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16. Abstract

This summary report presents the most important concepts, findings, and recommendations developed in this research project. Issues related to implementation of the research results are also discussed in detail.

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# PLAN FOR DEVELOPING A MATERIALS PERFORMANCE DATABASE FOR THE TEXAS DEPARTMENT OF TRANSPORTATION


Zhanmin Zhang
David W. Fowler
W. Ronald Hudson



Project Summary Report Number 1785-S

Research Project 0-1785
Project Title: *Develop Basic Information to Be Used for Developing a Plan to Monitor Performance of Materials*

Conducted for the

**TEXAS DEPARTMENT OF TRANSPORTATION**

in cooperation with the

**U.S. DEPARTMENT OF TRANSPORTATION**
**Federal Highway Administration**

by the

**CENTER FOR TRANSPORTATION RESEARCH**
**Bureau of Engineering Research**
**THE UNIVERSITY OF TEXAS AT AUSTIN**

September 1999

## IMPLEMENTATION RECOMMENDATIONS

This project focused on a plan for developing a materials performance database for the Texas Department of Transportation. Currently, all the material-related data are stored in Excel or other spreadsheet format and the analyses are performed using an ad hoc approach. Owing to the amount and complex nature of the data, the current data storage and analysis approach has proved to be insufficient to monitor the performance of materials. In order to standardize the data management and performance-monitoring procedures and to ensure the continuity of the efforts in this area, a robust and reliable GIS-based materials database is urgently needed. The system should allow integration with Excel, Word, and other common software so that data already being entered by districts on automated forms will be captured by the database without duplicating data input. The following tasks are recommended for the implementation:

1. **Needs Analysis and User Requirements:** Work with the Construction Division, other related divisions/sections, and the project director to finalize and prioritize a list of material data types (e.g., hot mix, concrete, and flexible base) and the data processing and analysis functions that the database needs to support. Research Report 1785-2 has already developed recommended materials and analysis functions. Existing material data and analysis procedures currently available in Excel and other formats will also be taken into consideration in this process. This effort will finalize user requirements for the proposed database development.

2. **Conceptual Design of the Database**: Finalize the conceptual design for the database using the information from Task 1 and the conceptual framework outlined in Research Report 1785-2. The conceptual design will account not only for the requirements established under Task 1 but also for the compatibility and interface between the material database and other databases being used by TxDOT, including ForenSys, PMIS, and SiteManager. In addition, the appropriate tools and computing environment for programming the database will be determined to ensure that the database will be compatible with TxDOT's computing environment.

3. **Database Development:** Once the final conceptual design of the database is approved by the project director, proceed with the actual development of the database. At the first stage of database development, emphasis will be given to basic database functions, such as those relating to data entry, editing, and query.

4. **Database Population**: Design the database such that it will incorporate or interface with all software currently being used or proposed for use in TxDOT. This design feature will prevent duplication of data entry into the database wherever possible. The Construction Division has collected a considerable amount of material data, such as aggregate, hot-mix properties, and other miscellaneous data. Currently these data are stored in Microsoft Excel or in other spreadsheet formats. Once the database is developed, these data need to be converted and imported into the developed material database for future use.

As a pilot implementation exercise, the database will be populated with material construction data for a selected district (e.g., information on concrete, hot mix, and flex base). In other words, the product of the implementation will be a fully functioning database that can be used by the selected district to perform the functions described above.

**5. Data Analysis Module:** After completion of Tasks 1 through 4, at which point all the material data will be easily accessed through the database, add, in the second stage of the database development, certain routinely used material data analysis functions (such as standard deviations, sorting, and histograms) to support practical use of the database. Specific analysis functions to be added will be determined through consultation with the project director.

**6. Graphical Data Display Module:** To enhance the user friendliness of the database, add a set of graphical data display functions to the database. The graphical data display module will include such functions as profile graph and data summary charts.

**7. User's Manual:** Develop a user's manual to support the operation of the database.

**8. Technical Memorandum:** Provide a technical memorandum summarizing the database development. The memo should include recommendations for future database improvements.

