
Shrinkage (x = microstrain)	ASTM C 157	NA	600 ? x < 800	400 ? x < 600	x < 400

Product Evaluation Committee (PEC) Meeting Recap

FIELD TEST UPDATE

Liquid Pavement Markings are Under Evaluation

Recent efforts to increase the safety of the motoring public include the use of improved pavement- marking materials. The use of durable liquid pavement-marking materials instead of standard paint and beads was discussed in the last issue of our newsletter. As we reported, the PEC approved a field test of HPS-4 modified urethane and HPS-5 polyurea marking materials from Innovative Performance Systems (IPS). Recently, these products were installed along with LPM 1200 polyurea marking from 3M on US 395 south of Carson City in Douglas County on contract 3027.

Photo 3. Monitoring of initial retroreflectivity values of the applied pavement marking in accordance with ASTM D4061 testing procedures.

During the course of a one-year evaluation, six test sections will be monitored for retroreflectivity performance as measured in millicandelas per square meter per lux, as well as for durability and appearance. The work plan and field-test procedures have been developed along the lines of standard practices recommended by AASHTO/NTPEP and are based on ASTM D713 (Standard Practice for Conducting Road Service Tests on Fluid Traffic Marking Materials) and on ASTM D913 (Standard Test Method Evaluating Degree of Resistance to Wear of Traffic Paint). Additionally, our test protocol includes laboratory evaluation and life-cycle cost analysis. The purpose of this field test is twofold. If these products perform well, the data collected will be used for developing specifications and qualified product lists for liquid pavement markings. Also, as mentioned earlier, this field test is part of a research project on alternative, durable-pavement marking materials. The intent of this research is to develop a matrix that enables users to choose durable-pavement marking materials on the basis of their performance and optimal use. **?**

Photo 2. Installation of LPM 1200 polyurea marking using mobile, truck mounted and self-contained pavement marking machine.

APPROVED

Asphaltic Plug Expansion Joint Material

On recommendation of the Bridge Division, the PEC approved a trial installation of the A.P.J. asphaltic plug expansion joint system for bridges from Silicone Specialties, Inc. (SSI). The Bridge Division recommended a field test of this system since our acceptance criteria for this type of product includes a field test evaluation option. The A.P.J. will be installed on a bridge within a construction contract and evaluated over a one-year period.

The A.P.J. system consists of the following components: 1) bridge joint binder (APB), which is a thermoplastic-modified asphalt; 2) aggregate (APA) which is normally

Photo 4. Field installation of the A.P.J. system from SSI on a Texas bridge.

basalt, gabbro, or granite of the specified gradation; and 3) backer rod which is a cross-linked, closed-cell polyethylene, expansion joint filler capable of withstanding the elevated temperature of the binder. The resulting "plug" accommodates expansion movement. According to the vendor, depending on the ambient temperature and joint depth, the joint could be ready for traffic in one-half (1/2) hour. The system is limited to a maximum horizontal movement of up to 2 inches, max vertical movement of +/- ½", a minimum depth of 8 inches, installation width of up to 20 inches and a maximum gradient of 4%.

States that have used the A.P.J. system include Massachusetts and Rhode Island. Survey results showed that these DOT 's approved the system for retrofit applications and placed this product on their QPL. The states' representatives indicated that it was easy to apply and performed well during the evaluation period. If the SSI's product performs well under Nevada conditions, it will be added to our QPL for asphaltic-plug joints.**?**

QPL for Emergency Vehicle Detectors

To ensure that approval of emergency vehicle detectors is consistent with the established product evaluation process, Traffic Engineering proposed establishing a QPL for traffic pre-empting devices under section 623.02.26. The initial QPL is comprised of two systems from Tomar and 3M which have been used successfully in the past.

A traffic "pre-empt" system is intended to identify the presence of designated priority vehicles and enable such vehicles to remotely cause the traffic signal controller to advance to and/or hold a desired traffic signal display by using existing controller functions.

In the future, companies seeking approval of their product will be directed to submit a product evaluation proposal for acceptance under current NDOT specifications. Once traffic engineers evaluate a new product and determine that it complies with NDOT standard specifications for emergency vehicle detectors, it will be added to the QPL.**?**

Continued from page 2 (Concrete Cracking)

placement of concrete early in the evening considerably reduced the evaporation rate of concrete. The study also showed that acceptable evaporation levels (below the suggested limits) could be achieved if the wind speeds on the concrete could be reduced through windshields or moist curing with blankets (by Dr. David Sanders).**?**

The Research Division administers the department's research, development and technology transfer program and serves as the clearing-house for product evaluations.

