Identifying Number: **MPC-305**
Continuation, Year 23, Third Year

Project Title:

Jointed Plain Concrete (JPC) Design and Construction Review-Year 3

University:

South Dakota State University

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Description of Research Problem:

SDDOT has not reviewed performance of Portland Cement Concrete (PCC) jointed plain concrete (JPC) pavements for many years. In 2007 SDDOT changed JPC joint spacing from 20' to 15' on new, thinner concrete pavements due to the rapid development of roughness on many new JPC projects. Many of these projects have had ride incentive paid to the Contractor upon the completion of the pavement, so the pavements themselves have been completed to a more than satisfactory standard. It seems that with the 20 ft. joint spacing perpendicular to the lane, once these pavements go through 1 or 2 freeze-thaw cycles any curling and warping that does take place is compounded by the repetitious joint spacing and the fact that both vehicle tires cross the joint plane at the same time. There are numerous pavements in South Dakota that have been paved within the last 10 years that demonstrate this problem.

In addition, there is a need to revisit the SDDOT current load transfer and joint design especially with regard to sealing and the number of dowels required to provide adequate load transfer. The literature indicates that the

number of dowels can be reduced with no ill effects as long as the modification still provides sufficient load transfer in the wheel paths. Many states have also adopted a no seal approach to joints, especially if a drainable base is employed. SDDOT has no plans for constructing drainable bases in the future and there is a need to evaluate the effects of not sealing joints or using a lower cost joint sealant (hot pour) in place of the standard silicone sealant that is currently employed on moisture infiltration and the accumulation of “incompressibles” in the joint.

In addition, the introduction of larger aggregate in the concrete mix, pea gravel to provide improved workability and optimized overall gradation could result in a lower cement content requirement with enhanced performance. Larger aggregate with the reduced cement content could also decrease the likelihood of curling and warping improving ride quality and increasing service life. The use of newer, more effective concrete curing compounds or an increase in the rate of curing compound application could also minimize curling and warping and maximize ride quality while extending service life.

Research is needed to look at joint performance, tied to ride quality and overall pavement performance with the overall goal of optimizing current joint design and sealing practices while enhancing pavement smoothness, all with the goal of minimizing costs and improving quality.

Research Objectives:

1. To review available literature and field performance of various concrete pavement designs, especially with regard to joint and sealant systems, to determine any possible beneficial changes to current practice.
2. To develop optimized concrete mix designs incorporating larger top size aggregate and pea gravel to provide good workability at lower cement contents and resist thermal effects.
3. To construct and evaluate appropriate JPC test sections to resolve any performance issues with regard to potential changes in design or construction

Research Approach / Methods:

The project will include the following tasks:

1) Review current literature with respect to performance and economical benefits of modifications to current standard JPC design and construction practices.
2) Meet with the technical panel to review project scope and work plan.

3) Develop optimized concrete mix designs using both limestone and quartzite incorporating a larger top size aggregate gradation (similar to the mix designs used for CRCP) and pea gravel or coarser sand fraction in the mix with a reduced cement content. The mixes should be screened for workability and durability (both individual components as well as the proposed concrete mix), comprised of typical, locally available materials and be available for incorporation into plan notes by November, 2008.
4) Conduct performance evaluations and load transfer testing using the SDDOT FWD on a project incorporating a reduced dowel content (US 212 west of Belle Fourche, if feasible) to determine load transfer efficiency compared to a control project to the east on US 212 with normal dowel configurations. This project should also include joint sealant test sections consisting of five clusters of four panels for each type, minimum, incorporating hot pour sealant, using SDDOT's current design, and a green cut with no sealant at the appropriate width for comparison. The test sections should also comprise a separate pavement section, at least one mile in length, with a double rate of curing compound application.
5) Conduct performance evaluations, including profilograph and profilometer measurements as well as rod and level determinations on a project incorporating a series of experimental curing compound applications (I29 north of Brookings, if feasible) to determine degree of curling and warping in the pavement sections, with each at least one mile in length, with a double rate of curing compound application for one section, conventional curing compound application rate for one section and ά-methyl-styrene at recommended application rate for the third.
6) Develop an instrumentation plan for monitoring slab movement and moisture ingress for inclusion in a JPC project to be built in 2009.
7) Develop plan notes for a project on I29 south of Brookings scheduled for construction during the 2009 construction season including:
   - o Optimized minimum cement large aggregate/pea gravel concrete mix design requirements
   - o Hot pour and green cut (no sealant) test section layout compared with standard silicone
   - o Recommendations for curing compound application rates and types based on prior results
8) Develop plan notes for a project on I90 at Sturgis scheduled for construction during the 2009 construction season including:
   - o Optimized minimum cement large aggregate/pea gravel concrete mix design requirements
   - o Hot pour and green cut (no sealant) test section layout compared with standard silicone

- o Recommendations for curing compound application rates and types based on prior results

9) Conduct performance evaluations and load transfer testing using the SDDOT FWD on a project incorporating a reduced dowel content (SD 50 west of Vermillion, if feasible) planned for 2009 construction to determine load transfer efficiency compared to a control project with normal dowel configurations. This project should also include joint sealant test sections consisting of five clusters of four panels for each type, minimum, incorporating hot pour sealant, using SDDOT's current design, and a green cut with no sealant at the appropriate width for comparison. The test sections should also comprise a separate pavement section, at least one mile in length, with a double rate of curing compound application.
10) Provide recommendations for concrete mix design requirements using larger aggregate and pea gravel or coarse sand consistent with the SDDOT Wide Band/Narrow Band concrete mix requirements under development. These recommendations should also include any necessary durability requirements for pea gravels and coarse sands minimizing the likelihood of impacts due to ASR, ACR , D-cracking or other deleterious processes.
11) Provide recommendations for alterations in current JPC design and material requirements based on the results of the research with the proviso that any modifications to current practice result in equivalent or improved pavement performance.
12) Prepare a final report and executive summary of the research methodology, findings, conclusions, and recommendations.
13) Make an executive presentation to the SDDOT Research Review Board at the conclusion of the project.

MPC Critical Issues Addressed:

#15 Improved Infrastructure Design
#16 Infrastructure Longevity

Contributions/Potential Applications of Research:

Implementing the results of this research effort, based on actual pavement performance, could result in a significant savings to the Department without any reduction in JPC quality or durability.

Potential Technology Transfer Benefits: At the end of the study, a comprehensive report will be published to document the research procedures and results. Technical presentations will be offered to DOT engineers and technicians in Region 8 to transfer the knowledge learnt from the research.

Graduate and undergraduate students also will be trained to conduct research and apply procedures for the design of jointed plain concrete pavements.

Time Duration:

July 1, 2010 – June 30, 2010

Total Project Cost:

$35,766

MPC Funds Requested During Year 3:

$11,479

Source of Matching Funds During Year 3:

SDDOT and SDSU: $24,287

TRB Keywords:
Jointed Plain Concrete, JPC, Portland Cement Concrete Pavement, PCCP, Pavement Joints.