## DISCLAIMERS



## ACKNOWLEDGMENTS

This project has benefited from the contributions of a number of TxDOT staff. Without their generous help and guidance, this final product would be severely diminished. In particular, we acknowledge the guidance provided by the project advisory committee members listed below. Additionally, we appreciate the generosity of those who agreed to be interviewed during the course of this research. These individuals include Paul Krugler, Kim Hajek, Frank Williams, Scott Lambert, Floyd Inman, and Steve Smith.

**Project Advisory Committee:**

| | | |
|---|---|---|
| Mr. Gerald Freytag | Current Project Coordinator | Yoakum District |
| Mr. Mike Koen | Project Director | Construction Division |
| Mr. George Lantz | Former Project Coordinator | Construction Division |

Research performed in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration.

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## SUMMARY OF RESEARCH FINDINGS

## INTRODUCTION

Materials and materials properties/characteristics are essential design elements in construction engineering. Within a given transportation infrastructure, for example, materials properties and characteristics can ultimately control the performance of that infrastructure. Despite pronouncements regarding exotic, new materials and changes in available materials, most of the natural and synthetic materials available for transportation construction within Texas are indigenous. As a consequence, precedents for materials use and performance have historically been based on practical experience with specific material sources.

Now, however, materials sources and observed performance are changing. Changes in the performance and properties of materials have occurred with the development of new asphalt and other material sources within Texas (including importation of Mexican cement). In addition to new sources of transportation materials, new design procedures, such as the SuperPave specifications, are calling for more complex and expensive testing.

These changes in material properties and in design/specification procedures make it increasingly important to establish a database record of material properties and material data within the state. With such a database, it will be easier for an agency — particularly the Texas Department of Transportation (TxDOT) — to evaluate the performance of available materials. In order to handle the vast amount of information and data required to monitor the performance of materials used by TxDOT, a *computerized* database will be necessary. Based on current computer and information systems technology, it is clear that a computerized database represents a reasonable solution to this emerging problem. This computerized database and information system, which will generally be referred to as the "proposed database" throughout this report, must be able to store, retrieve, update, modify, analyze, and display the basic information required to monitor the performance of materials.

In September 1997, TxDOT initiated Project 0-1785, *Develop Basic Information to Be Used for Developing a Plan to Monitor the Performance of Materials*. The goal of the project was clearly stated in the project title itself. Since a database is considered a necessary part of this plan, the true goal or purpose of this project was to develop the information necessary to build a performance-monitoring database. However, this project in no way sought to actually produce a database. On the contrary, its goal was to provide most of the information necessary to allow TxDOT to develop such a database, when specific decisions are made based on the findings and recommendations from this research.

## FACTORS AFFECTING MATERIALS PERFORMANCE

A variety of factors can affect the performance of materials. As illustrated in Figure 1, factors affecting the performance of a transportation material can be grouped into six categories: (1) construction, (2) traffic, (3) design and mix proportioning, (4) environment, (5) constituents, and (6) adjacent materials.