Research and Technology Review is published quarterly by the NDOT Research Division. Its purpose is to provide the latest information on the NDOT research activities including product evaluation and other pertinent research topics.

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If you have comments or need additional information regarding any of the topics discussed in this issue, please contact **Alan Hilton,** Research Division Chief, *at (775) 888-7803. ahilton@dot.state.nv.us*

NDOT LIBRARY RECENT ACQUISITIONS

(Received July 1 through September 30, 2001)

HYDRAULICS/ENVIRONMENT

Hydraulic Performance of Several Curb and Gutter Inlets (BB-895), Florida DOT; **A01-097**

Noise and Skid Measurements on US 285 in Turkey Creek Canyon Area, Project NH 2854-068 (CDOT-RI-R-2001-9), Colorado DOT; **5289**

Calculation of Bridge Pier Scour using the Erodibility Index Method (CDOT-DTD-R-20000-9), Colorado DOT; **5326**

Investigation of Agents of Practical Use to Stabilize Slope & Erosion along the I-55 corridor south of Sikeston, Missouri (RDT 01-006) Missouri DOT; **5672**

MAINTENANCE

Development of an Advanced Snowplow Driver Assistance System (ASP-II), (FHWA/CA/OR-2001/03**;** California DOT; **A01-101**

MATERIALS/PAVEMENTS

Evaluation of Alignment Tolerances for Dowel Bars and Their Effects on Joint Performance (RC-1395), Michiga DOT; **A01-098**

Evaluation of Early Entry Sawing of PCC Pavement (RDT01-010), Missouri DOT; **A01-105**

Calculation of Bridge Pier Scour using the Erodibility Index Method (CDOT-DTD-R-20000-9), Colorado DOT; **5326**

Performance of Lime in Hot Mix Asphalt Pavements, (RDT01-009), NDOT; **5222**

Characterization of Nevada's 1993, 1994, and 1995 Binders Using SHRP Tests (RDT95-014), NDOT; **5351/5120**

Evaluation of Crumb Rubber Modified Paving Mixtures in the State of Nevada, (RDT97-016), NDOT; **5332**

Development of Pavement Performance Analyses and Procedures (RDT00-017), NDOT; **5430**

Headlight Glare Screen Panels Cold Temperataure Performance Impact Test (RDT93-015), NDOT; **5328**

AASHTO Design of Pavement Structures, AASHTO; **5140**
Stone Mastic Asphalt in Colorado (CDOT-DTD-R-2001-1, Colorado DOT; **5361**

Construction and Performance of a Stone Matrix Asphalt Mix Test Section in Virginia (FHWA/VA-95-R27) Virginia DOT; **5453**

Long Term Performance of Stone Interlayer Pavement (01-1TA), Louisiana DOT; **5573**

Evaluation of Structural Capacity of Shoulder During Rehabilitation of I-10 near Rayne Acadia Parish (01-2TA, Louisiana DOT; **5572**

Guidance Document for Reclaimed Portland Cement Concrete (PA 2001-019-96-30-(5), Pennsylvania DOT; **5654**

LTPP Data Analysis: Factors Affecting Pavement Smoothness (20-50(08/13)#33), NCHRP; **5687**

Effects of Aggregate Angularity on VMA and Rutting of KDOT Superpave Level 1 Mixes (KU-98-5), Kansas DOT; **5695**

Performance and Constructability of Silica Ffume Bridge Deck Overlays (K-Tran:KU98-4), Kansas DOT; **5696**

Evaluation of Anti-Stripping Agents Using the Asphalt Pavement Analyzer (K-Tran:KU-99-3), Kansas DOT; **5699**

Bituminous Materials Research Series (NCHRP Projects 9-11, 9-12, & 9-13 (CD)), Segregation in Hot- Mix Asphalt Pavements, Incorporation of Reclaimed Asphalt Pavement in the Superpave System, Evaluation of Wate Sensitivity Tests; NCHRP; **5700**

PLANNING/PROGRAM DEVELOPMENT

Transportation Engineering Annual Catalog, Northwestern University; **5266**

Estimating Link Travel Time on I-70 Corridor: A Real-Time Demonstration Protype (CDOT-DTD-R-2000-15), Colorado DOT; **5322**

An Evaluation of Driver Education in Pennsyvania (PA-2000-025+97-04(59)), Pennsylvania DOT; **5362**

Summer Transportaton Instutute 2000, Cheyney University of Pennsylvania (PA-2001-006+97-04(76)), Pennsylvania DOT; **5363**

Construction and Materials Community Training and Education Plan (FHWA-PA-2001-004+97-04(23)), Pennyslavnia DOT; **5364**

