Impact of Forecasted Freight Trends on Highway Pavement Infrastructure

by

Sathish Kannan Nagarajan

A Thesis Presented in Partial Fulfillment
of the Requirements for the Degree
Master of Science

Approved April 2016 by the
Graduate Supervisory Committee:

Benjamin Shane Underwood, Chair
Kamil Kaloush
Michael Mamlouk

ARIZONA STATE UNIVERSITY

May 2016

ABSTRACT

The major challenge for any pavement is the freight transport carried by the structure. This challenge is expected to increase in the coming years as freight movements are projected to grow and because these movements account for most of the load related distresses for the pavement. Substantial effort has been devoted to identifying the impacts of these future national freight trends with respect to the environment, economic growth, congestion, and reliability. These are all important aspects relating to the freight question, but an equally important and often overlooked aspect of this issue involves the impact of freight trends on the physical infrastructure. This study analyzes the impact of future freight traffic trends on 26 major interstates representing 68% of the total system mileage and carrying 80% of the total national roadway freight. The pavement segments were analyzed using the Mechanistic Empirical Pavement Design Guide software after collecting the relevant traffic, climate, structural, and material properties. Comparisons were drawn between the expected pavement performance using current design standards for traffic growth and performance predictions that incorporated more detailed freight projections which themselves considered job growth and six key drivers of freight movement. The differences in the resultant performance were used to generate maps that provide a bird's eye view of locations that are especially vulnerable to future trends in freight movement. The analysis shows that the areas of greatest vulnerability include segments that are directly linked to the busiest ports, and surprisingly those from Atlantic and Central states that provide long distance connectivity, but do not currently carry the highest traffic volumes.

DEDICATION

This thesis work is dedicated to my parents Parameswari Ramakrishnan and Nagarajan Nagasundaram, who have been my constant source of support and guidance in every stage of my life.

ACKNOWLEDGMENTS

I would like to express my deep gratitude to my advisor Dr. Shane Underwood for giving me an opportunity to work with him. He helped me to continuously improve my skills and develop as an able researcher. I am thankful to him for his valuable lessons on Mechanistic Empirical Pavement Design Guideline, which formed the basis for this thesis, and the opportunities to present my research work at various different forums and conferences. He has been a constant driving force throughout my masters program.

I want to thank my other committee members Dr. Kamil Kaloush and Dr. Michael Mamlouk for teaching me the important concepts in pavement engineering and involving me in the various departmental activities.

I would like to acknowledge Dr. Jeffrey Stempihar for his valuable inputs throughout the course of my research. I would like to thank my research group members Padmini, Akshay, Jose, Ramadan, Hossein and Ashraf for their support throughout my course of study.

I would like to gratefully acknowledge the National Transportation Center at Maryland for the financial support extended for this project. I would also like to thank ADOT and other state and private agencies for helping me with the various inputs required for the study.

I would like to thank my grandparents and family members for all their love, prayers and motivation they have provided throughout my career.

Finally, I would like to thank my friends here and in India for their continuous help and support.

TABLE OF CONTENTS

CHAPTER Page

CHAPTER Page

CHAPTER Page

APPENDIX

APPENDIX Page

LIST OF TABLES

Table Page

LIST OF FIGURES

Figure Page

Figure Page

1.0 Introduction

1.1 Background

The economic vitality and prosperity of a city/state/region/nation is closely related to freight transportation (Mani and Prozzi 2004). As the world develops and population increase, the demand for freight will likely increase and these impacts are expected to become more severe. As discussed by Kveiborg et al. 2006, changes in freight movement are directly related to the economic growth of the region wherein the increase in the number of trucks is mainly related to the increase in production. While this increase in truck movements is a sign of a healthy economy, it comes with its own negative effects such as increased congestion, increased CO_2 emission among others. One aspect that has received relatively little research attention is the impact, that this increased truck movements may create on the pavement infrastructure.

1.2 Study Objective

The objective of this research is to investigate and quantify the impacts of national freight traffic trends and volume projections on the major interstate routes in the United States, by considering the localized materials, structure, climate, and traffic conditions. The principle outcome of this study is identification of the major transportation corridors where projected freight trends may have the strongest negative impact on the transportation infrastructure.

1.3 Scope of Work

This research directly addresses the freight efficiency and reliability focus of the national transportation. Freight mobility has traditionally been investigated in terms of congestion, but in this study another component of the issue will be investigated: the impact of changes in freight movement on the pavement infrastructure. The findings from this study will add another dimension to the discussion of freight efficiency and reliability and inform public policies and infrastructure investment decisions for more efficient pavement planning programs.

1.4 Outline

Evaluating the effects of future freight movements on pavement infrastructure is not a simple problem since these projections depend on an assessment of current traffic conditions and an accurate prediction of economic and population growth. In addition, any accurate prediction of pavement deterioration requires along with the future freight traffic, consideration of the existing pavement and soil conditions, future traffic growth rate and the environmental conditions. In this project the current traffic, climate, soil and the pavement structural details for 26 of the major interstate routes in the United States has been considered as the input. Current freight trends are projected for future conditions and the pavement segments are analyzed using the Mechanistic Empirical Pavement Design Guideline method. The results thus obtained are analyzed with respect to the IRI, fatigue, rutting transverse cracking and faulting characteristics of the pavement segments, and those interstate segments that may be most affected by future traffic are identified and represented using a series of ArcGIS pavement distress maps.

1.5 Organization of Thesis

This thesis is divided into six chapters. Chapter 1 provides background and brief description of the work done in this research including the study objective, scope of work and an outline of the thesis. Chapter 2 summarizes the literature review conducted in support of the current research study, which covers the topics of Freight transportation in USA, pavement performance, pavement distresses, Mechanistic Empirical pavement analysis and design and Life Cycle Cost Analysis (LCCA). Chapter 3 provides information about the analysis segments, the rules for dividing the interstates in to segments, and a description of interstates considered for analysis. Chapter 4 describes the MEPDG simulation process. Chapter 5 presents a summary of main findings and the life cycle cost calculations. Chapter 6 provides conclusions of this research as well as the potential for future research.

2.0 Literature Review

2.1 Freight Transportation in USA

In the US, the freight demand is expected to grow from 16 billion tons today to 31.4 billion tons in 2035 (AASHTO 2007). Of this freight, 67% is carried on trucks over highways, and this trend too is projected to continue well into the future (Strocko et al. 2013). Projection of economic growth prediction for a region is one of the most unpredictable because the growth depends on numerous factors some of which may not be taken up at all. The reliability of these projections decreases with the overall projection period considered, e.g., a 20 year projection is less reliable than a 10 year projection. Nevertheless, many agencies and government groups rely on these projections in order to plan their congestion management strategies and/or their business practices. Much of this freight is being moved via highways, which is a pattern expected to continue into the foreseeable future (Costello 2014).

To date many studies that have evaluated this important issue have considered current and future freight movement in the context of environmental impacts, congestion and/or access reliability (McKinnon 1999, Sankaran et al. 2005, Facanha et al. 2006, Zeitsman et al. 2006, Alam et al. 2007, Wheeler and Figliozzi 2011, Lee et al. 2009, Protopapas et al. 2013). The findings from the Alam et al. (2007) study are particularly relevant; see Figure 1, as they show projected impacts of freight movement on congestion in a very power visual map. All these studies suggest a higher possibility of increase in freight traffic in the United States in the coming years, but none have focused specific attention on the impact of these projected freight trends on the performance of the infrastructure itself.

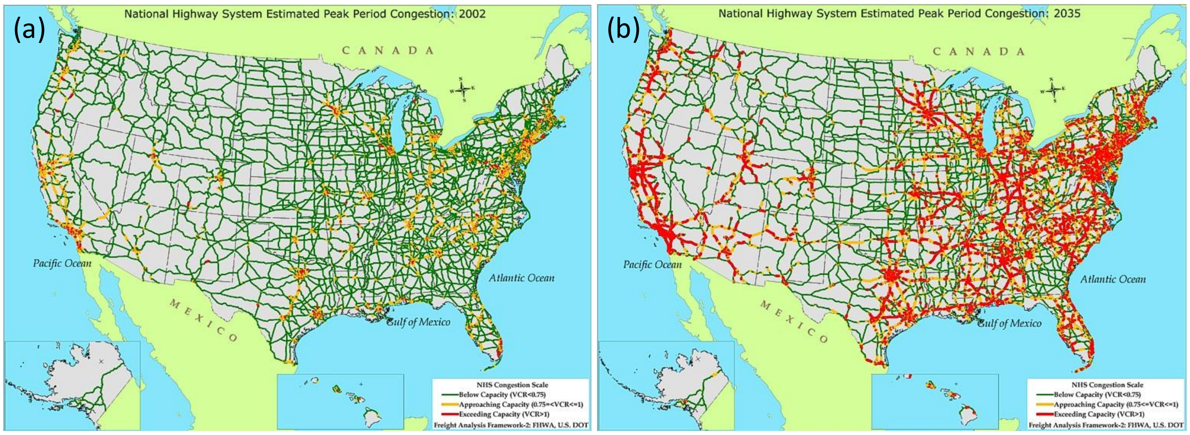


Figure 1: (a) Congestion on Major Corridors for 2002 and (b) Projected Congestion along Interstate Corridors for 2035 (Alam et al. 2007).

Many public sector transportation agencies have started to focus more on freight transportation issues. This focus reflects both the importance of freight transportation to sustaining economic growth and quality of life, but also a growing emphasis on freight planning in federal legislation, most recently as a result of MAP-21 incentives for states to establish state freight plans and state freight advisory committees (USDOT). The bill passed in 2012, directed the US Department of Transportation to develop a national freight strategic plan laying out a course of action to meet national freight policy goals designed to improve the movement of freight in the US.

2.2 Pavement Performance

Despite the substantial interest in freight movements, one aspect that has received relatively little attention is the potential impacts that the increased movement of goods may have on the transportation infrastructure. Such a lack of attention is surprising since the impacts of decreased pavement performance include:

- Increased user costs in terms of both vehicle operating costs and in delays from maintenance and preservation/rehabilitation activities (Hensher and Puckett 2005);
- Higher levels of localized pollution from congested traffic (Piecyk and McKinnon 2010);
- Larger errors in congestion projections due to the unaccounted for increases in pavement maintenance; and
- Incomplete information in the geometric, operations, and pavements planning steps for transportation development, which can result in increasingly less than optimal engineering solutions.

Taken together, these impacts can substantially affect the economic vitality of localities, states, regions, and the nation as a whole.

It is intuitive that an increase in traffic volume will negatively impact the infrastructure since it is known that large trucks are the primary source of road damage due to the high stresses that they impart on the pavement (Gillespie and Karamihas 1994, Salama et al. 2006). However, a unique relationship between traffic volume and rate of deterioration does not exist because other factors (local climate conditions, localized construction and material practices, and interactions between traffic volume and the traffic loads) can also impact the infrastructure performance. One specific challenge is that changes in traffic volume can be generally associated with changes in the loads carried by the traffic, which are in turn nonlinearly related to performance. This nonlinearity is expressed as the rule of three, referring to the exponent of the nonlinear relationship between performance and load. As an example, take the case where the applied pavement load is doubled. According to the rule of three this doubling of load would result in an increase in fatigue performance by a factor of eight ($2^3 = 8$). Similar issues exist for other distresses in both asphalt concrete and Portland cement concrete as well.