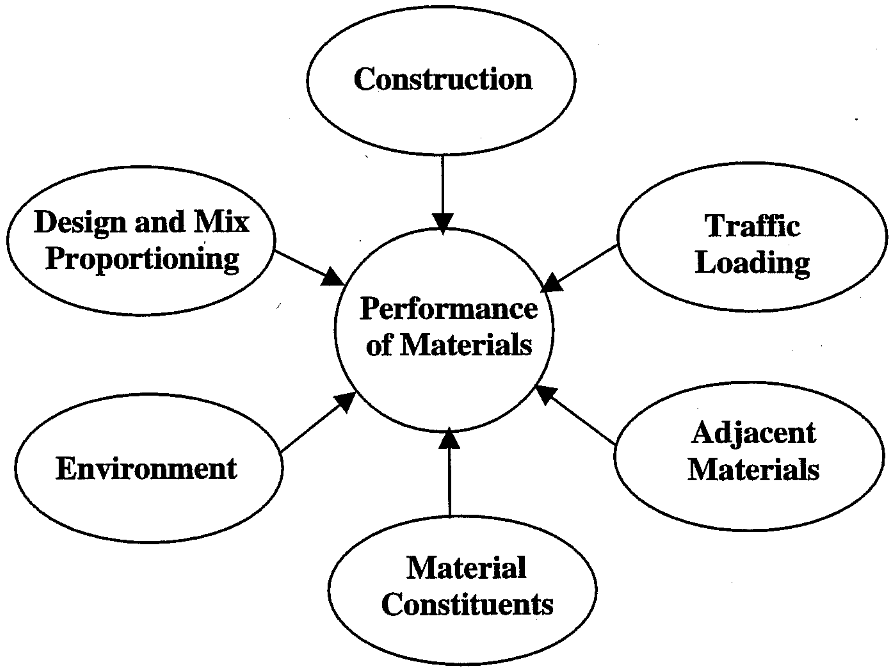


Figure 1. Factor categories affecting the performance of materials

Of course, any method for monitoring the performance of materials is subject to limited resources, limiting the number of categories and the levels of detail that can be taken into account.

## PERFORMANCE SCENARIOS

The performance of a material may be monitored in different ways. In transportation applications, different performance monitoring schemes can best be described as a set of performance scenarios, with each scenario defined according to the period over which the material is evaluated and the types of data needed to monitor that performance. Figure 2 shows a matrix of all the possible scenarios.

As indicated in Figure 2, there are four possible combinations of field/lab testing and long-term/short-term performance. Each of the combinations requires using different types of data elements. Scenarios A and B, including short-term performance using both field and lab-tested materials properties, will be the preferred scheme for monitoring the quality or performance of materials for the proposed database. Although it is feasible to monitor the long-term performance of materials through field tests (as in Scenario C), obtaining the long-term performance data would involve a long-term commitment to monitor the life cycle of certain sections. Scenario D would require the use of certain types of special equipment, such as the Texas Mobile Load Simulator (TxMLS).

| | SHORT-TERM | LONG-TERM |
|---|---|---|
| LAB | Scenario A | Scenario D |
| FIELD | Scenario B | Scenario C |

Figure 2. Matrix showing different performance scenarios

For a truly comprehensive performance evaluation of any material, the best approach would be a scenario in which information from all scenarios is synthesized. However, it would take years for such a scenario to work. With the understanding of the pros and cons associated with different scenarios, it is clear that using the short-term-based performance scheme (Scenarios A and B) as the starting point for the proposed database is more feasible. Once the first version of the database is developed and implemented, it can be further expanded to cover long-term and comprehensive performance-monitoring scenarios.

## A CONCEPTUAL DESIGN OF THE DATABASE

Figure 3 presents the conceptual design of the database — a blueprint for the actual development of the proposed database. The conceptual design defines the major components of the database, with the relevant information flowing throughout these components.

