To: National Research Advisory Committee (RAC) Members

From: Gary Hoffman, Chief Engineer
Pennsylvania Department of Transportation (PennDOT)

Date: May 7, 2001

Subject: **National Pooled Fund Study Number TPF-5(013)**
Effect of Multiple Freeze-Thaw Versus Deep Frost Penetration on Pavement Performance

The Pennsylvania Department of Transportation, cosponsored by the North Carolina Department of Transportation, in cooperation with the Federal Highway Administration (FHWA) has established the subject National Pooled Fund Study which is approved for 100% SP&R funding, without State match.

The objectives of the study are to determine the relative importance of deep-freezing versus multiple shallow freezes on the performance of flexible pavements. The project will also investigate various mechanisms that states have used in their designs to mitigate against the freeze issues and make recommendations on the most successful strategies. We believe that the data collected for the Long Term Pavement Performance studies provides the ideal opportunity to address this type of climatic issue. It is further believed that sufficient data of good quality has been collected by LTPP to make this project possible at this time. Attachment 1 provides additional study information and the proposed funding level needed to complete the study.

If your agency is interested in participating in this study, please complete the "Pooled Fund Project-Funding Commitment Form", attachment 2. Please contact either Gary Hoffman (PennDOT 717-787-6898) or Judith Corley-Lay (NCDOT 919-250-4094) if you have questions. **Completed forms may be faxed to Cheryl Richter at 202-493-3161 or sent to Ms. Richter at 6300 Georgetown Pike, HRDI-13, McLean, VA 22101-2296.** PennDOT is committing a total of $75,000 to this project, and North Carolina has committed $40,000.

We appreciate your consideration of the proposed pooled fund study.

Attachments: Project Statement/Proposal
Commitment Form

National Pooled-Fund Study
TPF-5(013)

Study Title: Effect of Multiple Freeze-Thaw Cycles Versus Deep Frost Penetration on Pavement Performance

Research Problem Statement: Seasonal weakening of pavement bases and subgrades due to frost action commonly occurs in most states and provinces. Even temperate states such as Texas, California, and North Carolina have regions within each state where pavement freezing occurs. Upper layer freezing occurs even in some places that are categorized as "no freeze" zones.

The rate of distress accumulation increases dramatically during periods when pavements are partially thawed. Damage occurring during these critical periods is generally associated with the weakening of pavement materials in the upper layers combined with impeded subsurface drainage due to underlying frozen materials. Many states have adapted their pavement systems to compensate for the deleterious effect of freeze-thaw.

Near the southern edge of the freeze/no-freeze zone, pavements are subjected to multiple freeze-thaw cycles each year. Further north, pavements may be subjected to fewer freeze-thaw cycles, but the depth of frost penetration is generally greater. It is not clearly understood how the trade-off between multiple freeze-thaw cycles versus having deep frost penetration affects the rate of pavement deterioration. State-to-state differences in materials standards and pavement design compensations further cloud our understanding.

Research is needed to sort out the effects of multiple freeze-thaw versus deep frost penetration on pavement performance. Ultimately, the project should determine whether there are pavement design and/or materials selection practices in use by various state DOTs that help to mitigate the effects of frost penetration on pavement performance. This information must be documented if we are to be able to make the transition from a purely empirical method of pavement design to a mechanistic-empirical method.

Research Objectives:

- The general objective of the pooled fund study is to quantify the effect of seasonal frost penetration on the rate of loss of pavement performance.
- The extent to which local adaptations of materials standards and pavement thickness designs have compensated for and/or mitigated the effect of seasonal frost penetration should be established.

Research Approach:

Task 1. Make a comparison of performance data from the LTPP Seasonal Monitoring Program (SMP) sites that are located in the southern reaches of the wet-freeze zone or the northern reaches of the wet-no freeze zone versus those sites that are further north in the wet-freeze zone. Contrast these findings with pavement performance in the dry-freeze and wet-no freeze climatic regions.

Initial trend analysis studies should determine whether the SMP data support the contention that the rate of accumulation of pavement distress is greater (more rapid) in climatic zones where there is a large number of annual freeze-thaw cycles versus deep frost penetration.

The possibility of using LTPP SMP data to study the effect of frost penetration should be assessed by a trend analysis in which the rates of distress accumulation with be analyzed for correlation with number and duration of partial thaw events as inferred from climatic (temperature) data. The trade off between materials quality, availability of moisture beneath the pavement, and severity of frost penetration on the rate of distress accumulation should be included in the trend analysis.

Task 2. If the trend analyses support the basic project assumptions, a detailed analysis of the effect of multiple freeze-thaw cycles versus deep frost penetration on pavement performance should be undertaken. The study should attempt to quantify the effect on pavement performance based on the analysis of:

Climatic data (rainfall, freezing index, and thawing index from temperature data)
Frost depth (temperature sensors and resistivity data)
Deflection data (stresses and strains calculated from layer material properties)
Performance data (distress and permanent deformation)
Soils and material properties
Traffic data.

Task 3. The extent to which local adaptations of materials standards and empirical pavement design practices have been effective at reducing the rate of loss of pavement performance should be established.

Adjacent states in the same climatic zone can be expected to have developed different approaches to compensate for pavement deterioration due to freeze-thaw. Some of these methods may be more effective than others. Using the data developed in Task 2, recommend ways in which mechanistic design methods can appropriately consider the most effective adaptations.

Research Product: The project report shall include documented relationships between the duration and the number of freeze-thaw cycles and pavement performance in terms of roughness, cracking and permanent deformation. The report shall identify effective methods used to compensate for the effects of frost penetration beneath pavements, and recommend ways to consider these methods in mechanistic-empirical pavement design.

Estimate of Problem Funding and Research Period:

Funding:	$375,000
Period:	2.5 years
Project commitment during Spring 2001.	
Begin project:	Fall 2001.
Project completion:	Spring 2004.

Urgency, payoff potential, and implementation: This project will lead to the production of valuable design information concerning freeze-thaw effects and their mitigation. The payoff potential is excellent in terms of improved pavement performance for a large number of states having either deep frost penetration or multiple freeze-thaw cycles each year. Data availability and data quality in the LTPP database are believed to be adequate to allow the project to produce sound results. Thus, this project should be undertaken as soon as possible.

Issues: Funding for analysis of LTPP data has been severely reduced in the TEA-21 budget allocation. Without a pooled fund study, this project will not be undertaken and the relationship between pavement performance and multiple freeze-thaw cycles will not be developed.

Management: Managed by the FHWA. Selection of the contractor to perform the work will be done by a panel made up of representatives of states contributing to the pooled fund project.

POOLED FUND STUDY
FUNDING COMMITMENT FORM

PROJECT TITLE: Effect of Multiple Freeze-Thaw Cycles Versus Deep Frost Penetration on Pavement Performance, TPF-5(013)

STATE: **DATE:**

We wish to participate in the pooled fund study entitled
"_____".

This project is being sponsored by _____.

Yes _____ **No_____**

PROPOSED TOTAL LEVEL OF FUNDING SUPPORT: $_____
(Note: This is an authorization of funds. States will be asked to obligate funds later through the Federal-aid process.)

		COMMENTS ON FUNDING LEVELS
2001	**$_____**	**_____**
2002	**$_____**	**_____**
2003	**$_____**	**_____**

COMMENTS: (If a state plans to use funds other than SP&R, please comment below.

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STATE CONTACTS:

Technical Contact:_____ Phone_____

SP&R Funding Contact: _____ Phone_____