2.3 Pavement Distresses

When engineers consider pavement performance they generally focus on the overall pavement smoothness as well as the distresses of fatigue cracking, rutting, and thermal cracking in the case of flexible pavements. Of these three distresses the first two can be readily associated with load related phenomenon, while the third stems from the pavement response to temperature changes. The process of fatigue cracking occurs through the repeated application of load cycles, which while individually not large enough to cause a structural pavement failure do contribute some incrementally small amount of damage in the pavement system. The distress generally appears first as cracks longitudinal or transverse to the travel direction and isolated to the wheel paths, Figure 2(a). With continued loading these cracks generally coalesce and grow until they reach a regular cracked pattern that resembles the scale pattern of an alligator, Figure 2(b). This pattern leads to the colloquial name for this type of distress: alligator cracking. In most low severity cases fatigue cracking can be mitigated through proper maintenance operations, but if this process does not occur in time then water can infiltrate the pavement system and lead to relatively rapid structural failure.

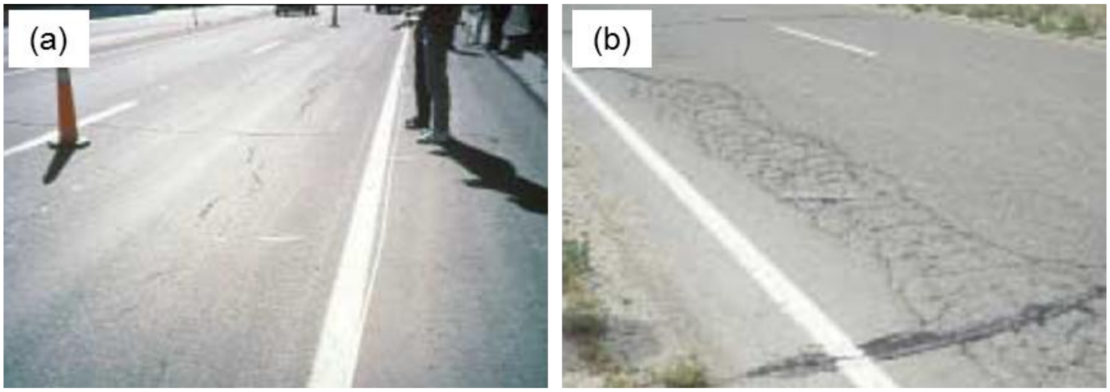


Figure 2: Examples of Fatigue Cracking in Asphalt Pavements; (a) Low Severity and (b) High Severity (Miller and Bellinger 2003).

The second load associated distress of principle interest is rutting, which manifests as longitudinal depressions in the pavement surface, Figure 3. Rutting can occur because of extreme deformation in any single pavement layer or due to relatively small accumulation across any of the individual layers. In the case of rutting the major concern is with respect to safety as water can accumulate in these depressions and lead to hydroplaning. In some extreme cases the depressions can be accompanied by large upheavals on either side, which can pose additional safety concerns from lane changes.

Figure 3: Examples of Rutting Distress in Asphalt Pavement.

The two primary types of distresses considered in the case of rigid pavements are transverse cracking and faulting. The presence of a thermal gradient in a PCC slab can induce significant stresses that, in conjunction with traffic loading, can lead to the development of transverse cracks as shown in Figure 4. Depending on the slab design, loading location, and temperature factors, this cracking can occur at mid-slab or at the slab corners. Transverse cracking mechanism is also caused by temperature shrinkage. As the PCC slab undergoes a drop in temperature, it will try to contract. The contraction is restrained by friction along the slab-base interface. If the frictional restraint is high enough or if the joint spacing is long enough, the tensile stress generated at midslab can exceed the strength of the concrete and a crack will develop (Hoerner et al 2001).

Figure 4: Example of Transverse Cracking in Rigid Pavement

Faulting is the difference in elevation between adjacent slabs and is a condition that affects the overall ride quality of a pavement as shown in Figure 5. It is most commonly the result of poor or inadequate load transfer across transverse joints. When the wheel load moves from the approach slab to the adjacent slab, the differential movement can induce pumping of the fine materials, which erodes the base material and further accelerates the distress. This pumping action can also lead to a continuous build-up of fines that causes the approach slab to lift or displace upwards relative to the leave slab causing faulting. It also creates a void beneath the leave side of the joint that can lead to the development of corner breaks.

Figure 5: Faulting in Rigid Pavement

2.4 Mechanistic Empirical Pavement Analysis and Design

Until recently accurate analysis of these impacts was not possible. The emergence of nationally verified mechanistic-empirical pavement analysis methods has overcome this limitation as this method represents a different paradigm of pavement analysis from that of the empirical process (Li et al. 2011). Factors influencing the pavement performance such as traffic, climate, pavement structure, and material properties are explicitly considered in the inputs. Then the principles of engineering mechanics are used to predict the critical pavement responses, which are coupled to mechanistic and empirical relationships established from engineering experience to predict the material damage and ultimately the pavement distress.

The Mechanistic-Empirical Pavement Design Guide (MEPDG) was first released in 2004 under the NCHRP project I-37A. It provides guidelines for designing the in-common features of flexible, rigid and composite pavements. It also provides procedures for evaluation of existing pavement and recommendations for rehabilitation. The computational software that makes up the MEPDG uses an integrated analysis approach. It predicts pavement performance over time by taking into account the interaction amongst the input factors (climate, structure, materials, and traffic). The software offers hierarchical levels of inputs based on the accuracy of details available. Level 1 input provide for the highest levels of accuracy and the lowest level of uncertainty. Level 1 material input requires extensive laboratory or field testing. Level 2 inputs provide an intermediate level of accuracy that involves a limited testing program and intermediate levels of accuracy. Level 3 inputs require a low level of accuracy, which may include typical average values for the region. National default values provided in the MEPDG software can also be used as level 3 inputs.

The MEPDG also includes comprehensive temperature and moisture consideration of the pavement system over the design life through the incorporation of Enhanced Integrated Climatic Model (EICM). It simulates the changes in the characteristics of the pavement and subgrade in coordination with the climatic conditions. The software has a built-in record of weather stations, which allows user to select the adjacent weather station. It still lacks a complete database for some of the weather stations, but has an accommodation to interpolate the climatic data from adjacent weather stations.

The software considers traffic by accounting for the full axle load spectrum. The traffic data are categorized by truck traffic volume, traffic volume adjustment factors, axle load distribution factors, and the general traffic inputs such as axle configuration, wheelbase and the axles per truck. The properties of materials used for construction constitute the material input. Material parameters associated with pavement distress criteria are related to the measure of the material's resistance to damage (tensile strength, plastic deformation resistance, etc.).

Pavement performance is primarily concerned with the functional and structural performance. The structural performance of a pavement relates to its physical condition (such as fatigue cracking and rutting in flexible pavement). Such key distresses can be predicted directly using the mechanistic concepts. Ride quality is the predominant factor in determining the functional performance, which is measured by the International Roughness Index (IRI). In MEPDG, IRI is estimated incrementally over the analysis period by incorporating distresses such as cracking, rutting as major factors influencing the loss of smoothness of pavement. The MEPDG procedure accumulates damage on a monthly basis over the entire analysis period. It simulates how pavement damage occurs in nature, incrementally load by load over continuous time periods. The procedure also allows for aging of pavements.

2.5 Life Cycle Cost Analysis (LCCA)

Life cycle cost analysis is an analysis technique that is built on well founded principles of economic analysis to evaluate the overall long term economic efficiency between competing alternative investment options. The procedure identifies the best value (the lowest long term cost that satisfies the performance objective) for investment expenditures. The National Highway System (NHS) Designation Act of 1995 specifically required states to conduct life cycle cost analysis on NHS projects costing $25 million or more.

LCCA is an analysis technique that supports more informed and better investment decisions. It builds on some well founded principles of economic analsysi that have been used to evaluate highway and other public works investments for years, but LCCA has a slightly stronger focus on the longer term. It incorporates discounted long term agency, user, and other relevant costs over the life of a highway to identify the best value for investment expenditures. Life cycle cost analysis should be conducted as early in the project development cycle as possible. The LCCA analysis period or the time frame for which alternatives are evaluated should be sufficient to reflect long term cost differences associated with reasonable design strategies. While FHWA's LCCA policy statement recommends an analysis period of at least 35 years for all pavement projects, including new or new or total reconstruction projects as well as rehabilitation, restoration, and resurfacing projects, an analysis period range of 30 to 40 years is not unreasonable. Future cost and benefit streams should be estimated in constant dollars and discounted to the present using a real discount rate. Although nominal dollars can be used with nominal discount rates, use of real/constant dollars and real discount rates eliminates the need to estimate and include an inflation premium. The discount rates employed in LCCA should reflect historical trends over long periods of time. Although long term trends for real discount rates hover around 4 percent, 3 to 5 percent is an acceptable range and is consistent with historical values. Performance periods for pavement designs and rehabilitation strategies have a significant impact on analysis results. Longer performance periods for individual pavement designs require fewer rehabilitation projects and associated agency and work zones user costs. Routine, reactive type annual maintenance costs have only a marginal effect on NPV. They are hard to obtain, generally very small in comparison to initial construction and rehabilitation costs, and differentials between competing pavement strategies are usually very small, particularly when discounted over 30 to 40 year analysis periods. Salvage value should be based on the remaining life of an alternative at the end of the analysis period as a prorated share of the last rehabilitation cost.

User costs are the delay, vehicle operating, and crash costs incurred by the users of a facility and should be included the LCCA. Vehicle delay and crash costs are unlikely to vary among alternative pavement designs between periods of construction, maintenance, and rehabilitation operations. User costs are heavily influenced by current by current and future roadway operating characteristics. They are directly related to the current and future traffic demand, facility capacity, and the timing, as well as any circuitous mileage caused by detours. Directional hourly traffic demand forecasts for the analysis year in question are essential for determining work zone user costs.

Expenditure stream diagrams are developed once all the cost calculations are made. These are graphical representation of expenditures over time. They are generally developed for each pavement design strategy to help visualize the extent and timing of expenditures. Normally costs are depicted as upward arrows at the appropriate time they occur during the analysis period, and benefits are represented as negative cost or downward arrows. Once all costs and their timing have been developed, future costs must be discounted to the base year and added to the initial cost to determine the Net Present Value (NPV) for the LCCA alternative. NPV is the economic indicator of choice, and the basic NPV formula for discounting discrete future amounts at various points in time back to some base year is:

$$NPV = Initial\ Cost + \sum rehab\ cost\ \{1/(1+i)^n) \qquad (1)$$

The overall benefit of conducting a life cycle cost analysis is not necessarily the LCCA results themselves, but rather how the designer can use the information resulting from the analysis to modify the proposed alternatives and develop more cost effective strategies. LCCA results are just one of many factors that influence the ultimate selection of a pavement design strategy. The final decision may include a number of additional factors outside the LCCA process, such as local politics, availability of funding, industry capability to perform the required construction, and agency experience with a particular pavement type. Many assumptions, estimates, and projections fed the LCCA process. The variability associated with these inputs can have a major influence on the confidence of the results. The accuracy of LCCA results depends directly on the analyst’s ability to accurately forecast such variables as future costs, pavement performance, and traffic for more than 30 years into the future (Walls & Smith, 1998).