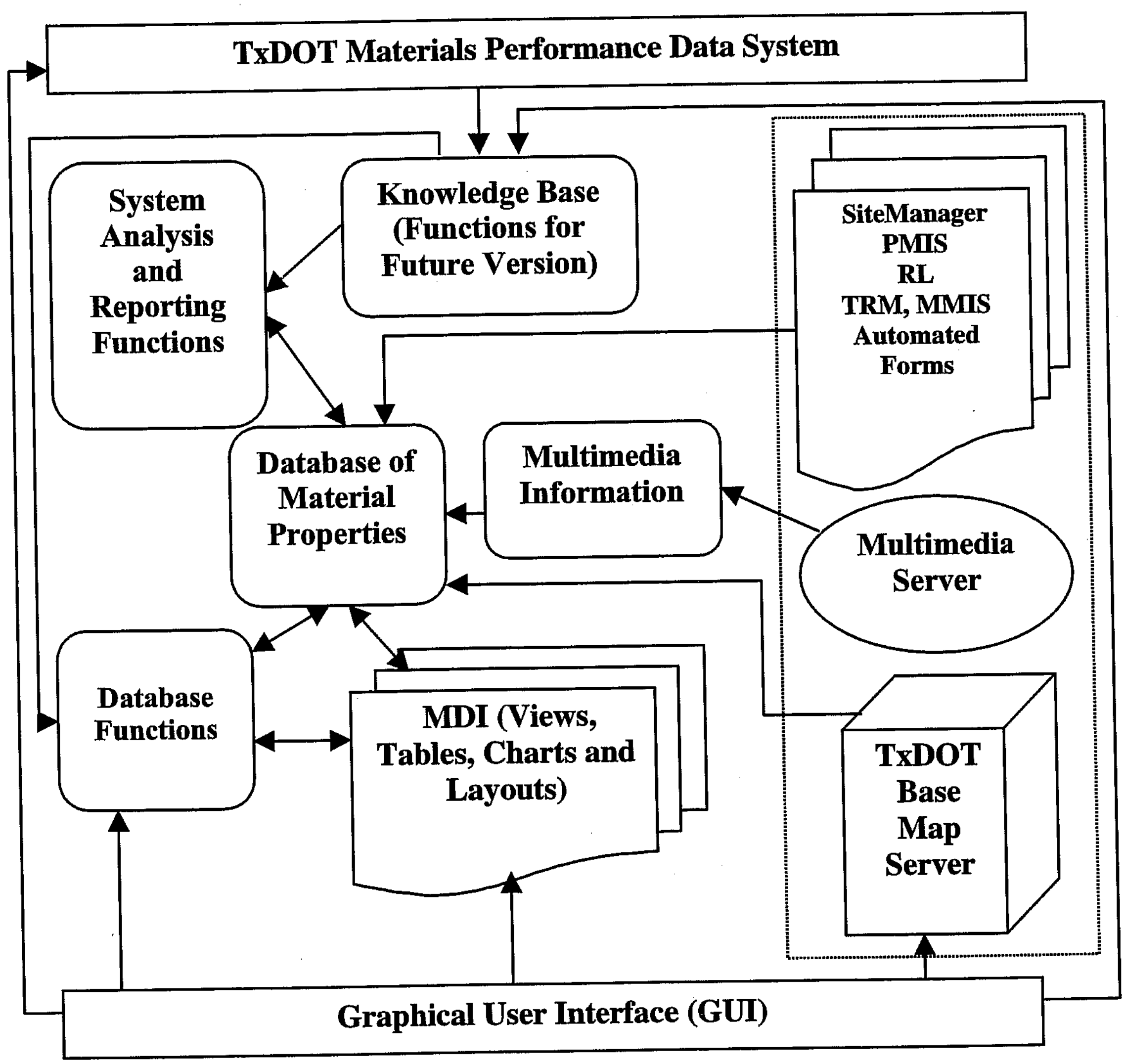


Figure 3: Conceptual framework design for TxDOT materials performance database

The proposed database, if implemented according to the recommended plan, will be able to perform such specific tasks as:

- Display a map highlighting all the sections of roadway in a district that were constructed with an average lab density (or compressive strength, asphalt content, or other property) that is above the districtwide average.
- Compare the maintenance costs of those sections (above) with average sections.
- Display the average standard deviation (construction variability) for a specific parameter for each contractor.
- Correlate maintenance costs or pavement life with construction variability.

## IMPLEMENTATION

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## COST OF THE DATA STORAGE MEDIA FOR IMPLEMENTING THE DATABASE

Traditionally, the cost of data storage media has been one of the factors that impede large database development and implementation. With the rapid advancement of computer technologies, however, the cost of data storage has now dropped to a point where it no longer poses a hurdle for database implementation.

For example, the photo-logging system in the Odessa District, which is considered one of the largest data storage systems, uses a 90 GB Raid System to store about 8,000 miles of images. A Dell Poweredge 6300 with a 252 GB storage space is currently priced at $7,799:

$$\frac{\textbf{90 GB}}{\textbf{8000 mi.}} \quad \times \quad \frac{\textbf{\$7,799}}{\textbf{252 GB}} \quad = \quad \textbf{\$0.3482 per mile}$$

In other words, for such a large system, the unit price for storage is only $0.3482 per mile. Assuming that there is an average of 10,000 miles in each district, the total cost for a statewide system would be:

**10,000 miles / District x 25 Districts x $0.3482 / mile = $87,050**

which is about $3,500 per district.

In summary, costs for data storage should not restrict the development and implementation of the proposed database.