

Database Development for Pavement Performance Modeling

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Abstract— *Pavement Management System (PMS) is defined as set of tools or methods that can support decision makers in finding the optimum strategies for providing, evaluating, and maintaining pavement condition in acceptable level. The Iowa Pavement Management Program (IPMP) provides information about Iowa highways such as distress data and maintenance activities.*

One of the most factors that affect pavement performance is weather factors (temperature, freeze-thaw cycles, and rainfall). The historical climate data was obtained from Iowa Environmental Mesonet (IEM) for counties in the state of Iowa.

The pavement condition and climate data can be integrated for pavement performance modeling. The Geographic Information System (GIS) is identified as an effective tool for data integration.

The primary goal of this paper is to utilize the GIS tools to integrate pavement conditions and climate data for improving Iowa PMS.

Keywords— *PMS, Iowa, GIS, IEM, Integration pavements.*

I. INTRODUCTION

State highway agencies spend millions of dollars in collecting several types of data such as road roadway inventory, traffic, climate and pavement condition data. Iowa DOT spends \$75/mile for local roads and \$60/mile for county roads for data collection [5]. Highway agencies spend over five billion dollars for repairing roads that damaged by snow, and around \$1100 was spent by state and local transportation agencies on winter maintenance [7]. In 1994, Iowa Department of Transportation (DOT) had launched a project called Iowa Pavement Management Program (IPMP) that allows the transportation agencies to implement pavement management on their roadways [8]. A collection, management, and integration data are a critical component of asset management system, and accurate data provide reliable information that can be relied on for effective and efficient decision making [3]. Collected data mainly depends on the level of decisions that required to

be taken. The level of data detail varies among project, network, and strategic management levels. After acquiring data, there are several methods and technologies have been used by many agencies to manage a wide range data such as Geographic Information System (GIS). The GIS has the capability to link different data sources for any transportation agency to facilitate decision making. In GIS, the databases can be integrated into one database to be used in the analysis for support decision-making process.

Predicting pavement performance requires information about pavement distresses, traffic loading, and climate data, etc. These data are often from different agencies or offices, and might each data source use different data format or referencing systems.

To facilitate the modeling process and other pavement management systems activities, it would be required to integrate these different data in one data format. FHWA (2010) reported two approaches that can be used for data integration [2]: fused databases and interoperable databases. For a fused database, multiple data resources combine into one database for one time, whereas interoperable database utilizes series of data sources by using multiple queries to relate data from different databases.

The primary objective of this study was to develop a database by integrating the pavement condition data from Iowa DOT Pavement Management Information System (PMIS) and climate data from Iowa Environmental Mesonet (IEM) to utilize for developing pavement performance prediction models for flexible, rigid, and composite pavements.

II. IOWA DOT PMIS DATA

The IPMP database includes most information about highway systems such as section identification, construction history, design, maintenance, distress, and other factors that influence pavement performance. Iowa DOT PMIS manages around 23,500 miles of roads in Iowa for developing, implementing, and operating a pavement management system [4]. The pavement condition data is collected every year for half of the

network, and the other half is gathered in the following year. For instance, the pavement condition data is gathered for northwest Iowa in even years and the southeast Iowa in odd years as shown in Figure 1.

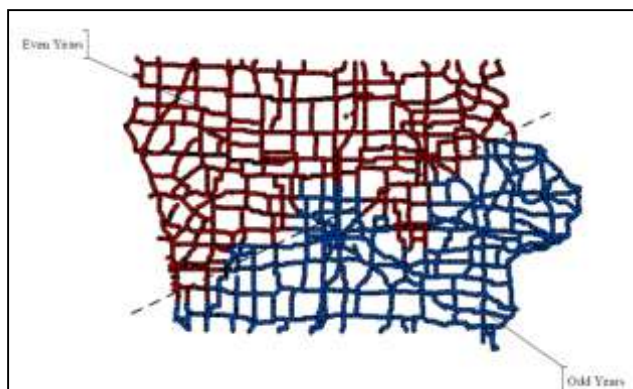


Fig. 1: Data Collection Practice (Jeong et al. 2016)

III. IOWA ENVIRONMENTAL MESONET (IEM)

Environmental conditions have significant impacts on pavement performance. Average Temperature, freeze-thaw cycle, and snowfall and rainfall amount have a direct effect on pavements performance over their service life.

Breakah et al. (2011) reported several factors of climate that affect pavement performance as follows [1]:

- Temperature affects strength of flexible pavements
- Freeze-thaw cycles affect the resilient moduli of unsterilized material
- The subgrade is weaker in spring and stronger in winter.
- Frost penetration affect the subgrade when it thaws (In the state of Iowa, the frost penetration ranges from 45 and 75 in).
- Rainfall affects subgrades and level of water table.

Therefore, it is essential to understand the behavior of pavement with environmental factors to be able to predict future pavement performance.

Iowa Environmental Mesonet (IEM) develop by Iowa State University (<http://mesonet.agron.iastate.edu/>). The IEM developed files of climate data that have collected from Federal Aviation Administration/National Weather Service that located in at the larger airport and Cooperative Observer Program (CCOP) network [1]. These files contain climate data for each county for a period from 1951 to 2017. Some counties have more than one weather station. Figure 2 shows the distribution of weather station over the state of Iowa.

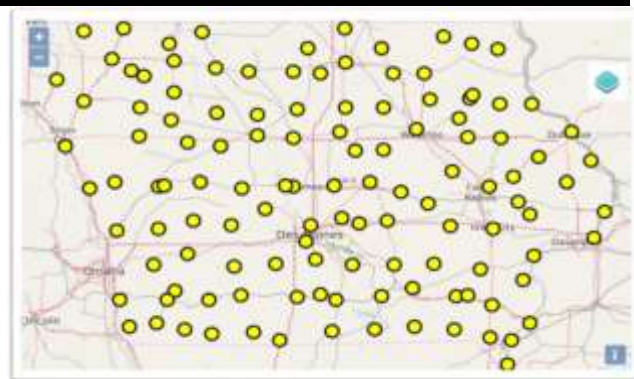


Fig. 2: Distribution of Mesonet weather stations across the state of Iowa

IV. INTEGRATING CLIMATE AND PMIS DATA

The purpose of data integration was to facilitate pavement performance modeling. The weather data were obtained from Iowa Environmental Mesonet (IEM) from 1998 to 2015. Ninety-nine weather stations have been selected to represent the environmental condition in Iowa. In case any counties have more than one weather station, the station that located near to the county center is selected. Figure 3 shows the counties map of the state of Iowa.



Fig. 3: Iowa's Counties

The Geographic Information System (GIS) was used to relate available weather data to highway networks to evaluate the effect of weather on pavement performance. The climate data is stored in point stations, and each county has many point stations. Therefore, any weather station that is approximately located in the center of each county was selected and then its data was used for the highways within that county.

V. CONCLUSION

The central component of the transportation asset management is the available data that can help the highway agencies to take the right decision. The available data are often obtained from different resources. These various databases can be integrated by using GIS which helps to relate all relevant information. In this study, the

GIS was used to integrate the environmental data from IEM and pavement condition data from Iowa DOT to be ready for use in developing pavement performance prediction models for flexible, rigid, and composite pavements for Iowa highways.

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