3.0 Methodology

3.1 Analysis Sections

The overall goal of this project is to assess the sensitivity of the pavement infrastructure along key interstate routes to freight movement projections. The methodology used to meet the objective described in section 1.2 is based on comparative analysis of pavement performance predictions using 1) the current traffic projections used by Departments of Transportation (DOTs) and 2) traffic projections that make explicit allowance for future freight trends. In lieu of the fact that this study is national in scope, these predictions are performed using the nationally calibrated version of the MEPDG. Evaluating the effects of future freight movements on pavement infrastructure is not a simple problem since these projections depend on an assessment of current traffic conditions and an accurate prediction of economic and population growth. In addition to consideration of future freight trends, accurate prediction of pavement deterioration requires consideration of the existing pavement structure, soil conditions, and climate. This data is not readily available in a single database and so multiple sources were researched and collected in order to obtain the required inputs. The project was limited in scope to consider only interstate pavements. In total, 26 different interstates were considered, as shown in Figure 6 and include I-5, I-10, I-15, I-20, I-24, I-35, I-40, I-44, I-55, I-64, I-65, I-69, I-70, I-75, I-76, I-77, I-78, I-80, I-81, I-82, I-83, I-84, I-85, I-90, I-94, and I-95. In total three different types of pavement systems were considered; asphalt concrete pavements, portland cement concrete pavements, and asphalt concrete overlay pavements. The asphalt concrete pavement and the asphalt concrete overlay (composite) types were combined together as their performance metrics were the same.

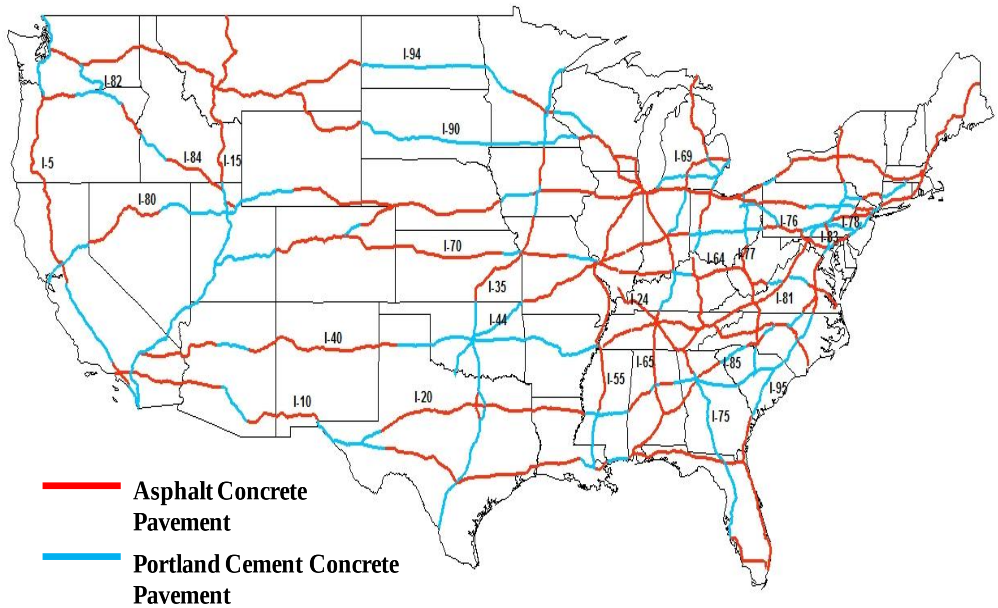


Figure 6: Map of Selected Interstates.

These interstates are selected based on the vehicular traffic they carry, the strategic importance to freight movement (port connectivity), their inclusion in the MAP-21 Primary Freight Network (MAP 21, 2012), and their geographic diversity. These 26 interstates represent 68% of the total interstate system by mileage (32,228 miles) and approximately 80% by freight volume (10.5 Billion Tons). It is noted that the selected interstates also connect all the top US-International trade freight gateways (FHWA 2013). The method used to organize this analysis into manageable pieces and still obtain an accurate assessment involved segmenting the routes into smaller and more uniform sections. This segmentation was based principally upon traffic, climate, and subsurface since these factors are known to contribute substantially to pavement performance. In addition, state boundaries were also used to segment the interstates as each state has its own set of pavement specifications, which will affect the materials utilized along each segment. In total there are 272 segments that have been analyzed for this study, and these are described in more detail below.

3.2 Segmentation Rules

The four main factors determining the stability of a pavement section are the traffic carried by the section, the climate in the area of the pavement, the soil over which the pavement is built, and the materials used in the paving layers. All other factors being equal if a pavement carries more traffic the process of deterioration will be faster and the probability of failure of the section will increase. Likewise, more extreme temperatures, greater amounts of precipitation, and inferior soils can hasten pavement deterioration. Materials are generally project specific, but are selected and designed following the guidelines and specifications laid out by State Departments of Transportation. The paragraphs below detail the rules applied in three of these categories (traffic, climate, and soil). The fourth criteria, state boundaries, were identified through geospatial mapping of the interstate routes.

3.2.1 Traffic

To segment the interstate routes by traffic, each available traffic segment (mile marker in some cases or larger sections in other cases) was ranked on a scale of 1 to 5. The assignment was based on the Average Annual Daily Truck Traffic (AADTT) values in the base year (2012);

- 1 = < 5,000,

- 2 = 5,001 – 10,000,
- 3 = 10,001 – 15,000,
- 4 = 15,001 – 20,000, and
- 5 = > 20,000

To populate this traffic database, data was collected from the National Highways Planning Network (NHPN 2015) and the various state Departments of Transportation, where it was found that each department generally follows its own format. Some provide the exact AADTT data on a mileage basis, but most do not. Some of the states provide the traffic values by sections on their county maps while some states provide it in other formats such as *.kml (Google earth) and *.shp (GIS applications). In cases where states provided only the average annual traffic, the department's design documentation was reviewed to identify either site specific or generally applied truck factors.

3.2.2 Soil

The second factor considered for the segmentation of interstates was the soil type for the region. The extensive mapping effort completed under NCHRP 9-23B was used for this purpose. In this project, researchers compiled soil maps, like that shown in Figure 7, by reviewing available databases and applying certain empirical predictive equations to estimate engineering properties. In this figure, each colored region represents an area of approximately uniform soil conditions. The database is available as an online application (http://nchrp923b.lab.asu.edu/index.html). An example of the output from this application is given in Figure 8, where it is seen that soil characteristics for a particular site are compiled as a function of depth according to AASHTO classification and engineering properties. In the AASHTO classification system soils are denoted as either A1, A2, A3, A4, A5, A6, or A7 with A1 denoting highly course and A7 denoting very fine soil. The strength of a pavement and the drainage conditions depend on its subgrade soil.

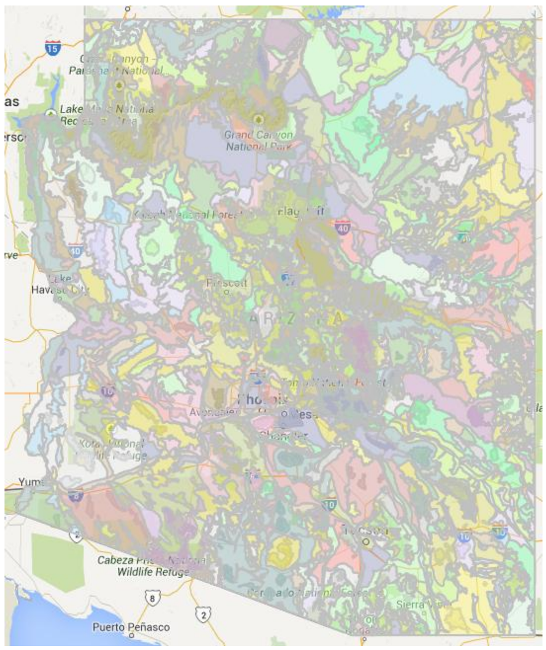
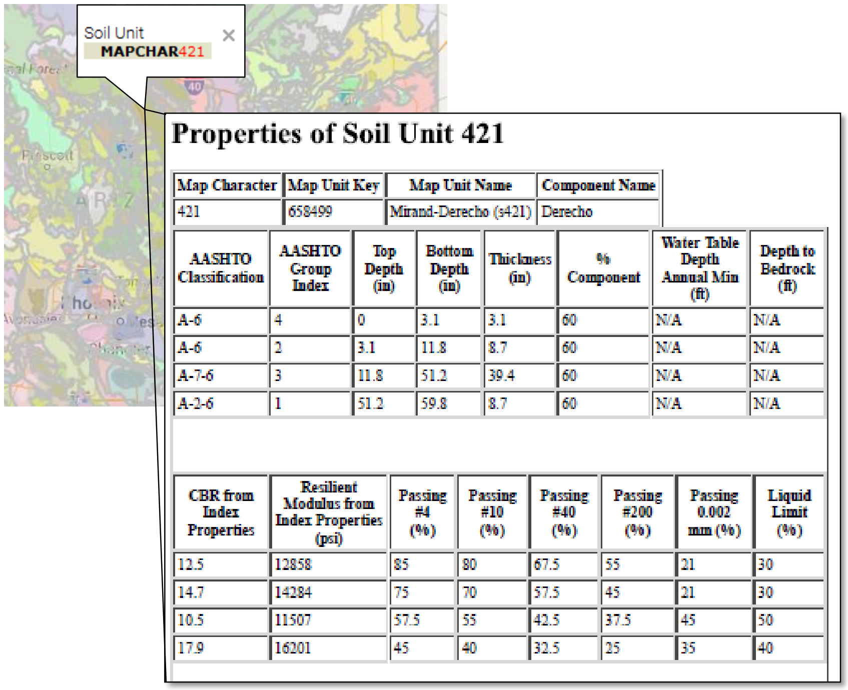


Figure 7: Example Map in NCHRP 9-23B Soil Map Application (State of Arizona).



Map Character	Map Unit Key	Map Unit Name	Component Name
421	658499	Mirand-Derecho (s421)	Derecho

AASHTO Classification	AASHTO Group Index	Top Depth (in)	Bottom Depth (in)	Thickness (in)	% Component	Water Table Depth Annual Min (ft)	Depth to Bedrock (ft)
A-6	4	0	3.1	3.1	60	N/A	N/A
A-6	2	3.1	11.8	8.7	60	N/A	N/A
A-7-6	3	11.8	51.2	39.4	60	N/A	N/A
A-2-6	1	51.2	59.8	8.7	60	N/A	N/A

CBR from Index Properties	Resilient Modulus from Index Properties (psi)	Passing #4 (%)	Passing #10 (%)	Passing #40 (%)	Passing #200 (%)	Passing 0.002 mm (%)	Liquid Limit (%)
12.5	12858	85	80	67.5	55	21	30
14.7	14284	75	70	57.5	45	21	30
10.5	11507	57.5	55	42.5	37.5	45	50
17.9	16201	45	40	32.5	25	35	40

Figure 8: Engineering Parameters from NCHRP 9-23B Application.