External Validity Test for Discrete Choice Transportation Forecasting Models Based on the Stated Choice Approach (NJ-99-003-NCTIP4**),** New Jersey DOT; **5689**

STRUCTURES

Precast-Girder Cracking Phase II - Causes & Design Details (RDT 01-008), Missouri DOT; **A01-100**

Analysis of the Bridge Barrier Railing, Type 4; Bridge Barrier Railing, Type 5; and Bridge Railing, Aesthetic Parapet Tube (R-1397), Michigan DOT; **A01-107**

Results & Recommendations of Forensic Investigation of Three Full-Scale GRS Abutment & Piers in Denver Colorado (CDOT-DTD-R-2001-6), Colorado DOT; **5262**

Regional, Long Term Assessment of Channel Stability along the Truckee River, Nevada, from Verdi to Pyramid Lake; Implicatiions to the Potential for Catastrophic Bridge Failure (RDT94-013), NDOT; **5343**

Assessment of Hoop Strains in the Flexural Plastic Hinge Region of Typical Bridge Columns (SSRP 2000/11), Caltrans; **5306**

Evaluation of Alignment Tolerances for Dowel Bars & their Effects on Joint Performance, (RC-1395), Michigan DOT; **5325**

Non-Linear Bridge Abutment Stiffnesses: Formulation Verification & Design Curves (RDT95-012), NDOT; **533**

Design Paramenters of Backfill for Design and Construction of Retaining Walls (2001-07), Colorado DOT; **5368**

Seismic Column Reinforcement Study (FHWA-PA-2001-015-96-29-(VII), Pennsylvania DOT; **5575**

Dry Shrinkage Evaluation of Bridge Decks with Class AAA & Class AA Concrete with/without Type K Cement (FHWA-PA-2001-001-96-09(4)), Pennsylvania DOT; **5675**

Evaluation of Corrosion Protection Methods for Reinforced Concrete Highway Structures (K-Tran:KU-99-6), Kansas DOT; **5697**

Comparison of Ground Penetrating Radar Bridge Deck Evaluation and Repair; Polk-Quincy Viaduct I-70, Topeka, Kansas (FHWA:KS-00-3), Kansas DOT; **5698**

TRAFFIC/SAFETY

Median Safety Study (Interstates and Expressways)(FHWA-PA-2001-009-97-04(1)) Pennsylvania DOT; **5220**

Absorption Air-Conditioning for Containership and Vehicles, (FHWA/CA/OR-2001/17) Caltrans; **5308**

Collision Experience with Speed Limit Changes on Selected California Highways (FHWA/CA-TO-2001/04) Caltrans; **5309**

Evaluation of Milled-In Rumble Strips, Rolled-In Rumble Strips and Audible Edge Stripe, Caltrans; **5310**

Effectiveness of Earthen Return Ramps in Reducing Big Game Highway Mortality in Utah, Final Report (UT-01.09), Utah DOT; **5369**

Bicycle-Friendly Shoulder Strips (PT1 2K15), Pennsylvania DOT; **5408**

Public Perception of Pavement Marking Brightness (MS 150), Minnesota DOT; **5574**

I-95 Corridor Coalition Field Operational Test #10: Coordianted Safety Management Volume II (FHWA-PA-2001-020-97-04(8), Pennsylvania DOT; **5678**

I-95 Corridor Coalition Field Operational Test #10: Coordianted Safety Management Volume III (FHWA-PA-2001-020-97-04(8), Pennsylvania DOT; **5679**

I-95 Corridor Coalition Field Operational Test #10: Coordianted Safety Management Volume IV (FHWA-PA-2001-020-97-04(8), Pennsylvania DOT; **5680**

Analysis of Design Attributes and Crashes on the Oregon Highway System (FHWA-OR-RD-02-01),Oregon DOT; **5676**

I-95 corridor Coalition Field Operational Test 10: Coordinated Safety Management; Volume I: Best Practices in Motor Carrier Safety Management (FHWA-PA-2001-020-97-04(8), Pennsylvania DOT; **5683**

Lane Occupancy Changes, Final Report (FHWA/NJ-2001-07), New Jersey DOT; **5688**

Evaluation of Arrow Panel Displays for Temperary Work Zones (FHWA-OR-RD-02-02, Oregon DOT; **5818**

REFERENCE BOOKS

Standard Handbook for Civil Engineering, South Florida Water Management District; **5135**

The Civil Engineering Handbook, Purdue University, Indiana; **5141**

AASHTO 2001 Publications Catalog, AASHTO**; 5156**

Catalog of U.S. Government Laws, Regulations, Decisions, and Guidelines, **5188**