For the process of segmentation, the soil properties need to be known on a mile-by-mile basis, and this required some processing of the database. In this database information can be obtained from by two methods, both of which are discussed here. In the first method, the user chooses to search for route information and is taken to a second screen where he/she selects state, route type (Interstate in this case), and milepost are first selected. The web application then identifies the latitude and longitude coordinates, which the user must then paste into the appropriate boxes on the main screen of the application. Next, the user selects the ‘Get Map’ button and the soil layer corresponding to that particular point is displayed in color. By then moving the cursor on top of the colored map region and selecting the region a soil unit, referred to as a ‘MapChar’, is then displayed and the user enters this into the report box to generate a soil unit report. In the second method the soil report selection procedure is the same, but to identify the search 'MapChar', the user first gets a state-wide map and then manually identifies the requisite milepost locations.

The soil unit report describes the AASHTO type of soil present in that region, the thickness of each layer, water table depth (if known), depth to bedrock, and the other engineering properties of the soil. The search databases identified and functions developed by the NCHRP 9-23b research team are capable of estimating the soil properties at multiple depths (more than 60 inches in some cases). Some soil units are completely homogenous with depth, e.g., they show the same soil type for the entire profile. However, in some cases there are two or more types of soils present. In such cases, the weakest type of soil present at that location is considered. For example, if a given location contains an A2 soil for the top 3 inches and A4 soil for the next 12 inches, the soil type of the location is set as A4 for the segmentation process.

Based on its engineering properties, the high quality soils are given a low rating and the lower quality soils were given a higher rating. The rating scale is as follows.

- 1 = A1 & A2,
- 2 = A3,
- 3 = A4,
- 4 = A5, and
- 5 = A6 & A7.

3.2.3 Climate

The third factor considered in segmentation was climate with special reference to the total precipitation over the region. One of the main reasons for pavement failure is the seepage of water into the pavement and its effect on the subgrade. Hence the effect of precipitation on the pavement deterioration was also used. In order to accommodate the severity of damage caused due to rainfall on the pavement segments, the following methodology was used.

Those places experiencing no or very little rainfall are least susceptible to pavement deterioration due to water seepage, and following the general convention followed in this report, those places were given a rating 1. Analysis of rainfall data for the 51 major cities in the US, Table 1 shows that the annual rainfall distribution in these cities fell into the range of approximately 15 to 60 inches per year as shown in Figure 9Figure 9.

Additional investigations also showed that there were also areas, like Laurel mountain in Oregon and Forks in Washington, that receive exceptionally high rainfall of more than 80 inches per year (NCDC 2010). Owing to the fact that the overall resolution of this study was larger than the scale of many of these microclimates, the index ranges were established based on the city-wise analysis. As shown in Figure 9 the distribution of precipitation in these cities was close to normal with a mean of 37 inches and a standard deviation of 14 inches. Using this distribution as a guide and with the desire to choose ranges with convenient rainfall totals and spaced in approximately one standard deviation intervals, the rating system of 1-5 was devised with the following ranges;

- 1 = < 15 inches per year,
- 2 = 16 – 30 inches per year,
- 3 = 31 – 45 inches per year,
- 4 = 46 – 60 inches per year, and
- 5 = > 60 inches per year.

Table 1: Rainfall Data for 51 Major US Cities.

City	Rainfall (in.)	City	Rainfall (in.)	City	Rainfall (in.)
Atlanta, GA	49.7	Jacksonville, FL	52.4	Portland, OR	43.5
Austin, TX	34.2	Kansas City, MO	39.1	Providence, RI	47.2
Baltimore, MD	41.9	Las Vegas, NV	4.2	Raleigh, NC	46.0
Birmingham, AL	53.7	Los Angeles, CA	12.8	Richmond, VA	43.6
Boston, MA	43.8	Louisville, KY	44.9	Riverside, CA	10.3
Buffalo, NY	40.5	Memphis, TN	53.7	Rochester, NY	34.3
Charlotte, NC	41.6	Miami, FL	61.9	Sacramento, CA	18.5
Chicago, IL	36.9	Milwaukee, WI	34.8	Salt Lake City, UT	16.1
Cincinnati, OH	41.9	Minneapolis, MN	30.6	San Antonio, TX	32.3
Cleveland, OH	39.1	Nashville, TN	47.3	San Diego, CA	10.3
Columbus, OH	39.3	New Orleans, LA	62.7	San Francisco, CA	20.7
Dallas, TX	37.6	New York, NY	49.9	San Jose, CA	15.8
Denver, CO	15.6	Oklahoma City, OK	36.5	Seattle, WA	37.7
Detroit, MI	33.5	Orlando, FL	50.7	St. Louis, MO	41.0
Hartford, CT	45.9	Philadelphia, PA	41.5	Tampa, FL	46.3
Houston, TX	49.8	Phoenix, AZ	8.2	Virginia Beach, VA	46.5
Indianapolis, IN	42.4	Pittsburg, PA	38.2	Washington, DC	39.7

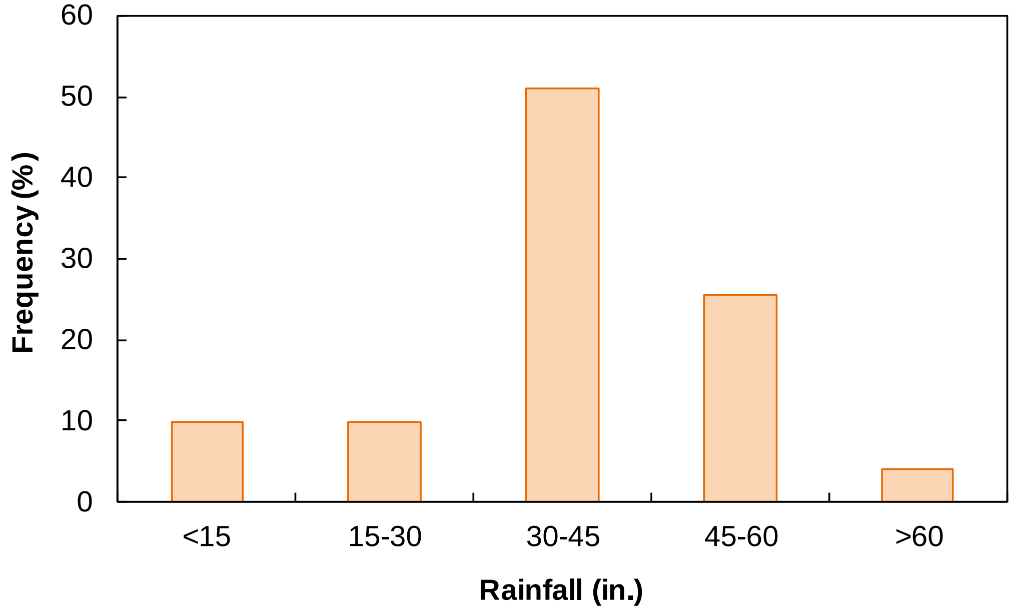


Figure 9: Rainfall Distribution in 51 Major Cities.

3.2.4 Combining Factors

The final segmentation of the interstate routes was based on the combined effect of all these factors, which was calculated by averaging the ratings of each of the three individual factors. Mileage sections with average ratings within the same whole point score were then taken to be a single section. Whenever there was an increase or decrease to the next whole point, a section was assigned to another segment. So for example, if generic section A had an average score of 3.4 and the following section (Section B) had a score of 3.9 they were taken to exist in the same segment. If Section B had a score of 4.1 the two sections would be assigned to different segments. The routes were also divided at the state boundaries because the design and construction details varied between states. Exceptions to the state boundary rule were made in cases where the interstate traversed one of the states for fewer than 40 miles, as in the case of Interstate 15 in Arizona. Additional limits on maximum and minimum length were assigned (200 and 50 miles respectively). The lower limit was relaxed only at a few places where the entire length of a pavement in a state was less than 50 miles, as in the case of Interstate 90 in Pennsylvania. Among all the interstates considered, Interstate 90 is the longest and also has the most number of segments for any interstate with 26 segments. Similarly Interstate 82 has the least number of segments as the entire length of 144 miles has been considered as a single segment.

3.3 Interstate Segments

In the following paragraphs a brief summary of the segmentation of each interstate is given. Appendix A contains a more detailed description of each analysis segment.

3.3.1 Interstate 5

Interstate 5 (I-5) runs north-south along the western coast connecting Mexico (near San Diego, CA) with Canada (near Blaine, WA). In total it traverses three states California, Oregon, and Washington and connects the major population centers of San Diego, Santa Ana, Anaheim, Los Angeles, Sacramento, Portland, and Seattle. It also provides connections to the San Francisco area through Interstates 580 and 505. It is the twelfth longest interstate in the US and the fifth longest north-south interstate. The total length of I-5 is 1,382 miles, with 797 miles in California, 308 miles in Oregon, and 277 miles in Washington. It has been divided into a total of 11 segments. These segments, their length and approximate descriptions are provided in Table 2.

Table 2: Interstate 5 Segments.

State	Length (Miles)	Sections			
		Name	**Length (Miles)**	**MP**	**Description**
California	797	I5-CA-1	85	0 to 85	San Diego County to Orange County
		I5-CA-2	189	86 to 274	Orange County to Kern County
		I5-CA-3	194	275 to 468	Kern County to San Joaquin County
		I5-CA-4	132	469 to 600	San Joaquin County to Glenn County
		I5-CA-5	197	600 to 797	Glenn County to Oregon border
Oregon	322	I5-OR-1	98	0 to 98	California border to Douglas County
		I5-OR-2	169	99 to 267	Douglas County to Marion County
		I5-OR-3	55	268 to 322	Marion County to Multnomah County
Washington	276	I5-WA-1	132	0 to 132	Oregon border to Pierce County
		I5-WA-2	46	133 to 178	Pierce County to Snohomish County
		I5-WA-3	98	179 to 276	Snohomish County to Canadian border

3.3.2 Interstate 10

Interstate 10 (I-10) is the southernmost transcontinental highway in the interstate system. It is one of the three coast to coast interstates in the country. It stretches from Santa Monica, California to Jacksonville, Florida. It is the fourth longest interstate in the US with a total length of 2,460 miles. Almost one third of its length lies within the state of Texas, but it also travels through major cities such as Los Angeles, California; Phoenix, Arizona; El Paso, Texas; San Antonio, Texas; Houston, Texas; New Orleans, Louisiana and Jacksonville, Florida. TO the east of Phoenix, Arizona (between Phoenix and Tucson) the route is a part of high priority corridor 26: CANAMEX Corridor. The length of I-10 in various states and the number of segments in each state is summarized in Table 3.

Table 3: Interstate 10 Segments.

State	Length (Miles)	Sections			
		Name	Length (Miles)	MP	Description
California	251	I10-CA-1	102	0 to 102	Los Angeles County to Riverside County
		I10-CA-2	149	103 to 251	Riverside County to Arizona border
Arizona	393	I10-AZ-1	137	0 to 137	California border to Maricopa County
		I10-AZ-2	145	138 to 282	Maricopa County to Pima County
		I10-AZ -3	111	283 to 393	Pima County to New Mexican border
New Mexico	164	I10-NM-1	164	0 to 164	Arizona border to Texas border
Texas	882	I10-TX-1	141	0 to 141	New Mexico border to Hudspeth County
		I10-TX-2	136	142 to 277	Hudspeth County to Pecos County
		I10-TX-3	161	278 to 438	Pecos County to Sutton County
		I10-TX-4	127	439 to 565	Sutton County to Kerr County
		I10-TX-5	46	566 to 611	Kerr County to Bexar County
		I10-TX-6	158	612 to 769	Bexar County to Colorado County
		I10-TX-7	113	770 to 882	Colorado County to Louisiana border
Louisiana	274	I10-LA-1	154	0 to 154	Texas border to Lafayette County
		I10-LA-2	67	155 to 221	Lafayette County to Jefferson County
		I10-LA-3	53	222 to 274	Jefferson County to Mississippi border
Mississippi	77	I10-MS-1	77	0 to 77	Louisiana border to Alabama border
Alabama	66	I10-AL-1	66	0 to 66	Mississippi border to Florida border
Florida	363	I10-FL-1	175	0 to 175	Alabama border to Gadsden County
		I10-FL-2	188	176 to 363	Gadsden County to Duval County

3.3.3 Interstate 15

Interstate 15 (I-15) is the eleventh longest interstate highway in the US and the fourth longest north-south interstate in the US. In total it traverses through six states of California, Nevada, Arizona, Utah, Idaho and Montana and covers the region between San Diego County and the Canadian border. It forms a part of CANAMEX corridor, a high priority corridor as a result of North American Free Trade Agreement.

After the construction of Interstate 15, California, Nevada and Utah have consistently ranked in the fastest growing states in the country, and subsequently, the route of I-15 has increased in population and traffic burden. It is estimated that more than 19% of the population of California, 70% of the population of Nevada, and 75% of the population of Utah lives in counties where I-15 is the primary interstate highway. The length of Interstate 15 in various states and the number of sections considered in each state are provided in Table 4.

Table 4: Interstate 15 Segments.

State	Length (Miles)	Sections			
		Name	Length (Miles)	MP	Description
California	289	I15-CA-1	111	0 to 111	San Diego County to San Bernardino County
		I15-CA-2	178	112 to 178	San Bern. County to Arizona boundary
Nevada, Arizona	124+ 30	I15-NV-1	154	0 to 124, 0 to 30	California border to Utah border
Utah	402	I15-UT-1	179	0 to 179	Arizona border to Iron County
		I15-UT-2	115	180 to 294	Iron County to Utah County
		I15-UT-3	108	295 to 402	Utah County to Davis County
Idaho	197	I15-ID-1	75	0 to 75	Utah border to Bingham County
		I15-ID-2	122	76 to 197	Bingham County to Montana border
Montana	396	I15-MT-1	199	0 to 199	Idaho border to Jefferson County
		I15-MT-2	197	200 to 396	Jefferson County to Canadian border

3.3.4 Interstate 20

Interstate 20 is a major east west Interstate highway in the southern United States. It starts at eastern Texas, runs through northern Louisiana, central Mississippi, western and north central Alabama, north central Georgia and ends at South Carolina. Some of the major cities covered by Interstate 20 are Abilane, Dallas in Texas; Ruston, Louisiana; Jackson, Mississippi; Birmingham, Anniston in Alabama; Atlanta, Augusta in Georgia; and Columbia, South Carolina. Interstate 20 in Dallas County is part of High priority corridor 55. The length of interstate in each of the states and the number of sections in each are summarized in Table 5.

Table 5: Interstate 20 Segments.

State	Length (Miles)	Sections			
		Name	Length (Miles)	MP	Description
Texas	636	I20-TX-1	84	0 to 84	Reeves County to Ward County
		I20-TX-2	177	85 to 261	Ward County to Taylor County
		I20-TX-3	165	262 to 426	Taylor County to Tarrant County
		I20-TX-4	101	427 to 527	Tarrant County to Van Zandt County
		I20-TX-5	109	528 to 636	Van Zandt County to Harrison County
Louisiana	190	I20-LA-1	190	0 to 190	Caddo County to Madison County
Mississippi	162	I20-MS-1	162	0 to 162	Warren County to Lauderdale County
Alabama	215	I20-AL-1	150	0 to 150	Sumtar County to St. Clair County
		I20-AL-2	65	151 to 215	St. Clair County to Cleburne County
Georgia	202	I20-GA-1	110	0 to 110	Haralson County to Morgan County
		I20-GA-2	92	111 to 202	Morgan County to Richmond County
South Carolina	142	I20-SC-1	142	0 to 142	Aiken County to Florence County

3.3.5 Interstate 24

Interstate 24 takes a diagonal or northwest-southeast orientation through southern Illinois, Kentucky, and Tennessee. The freeway even enters Georgia briefly. Interstate 24 makes up majority of a high traffic corridor between St. Louis, Missouri and Atlanta. Cities it serves include Metropolis, Illinois; Hopkinsville, Kentucky; Clarksville, Nashville in Tennessee. Interstate 24 traverses through 4 states.

Table 6 summarizes the length of interstate in each state and the number of sections considered for analysis.

Table 6: Interstate 24 Segments.

State	Length (Miles)	Sections			
		Name	Length (Miles)	MP	Description
Georgia, Tennessee	89	I24-GA-1	89	0 to 89	Georgia state line to Rutherford
Tennessee	91	I24-TN-1	91	0 to 91	Rutherford County to Hamilton County
Kentucky, Illinois	131	I24-KY-1	131	0 to 131	Clarksville to Williamson County

3.3.6 Interstate 35

Interstate 35 (I-35) is the ninth longest Interstate in the US highway system. It stretches from Texas in the south up to Canadian border in Minnesota. The entire interstate is a part of high priority corridor 23. Interstate 35 together with Interstate 29 provides a direct freeway connection between Mexico and Canada. The total length of the highway is 1,568 miles and it passes through six states. The length of Interstate 35 in each state and the number of sections considered for analysis are provided in Table 7.

Table 7: Interstate 35 Segments.

State	Length (Miles)	Sections			
		Name	Length (Miles)	MP	Description
Texas	586	I35-TX-1	151	0 to 151	Mexican border to Bexar County
		I35-TX-2	177	152 to 328	Bexar County to McLennen County
		I35-TX-3	77	329 to 405	McLennen County to Cooke County
		I35E-TX	96	0 to 97	Hill County to Denton County
		I35W-TX	85	0 to 85	Hill County to Denton County
Oklahoma	243	I35-OK-1	136	0 to 136	Texas border to Oklahoma County
		I35-OK-2	107	137 to 243	Oklahoma County to Kansas border
Kansas	236	I35-KS-1	141	0 to 141	Oklahoma border to Lyon County
		I35-KS-2	95	142 to 236	Lyon County to Missouri border
Missouri	115	I35-MO-1	115	0 to 115	Kansas border to Iowa border
Iowa	218	I35-IA-1	102	0 to 102	Missouri border to Story County
		I35-IA-2	116	103 to 218	Story County to Minnesota border
Minnesota	472	I35-MN-1	97	0 to 97	Iowa border to Dakota County
		I35-MN-2	163	97 to 260	Dakota County to Canadian border
		I35E-MN	85	0 to 85	Dakota County to Anoka County
		I35W-MN	127	0 to 127	Dakota County to Anoka County

3.3.7 Interstate 40

Interstate 40 (I-40) is the third longest Interstate in the United States and it travels from California in the west to North Carolina in the east. In total it traverses through eight states and some of the important cities including Raleigh, North Carolina; Nashville, Tennessee; Memphis, Tennessee; Oklahoma City, Oklahoma and Albuquerque, New MexiCounty Interstate 40 through California and Arizona is part of High Priority

Corridor 16 and 70: Economic Lifeline Corridor. The length of Interstate 40 and the number of sections in each of the states are given in Table 8.

Table 8: Interstate 40 Segments.

State	Length (Miles)	Sections			
		Name	Length (Miles)	MP	Description
California	155	I40-CA-1	155	0 to 155	Barstow County to Arizona border
Arizona	360	I40-AZ-1	146	0 to 146	Mohave County to Yavapai County
		I40-AZ-2	112	147 to 258	Yavapai County to Navajo County
		I40-AZ-3	102	259 to 360	Navajo County to New Mexico border
New Mexico	374	I40-NM-1	155	0 to 155	Arizona border to Cibola County
		I40-NM-2	102	156 to 257	Cibola County to Guadalupe County
		I40-NM-3	117	258 to 374	Guadalupe County to Texas border
Texas	177	I40-TX-1	67	0 to 67	New Mexico border to Potter County
		I40-TX-2	110	68 to 177	Potter County to Oklahoma border
Oklahoma	329	I40-OK-1	126	0 to 126	Texas border to Custer County
		I40-OK-2	94	127 to 220	Custer County to Okfuskee County
		I40-OK-3	109	221 to 329	Okfuskee County to Arkansas border
Arkansas	303	I40-AR-1	152	0 to 152	Oklahoma border to Faulkner County
		I40-AR-2	151	153 to 303	Faulkner County to Tennessee border
Tennessee	442	I40-TN-1	87	0 to 87	Arkansas border to Madison County
		I40-TN-2	130	88 to 217	Madison County to Davidson County
		I40-TN-3	160	218 to 377	Davidson County to Knox County
		I40-TN-4	65	378 to 442	Knox County to North Carolina border
North Carolina	422	I40-NC-1	162	0 to 162	Tennessee border to Iredell County
		I40-NC-2	98	163 to 260	Iredell County to Orange County
		I40-NC-3	162	261 to 422	Orange County to New Hanover County

3.3.8 Interstate 44

Interstate 44 is a diagonal east west route and a major Interstate route in the central United States. Its western terminus is Wichita Falls, Texas and its eastern terminus is St. Louis, Missouri. Major cities served by the Interstate are Oklahoma City, Tulsa in Oklahoma; Springfield, Sullivan, St. Louis in Missouri. The length of interstate in each of the states and the number of sections in each are summarized in Table 9.

Table 9: Interstate 44 Segments.

State	Length (Miles)	Sections			
		Name	Length (Miles)	MP	Description
Texas, Oklahoma	150	I44-TX-1	150	0 to 150	Wichita Falls to Oklahoma County
Oklahoma	191	I44-OK-1	191	0 to 191	Oklahoma County to Missouri state line
Missouri	290	I44-MO-1	153	0 to 153	Newton County to Pulaski County
		I44-MO-2	137	154 to 290	Pulaski County to St. Louis

3.3.9 Interstate 55

Interstate 55 is a major north south Interstate highway in the United States, connecting Gulf of Mexico to the Great lakes. The highway runs from LaPlace, Louisiana to Chicago, and covers the states Louisiana, Mississippi, Tennessee, Arkansas, Missouri and Illinois. The interstate parallels Mississippi river for much of its length. It travels through major cities such as Hammond, Louisiana; Jackson, Mississippi; Memphis, Tennessee; Blytheville, Arkansas; St. Louis, Missouri; and Lincoln, Pontiac, Chicago, Illinois. The length of the interstate in all 6 states and the number of sections considered for analysis in those states are summarized in Table 10.

Table 10: Interstate 55 Segments.

State	Length (Miles)	Sections			
		Name	Length (Miles)	MP	Description
Louisiana	66	I55-LA-1	66	0 to 66	LaPlace to Kentwood
Mississippi	289	I55-MS-1	103	0 to 103	Pike County to Hinds County
		I55-MS-2	186	104 to 186	Hinds County to DeSoto County
Tennessee, Arkansas	82	I55-TN-1	82	0 to 82	Mississippi state line to Blytheville
Missouri	216	I55-MO-1	96	0 to 96	Arkansas state line to Cape Girardeau
		I55-MO-2	120	97 to 216	Cape Girardeau to Illinois state line
Illinois	294	I55-IL-1	156	0 to 156	East St. Louis to McLean County
		I55-IL-2	138	157 to 294	McLean County to Chicago

3.3.10 Interstate 64

Interstate 64 is an Interstate in the eastern United States. The Interstate connects the St. Louis metropolitan, Missouri to the Hampton area of southeast Virginia. The interstate connects St. Louis, Missouri; Mt. Vernon, Illinois; Evansville, Indiana; Louisville, Frankfort in Kentucky; Huntington, Charleston in West Virginia; Charlottesville, Richmond, Hampton, Norfolk in Virginia. The length of interstate in each of the states and the number of sections in each are summarized in Table 11.

Table 11: Interstate 64 Segments.

State	Length (Miles)	Sections			
		Name	Length (Miles)	MP	Description
Missouri, Illinois	140	I64-MO-1	140	0 to 140	St. Charles to Grayville
Indiana	124	I64-IN-1	124	0 to 124	Posey County to Floyd County
Kentucky	183	I64-KY-1	64	0 to 64	Jefferson County to Woodford County
		I64-KY-2	119	65 to 183	Woodford County to Boyd County
West Virginia	174	I64-WV-1	174	0 to 174	Wayne County to Greenbrier County
Virginia	299	I64-VA-1	132	0 to 132	Alleghany County to Albemarle County
		I64-VA-2	167	133 to 299	Albemarle County to City of Chesapeake

3.3.11 Interstate 65

Interstate 65 is a major Interstate highway in the central United States. It is a cross country north-south highway connecting the Gulf of Mexico in the south to the great lakes. Interstate 65 also connects several major metropolitan areas in the Midwest and southern United States. It connects the four largest cities in Alabama (Mobile, Montgomery, Birmingham and Huntsville), Nashville, Tennessee; Louisville, Kentucky and Indianapolis, Indiana. The length of interstate in each of the states and the number of sections in each are summarized in Table 12.

Table 12: Interstate 65 Segments.

State	Length (Miles)	Sections			
		Name	**Length (Miles)**	**MP**	**Description**
Alabama	366	I65-AL-1	181	0 to 181	Mobile County to Elmore County
		I65-AL-2	185	182 to 366	Elmore County to Limestone County
Tennessee	120	I65-TN-1	120	0 to 120	Giles County to Robertson County
Kentucky	138	I65-KY-1	138	0 to 138	Franklin to Indiana Stateline
Indiana	262	I65-IA-1	76	0 to 76	Jefferson to Columbus
		I65-IA-2	186	77 to 262	Columbus to Gary

3.3.12 Interstate 69

Interstate 69 is an Interstate highway in the United States currently consisting of seven disjointed parts with an original continuous segment form Indianapolis, Indiana to Port Huron, Michigan. Data availability is limited in other parts, and this original section alone is been considered for the analysis. Major cities covered by this section are Fort Wayne, Indiana and Battle Creek, Flint in Michigan. The length of interstate in each of the states and the number of sections in each are summarized in

Table 13.

Table 13: Interstate 69 Segments.

State	Length (Miles)	Sections			
		Name	**Length (Miles)**	**MP**	**Description**
Indiana	158	I69-IN-1	158	0 to 158	Indianapolis to Steuben
Michigan	215	I69-MI-1	108	0 to 108	Branch County to Shiawassee County
		I69-MI-2	107	109 to 215	Shiawassee County to St. Clair

3.3.13 Interstate 70

Interstate 70 (I-70) is an East West highway, bisecting the country and traversing ten states. It runs through cities such Denver, Colorado; Kansas City, Missouri; St. Louis, Missouri; Indianapolis, Indiana; Columbus, Ohio; and Baltimore, Maryland. The interstate does not connect the two coasts as it ends at I-15 near Cove Fort, Utah.

Between Denver and Limon in Colorado, I-70 is part of high priority corridor 38, the Ports to Plains corridor, and the section of through Missouri is part of High Priority Corridor 61. The length of Interstate 70 and the number of sections in each state is summarized in Table 14.

Table 14: Interstate 70 Segments.

State	Length (Miles)	Sections			
		Name	Length (Miles)	MP	Description
Utah	230	I70-UT-1	89	0 to 89	Millard County to Emery County
		I70-UT-2	141	90 to 230	Emery County to Colorado border
Colorado	451	I70-CO-1	91	0 to 91	Utah border to Garfield County
		I70-CO-2	184	92 to 275	Garfield County to Denver County
		I70-CO-3	176	276 to 451	Denver County to Kit Carson County
Kansas	424	I70-KS-1	189	0 to 189	Colorado border to Russell County
		I70-KS-2	167	190 to 356	Russell County to Shawnee County
		I70-KS-3	68	357 to 424	Shawnee County to Wyandotte County
Missouri	253	I70-MO-1	148	0 to 148	Kansas border to Callaway County
		I70-MO-2	105	149 to 253	Callaway County to Illinois border
Illinois	138	I70-IL-1	138	0 to 138	Missouri border to Indiana border
Indiana	155	I70-IN-1	75	0 to 75	Illinois border to Hancock County
		I70-IN-2	80	76 to 155	Hancock County to Ohio border
Ohio, West Virginia	226+14	I70-OH-1	129	0 to 129	Indiana border to Licking County
		I70-OH-2	111	130 to 226, 0 to 14	Licking County to Pennsylvania border
Pennsylvania	169	I70-PA-1	54	0 to 54	West Virginia border to Westmoreland County
		I70-PA-2	115	55 to 169	Westmoreland County to Maryland border
Maryland	93	I70-MD-1	93	0 to 93	Pennsylvania border to Baltimore County

3.3.14 Interstate 75

Interstate 75 (I-75) is a major north-south highway traversing from Florida to Michigan. It provides a major link between the Southeast and Great Lakes regions and serves the cities of Miami, Florida; Naples, Florida; Fort Myers, Florida; Tampa, Florida; Atlanta, Georgia; Cincinnati, Ohio; Toledo, Ohio; and Detroit, Michigan. Interstate 75 in Ohio is part of High priority corridor 76. The total length of the highway is 1,786 miles and it passes through six states. The length of the highway in each state and the number of sections in each state is summarized in Table 15.

Table 15: Interstate 75 Segments.

State	Length (Miles)	Sections			
		Name	**Length (Miles)**	**MP**	**Description**
Florida	472	I-75-FL-1	194	0 to 194	Miami-Dade County to Sarasota County
		I75-FL-2	180	195 to 374	Sarasota County to Alachua County
		I75-FL-3	98	375 to 472	Alachua County to Georgia border
Georgia	356	I75-GA-1	110	0 to 110	Florida border to Crisp County
		I75-GA-2	92	111 to 202	Crisp County to Monroe County
		I75-GA-3	68	203 to 270	Monroe County to Fulton County
		I75-GA-4	86	271 to 356	Fulton County to Tennessee border
Tennessee	142	I75-TN-1	142	0 to 85	Georgia border to Kentucky boundry
Kentucky	173	I75-KY-1	88	0 to 88	Tennessee border to Madison County
		I75-KY-2	85	89 to 173	Madison County to Ohio border
Ohio	216	I75-OH-1	78	0 to 78	Kentucky border to Shelby County
		I75-OH-2	138	79 to 216	Shelby County to Michigan border
Michigan	399	I75-MI-1	132	0 to 132	Ohio border to Saginaw County
		I75-MI-2	87	133 to 219	Saginaw County to Ogemaw County
		I75-MI-3	180	220 to 399	Ogemaw County to Chippewa County

3.3.15 Interstate 76

Interstate 76 western route runs from Arvada, Colorado to Big Springs, Nebraska and the eastern route from Akron, Ohio to Bellmawr, New Jersey. The vast majority of the western route is in Colorado and passes through Denver and Fort Morgan. The eastern route forms a major east-west route across eastern Ohio and Pennsylvania. It joins the Philadelphia metropolitan area with Pittsburg, Akron and Cleveland, Ohio. The length of the Interstate and the number of segments considered are summarized in Table 16.

Table 16: Interstate 76 Segments.

State	Length (Miles)	Sections			
		Name	Length (Miles)	MP	Description
Colorado	187	I76-CO-1	66	0 to 66	Arvada to Morgan County
		I76-CO-2	121	67 to 187	Morgan County to Nebraska state line
Ohio	82	I76-OH-1	161	0 to 161	Medina County to Mahoning County
Pennsylvania	190	I76-PA-1	190	0 to 190	Ohio state line to New Jersey state line

3.3.16 Interstate 77

Interstate 77 is a north south Interstate highway that runs from South Carolina in the south to Ohio. Interstate 77 connects the southeast with eastern Great lakes region. Cities it serves include Columbia, South Carolina; Charlotte, North Carolina; Wytheville, Virginia and Akron, Cleveland, Ohio. The northern terminus is in Cleveleand at the junction with Interstate 90. The length of interstate in each of the states and the number of sections in each are summarized in Table 17.

Table 17: Interstate 77 Segments.

State	Length (Miles)	Sections			
		Name	Length (Miles)	MP	Description
South Carolina	91	I77-SC-1	91	0 to 91	Lexington County to York County
North Carolina	105	I77-NC-1	105	0 to 105	Mecklenburg County to Surry County
Virginia	67	I77-VA-1	67	0 to 67	Carroll County to Bland County
West Virginia	187	I77-WV-1	187	0 to 126	Mercer County to Wood County
Ohio	160	I77-OH-1	160	0 to 160	Washington County to Cuyahoga County

3.3.17 Interstate 78

Interstate 78 covers a length of 144 miles in the north eastern part of United States and runs through Pennsylvania, New Jersey and New York. Interstate 78 originates in Harrisburg, Pennsylvaia and ends at the Holland Tunnel, New York and runs through important cities such as Easton, Irvington, Newark and New York city. Interstate 78 in New Jersey is part of high priority corridor 63: Liberty corridor. The length of interstate in each of the states and the number of sections in each are summarized in Table 18.

Table 18: Interstate 78 Segments.

State	Length (Miles)	Sections			
		Name	Length (Miles)	MP	Description
Pennsylvania	77	I78-PA-1	77	0 to 77	Lebanon county to NJ border
New Jersey	72	I78-NJ-2	72	0 to 72	Town of Alpha to New York

3.3.18 Interstate 80

Interstate 80 (I-80) is a major trans-continental highway running from San Francisco, California to Teaneck, New Jersey. It is the second longest interstate in the United States. Interstate 80 in New Jersey is part of High priority corridor 63 (the Liberty Corridor). The total length of the Interstate is 2,900 miles and it traverses through 11 states. The length of I-80 in each of the states and the number of sections considered for analysis are summarized in Table 19.

Table 19: Interstate 80 Segments.

State	Length (Miles)	Sections			
		Name	Length (Miles)	MP	Description
California	207	I-80-CA-1	89	0 to 89	San Francisco County to Placer County
		I80-CA-2	118	90 to 207	Placer County to Nevada border
Nevada	416	I80-NV-1	183	0 to 183	California border to Humboldt County
		I80-NV-2	123	184 to 306	Humboldt County to Osino
		I80-NV-3	110	307 to 416	Osino to Utah border
Utah	193	I80-UT-1	120	0 to 120	Nevada border to Salt Lake County
		I80-UT-2	73	121 to 193	Salt Lake County to Wyoming border
Wyoming	404	I80-WY-1	173	0 to 173	Utah border to Sweetwater County
		I80-WY-2	141	174 to 314	Sweetwater County to Albany County
		I80-WY-3	90	315 to 404	Albany County to Nebraska border
Nebraska	456	I80-NE-1	178	0 to 178	Wyoming border to Lincoln County
		I80-NE-2	134	179 to 312	Lincoln County to Hall County
		I80-NE-3	144	313 to 456	Hall County to Iowa border
Iowa	289	I80-IA-1	110	0 to 110	Nebraska border to Dallas County
		I80-IA-2	179	111 to 289	Dallas County to Illinois border
Illinois	163	I80-IL-1	163	0 to 163	Iowa border to Indiana border
Indiana	150	I80-IN-1	69	0 to 69	Illinois border to Elkhart County
		I80-IN-2	81	70 to 150	Elkhart County to Ohio border
Ohio	239	I80-OH-1	91	0 to 91	Indiana border to Lorain County
		I80-OH-2	148	92 to 239	Lorain County to Pennsylvania border
Pennsylvania	311	I80-PA-1	147	0 to 147	Ohio border to Centre County
		I80-PA-2	164	148 to 311	Centre County to New Jersey border
New Jersey	68	I80-NJ-1	68	0 to 68	Pennsylvania border to Bergen County

3.3.19 Interstate 81

Interstate 81 is in the eastern part of United States. Its southern terminus is at Interstate 40 in Dandridge, Tennessee and its northern terminus at Wellesley Island, New York at the Canadian border. The Interstate covers 6 states, and it includes Tennessee, Virginia, West Virginia, Maryland, Pennsylvani and New York. Major cities covered by the Interstate are Bristol, Tennessee; Wytheville, Lexington in Virginia; Martinsburg, West Virginia; Hagerstown, Maryland; Harrisburg, Pennsylvania; and Syracuse, New York. The length of interstate in each of the states and the number of sections in each are summarized in Table 19.

Table 20: Interstate 81 Segments.

State	Length (Miles)	Sections			
		Name	Length (Miles)	MP	Description
Tennessee	76	I81-TN-1	76	0 to 76	Dandridge to Virginia border
Virginia	305	I81-VA-1	161	0 to 161	Washington to Botetourt County
		I81-VA-2	144	162 to 305	Botetourt County to Frederick County
West Virginia, Maryland	38	I81-WV-1	38	0 to 38	Ridgeway to Maugansville
Pennsylvania	233	I81-PA-1	116	0 to 116	Franklin County to Schuylkill County
		I81-PA-2	117	117 to 233	Schuylkill County to Susquehanna County
New York	189	I81-NY-1	130	0 to 130	Broome County to Ellisburg
		I81-NY-2	59	131 to 189	Ellisburg to Orleans

3.3.20 Interstate 82

Interstate 82 is in the northwest United States covering two states, and extending from Ellensburg, Washington to Umatilla, Oregon. The Interstate passes through Yakim, Toppenish, Sunnyside, Grandview and Richland in Washington, and Hermiston in Oregon. The entire length of 144 miles has been considered as a single segment. The details are summarized in Table 20.

Table 21: Interstate 82 Segments.

State	Length (Miles)	Sections			
		Name	Length (Miles)	MP	Description
Washington	144	I82-WA-1	144	0 to 144	Kittitas County to Umatilla County

3.3.21 Interstate 83

Interstate 83 runs for a short length of 85 miles in the eastern United States between Baltimore, Maryland and Harrisburg, Pennsylvania. Interstate 83 replaced US Route 111 from Baltimore upto the south of Lemoyne, Pennsylvania. Baltimore, York and Harrisburg are the important cities covered by the Interstate. Throughout Pennsylvania, I-83 is named ‘Veterans of Foreign Wars of the United States Memorial Highway’. The length of the Interstate and the number of segments considered are summarized in Table 22.

Table 22: Interstate 83 Segments.

State	Length (Miles)	Sections			
		Name	Length (Miles)	MP	Description
Maryland	34	I83-MD-1	34	0 to 34	Baltimore to Pennsylvania border
Pennsylvania	60	I83-PA-1	60	0 to 60	Shrewsbury to Dauphin County

3.3.22 Interstate 84

Interstate 84 is an Interstate highway with two non-contiguous sections. The western section runs from Portland, Oregon to a junction with Interstate 80 near Echo, Utah. The eastern section runs from Dunmore, Pennsylvania to Sturbridge, Massachusetts. Major cities covered by the eastern section are Pendleton, Ontarion in Oregon; Boise, Twin Falls in Idaho and Brigham City in Utah. And the major cities covered by the western section are Scranton, Pennsylvania; Middleton, New York; Bristol, Hartford in Connecticut. Interstate 84 traverses 7 states in total and table below summarizes the length of interstate in each state and the number of sections considered for analysis.

Table 23: Interstate 84 Segments.

State	Length (Miles)	Sections			
		Name	Length (Miles)	MP	Description
Oregon	394	I84-OR-1	103	0 to 76	Multnomah County to Wasco County
		I84-OR-2	178	77 to 161	Wasco County to Morrow County
		I84-OR-3	113	162 to 305	Morrow County to Malheur County
Idaho	276	I84-ID-1	114	0 to 114	Payette County to Elmore County
		I84-ID-2	162	0 to 116	Elmore County to Oneida COunty
Utah	110	I84-UT-1	110	0 to 110	Box Elder County to Summit County
Pennsylvania	54	I81-PA-1	54	0 to 54	Dunmore to New York state line
New York	71	I81-NY-1	71	0 to 71	Port Jervis to Connecticut state line
Connecticut	110	I81-CT-1	110	0 to 110	Danbury to Sturbridge

3.3.23 Interstate 85

Interstate 85 is a major interstate route in the southeastern United States and runs through the states of Alabama, Georgia, South Carolina, North Carolina and Virginia. The interstate serves as a major regional route in the southeast and connects Montgomery, Auburn, Alabama; Atlanta, Georgia; Grenville, South Carolina; Charlotte, North Carolina; and Petersburg, Virginia. Portions of proposed Interstate 85 that overlays U.S. 80 west of Montgomery is a part of High Priority Corridor 6. The length of the interstate in all 5 states and the number of sections considered for analysis in those states are summarized in Table 24.

Table 24: Interstate 85 Segments.

State	Length (Miles)	Sections			
		Name	Length (Miles)	MP	Description
Alabama	80	I85-AL-1	80	0 to 80	Montgomery to Georgia border
Georgia	170	I85-GA-1	59	0 to 59	Harris County to Fulton County
		I85-GA-2	111	60 to 170	Fulton County to South Carolina Border
South Carolina	149	I85-SC-1	149	0 to 149	Oconee County to Cherokee County
North Carolina	248	I85-NC-1	93	0 to 93	Cleveland County to Davidson County
		I85-NC-2	155	94 to 248	Davidson County to Warren County
Virginia	68	I85-VA-1	68	0 to 68	Mecklenburg County to City of Petersburg

3.3.24 Interstate 90

Interstate 90 (I-90) is the longest interstate highway in the United States with a mileage of 3,101. The interstate traverses through 13 states and Table 25 summarizes the length of interstate in each state and the number of sections considered for analysis.

Table 25: Interstate 90 Segments.

State	Length (Miles)	Sections			
		Name	**Length (Miles)**	**MP**	**Description**
Washington	297	I90-WA-1	149	0 to 149	King County to Grant County
		I90-WA-2	93	150 to 242	Grant County to Lincoln County
		I90-WA-3	55	243 to 297	Lincoln County to Idaho border
Idaho	68	I90-ID-1	68	0 to 68	Washington border to Montana
Montana	545	I90-MT-1	155	0 to 155	Idaho border to Missoula County
		I90-MT-2	85	156 to 240	Missoula County to Deer Lodge County
		I90-MT-3	160	241 to 400	Deer Lodge County to Gallatin County
		I90-MT-4	75	401 to 475	Gallatin County to Yellowstone County
		I90-MT-5	70	476 to 545	Yellowstone County to Wyoming border
Wyoming	209	I90-WY-1	135	0 to 135	Montana border to Campbell County
		I90-WY-2	74	136 to 209	Campbell County to South Dakota border
South Dakota	413	I90-SD-1	151	0 to 151	Wyoming border to Jackson County
		I90-SD-2	160	152 to 311	Jackson County to Davison County
		I90-SD-3	102	312 to 413	Davison County to Minnesota border
Minnesota	276	I90-MN-1	143	0 to 143	South Dakota border to Freeborn County
		I90-MN-2	133	144 to 276	Freeborn County to Wisconsin border
Wisconsin	185	I90-WI-1	185	0 to 185	Minnesota border to Illinois border
Illinois	109	I90-IL-1	109	0 to 109	Wisconsin border to Indiana border
Indiana	156	I90-IN-1	156	0 to 156	Illinois border to Ohio border
Ohio	245	I90-OH-1	103	0 to 103	Indiana border to Sandusky County
		I90-OH-2	142	103 to 245	Sandusky County to Pennsylvania border
Pennsylvania	46	I90-PA-1	46	0 to 46	Ohio border to New York border
New York	386	I90-NY-1	106	0 to 108	Pennsylvania border to Victa
		I90-NY-2	136	108 to 242	Victa to Utica
		I90-NY-3	144	242 to 385	Utica to Massachusetts border
Massachusetts	136	I90-MA-1	136	0 to 136	New York border to Suffolk County

Its western terminus is Seattle, Washington and eastern terminus is Boston, Massachusetts. It connects the major population centers of Madison, Wisconsin; Chicago, Illinois; Rockford, Illinois; Cleveland, Ohio; Toledo, Ohio; Buffalo, New York, Albany, New York; and Springfield, Massachusetts. Interstate 90 in the Seattle metropolitan area is part of High priority corridor 35: FAST Corridor.

3.3.25 Interstate 94

Interstate 94 (I-94) is the northern most east-west interstate highway connecting the Great Lakes and Intermountain regions. Interstate 94 has its western terminus in Billings, Montana and its eastern terminus at Blue Water Bridge in Michigan. It is the eighth longest interstate highway in the United States. The total length of this interstate is 1,585 miles and it passes through seven states. The length of interstate in each of the states and the number of sections in each are summarized in Table 26.

Table 26: Interstate 94 Segments.

State	Length (Miles)	Sections			
		Name	Length (Miles)	MP	Description
Montana	249	I94-MT-1	119	0 to 119	Yellowstone County to Custer County
		I94-MT-2	130	119 to 249	Custer County to North Dakota border
North Dakota	352	I94-ND-1	193	0 to 193	Montana border to Kidder County
		I94-ND-2	159	194 to 352	Kidder County to Minnesota border
Minnesota	258	I94-MN-1	115	0 to 115	Minnesota border to Todd County
		I94-MN-2	143	115 to 259	Todd County to Wisconsin border
Wisconsin	341	I94-WI-1	160	0 to 160	Minnesota border to Juneau County
		I94-WI-2	103	161 to 341	Juneau County to Illinois border
Illinois	59	I94-IL-1	59	0 to 59	Wisconsin border to Indiana border
Indiana	46	I94-IN-1	46	0 to 46	Illinois border to Michigan border
Michigan	284	I94-MI-1	74	0 to 74	Indiana border to Calhoun County
		I94-MI-2	112	75 to 186	Calhoun County to Wayne County
		I94-MI-3	98	187 to 284	Wayne County to Canadian border

3.3.26 Interstate 95

Interstate 95 (I-95) runs along the east coast and serves the area between Florida and New England. It runs through important cities such as Boston, Massachusetts; New York City, New York; Philadelphia, Pennsylvania; Baltimore, Maryland; and Washington DC in the north and Jacksonville and Miami, Florida in the south. I-95 is the longest north south interstate and the sixth longest interstate highway overall and passes through more states than any other interstate (15 states in total). The region served by this interstate has a population density more than three times greater than the US as a whole (US Census 2010). The portion of I-95 in Florida is part of High priority corridor 49: Atlantic Commerce Corridor. Through northern New Jersey, it is part of High Priority Corridor 63: Liberty Corridor. In Connecticut, I-95 is part of High Priority corridor 65: Interstate 95 Connecticut. Finally, a portion of I-95 in Maine is part of High priority corridor 50: East –West corridor from Watertown to Calais. The length of the interstate in all 15 states and the number of sections considered for analysis in those states are summarized in Table 27.

Table 27: Interstate 95 Segments.

State	Length (Miles)	Sections			
		Name	Length (Miles)	MP	Description
Florida	383	I95-FL-1	76	0 to 76	Miami-Dade County to Palm Beach County
		I95-FL-2	130	77 to 206	St. Lucie County to Brevard County
		I95-FL-3	177	207 to 383	Brevard County to Georgia border
Georgia	112	I95-GA-1	112	0 to 112	Florida border to South Car. border
South Carolina	199	I95-SC-1	82	0 to 82	Georgia border to Dorchester County
		I95-SC-2	117	82 to 199	Dorchester County to North Car. border
North Carolina	182	I95-NC-1	182	0 to 98	South Car. border to Virginia border
Virginia	174	I95-VA-1	101	0 to 101	North Carolina border to Hanover County
		I95-VA-2	73	102 to 174	Hanover County to Maryland border
Maryland	107	I95-MD-1	47	0 to 47	Virginia border to Baltimore
		I95-MD-2	60	48 to 107	Baltimore to Pennsylvania border
Pennsylvania	51	I95-PA-1	51	0 to 51	Delaware border to New Jer. border
New Jersey, New York	92+24	I95-NJ-1	116	0 to 98, 0 to 24	Pennsylvania border to Connecticut border
Connecticut	111	I95-CT-1	111	0 to 111	New York border to Rhode I. border
Rhode Island	43	I95-RI-1	43	0 to 43	Connecticut border to Mass. border
Massachusetts, New Hampshire	91+16	I95-MA-1	107	0 to 91, 0 to 16	Rhode I. border to Maine border
Maine	304	I95-ME-1	156	0 to 156	New Hampshire border to Somerset County
		I95-ME-2	148	157 to 304	Somerset County to Canadian border

4.0 Simulation Process

4.1 Introduction

A total of 272 segments were considered for the analysis. For each of these sections, detailed information on the climate, traffic, materials, and structural conditions were obtained from the respective sources. These inputs were then used with the NCHRP 1-37A Mechanistic-Empirical analysis method to predict the performance of the pavement infrastructure under the state of the practice traffic projections. These predicted performance metrics formed the baseline, or control conditions for the current study. Subsequent to these control predictions a second set of predictions were made inclusive of broader economic analysis based freight movement trends. The ratio in performance metrics were then used to identify interstate sections expected to be more sensitive to expected freight trends.

4.2 Mechanistic-Empirical Process

As outlined in the introduction chapter and summarized in Figure 10 below, the NCHRP 1-37A Mechanistic-Empirical analysis method uses a three step approach to predict pavement performance. Step 1 consists of the development of input values for the analysis. During this stage, potential structural options are identified for consideration in Step 2 (analysis). Also in this stage, pavement materials characterization and traffic input data are developed. The enhanced Integrated Climatic Model (EICM), a climatic effects modeling tool, is used to model temperature and moisture within each pavement layer and the sub grade. The climatic model considers hourly climatic data described later on in Section 4.3.2. The pavement layer temperature and moisture predictions from the EICM are calculated hourly over the design period and coupled with secondary effects models to estimate material properties for the foundation and pavement layers as functions of temperature and/or moisture condition. To produce an accurate analysis that considers both daily and monthly variations in temperature, the hourly changes are used to compile five different representative temperature profiles for each month. Subsequent analysis then treats these profiles, referred to as quintiles, as the potential temperature variations for a given month. Step 2 of the design process is the structural/performance analysis. The structural section is analyzed incrementally over time using the pavement response and distress models, and the outputs of the analysis are the accumulated damage and the expected amount of distress and smoothness over time. Step 3 involves the assessment of the structural viability of the pavement based on the damage accumulation and the distress summary of the analysis. In the following paragraphs a brief introduction to the damage and damage modeling process are presented.

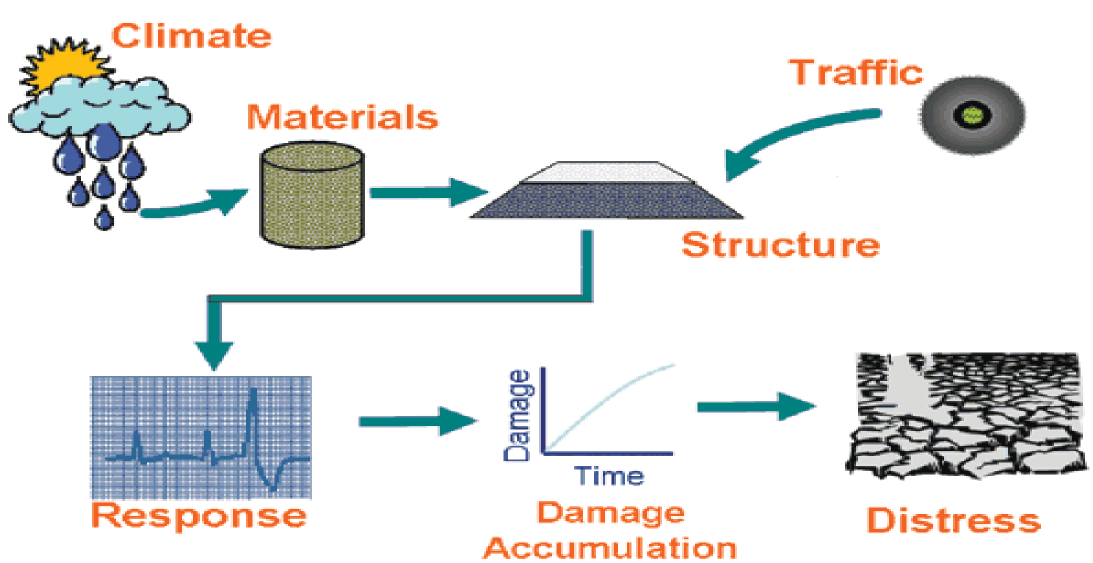


Figure 10: Schematic Overview of Mechanistic-Empirical Analysis Process. [Source: FHWA]

4.2.1 Pavement Response Modeling

There are many methods that exist for predicting the stress and strains response of flexible pavements to vehicular loading, e.g., layered elastic analysis, layered viscoelastic analysis, elastic and viscoelastic based finite element modeling, etc. Of these, the layered elastic analysis (LEA) technique has been chosen for use in the mechanistic-empirical process because of its overall simplicity, widespread familiarity, general accuracy (if used properly), and (most importantly) computational efficiency. The mathematical details of the LEA process are presented in great detail elsewhere, here the implementation of this method as it relates to the current work are presented.

As the name implies, LEA treats all pavement layers as linear elastic, meaning that the stress and strain are assumed to be perfectly proportional to one another at all levels. This constant of proportionality, the Elastic modulus, forms the primary mechanical property of interest and must be estimated for each and every pavement layer and sub-layer. Other important assumptions in the linear elastic analysis process include:

- The materials are homogeneous and isotropic;
- The applied load has a circular footprint;
- The layers are all perfectly horizontal and extend in infinite directions in the plane perpendicular to the applied load (the x-y plane);
- The mechanical properties are independent of x-y location (but can vary by depth, z);.

- The bottom layer is infinitely thick; and
- All layers/sub-layers are fully bonded.

An important part of any structural analysis process is identifying the important locations where the response should be identified. This facet of structural analysis is also true in the case of pavements, but the process is complicated somewhat because, while the nature of loading is always the same (vertical load to the horizontal pavement surface), the positioning of these loads can change (for example with a single, tandem, tridem, or quad loading axle). The specific implementation of LEA in the mechanistic-empirical analysis used here overcomes this shortcoming by analyzing a pre-determined matrix of x-y locations that allow the results to be generalized to any likely condition. Figure 11 demonstrates the method used, which exploits the linear superposition principle that stems from the use of linear elasticity as the basic mechanical theory in the response modeling.

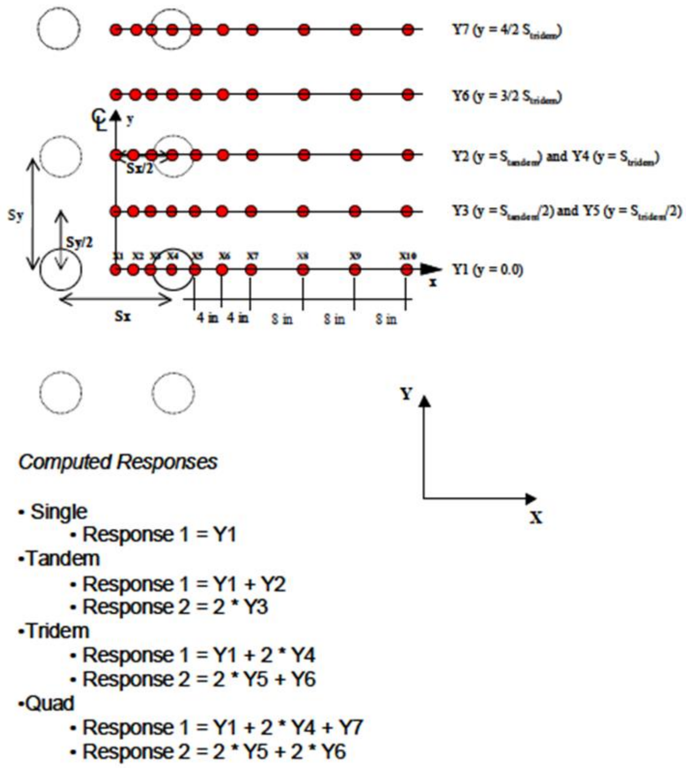


Figure 11: Summary of Method Used to Consider Multiple Axle Configurations in the LEA (ARA 2004).

In addition to coordinates in the x-y plane there are also relevant analysis points at different depths. The depth-wise locations for the response variables are framed with respect to either the fatigue or rutting distresses. In the case of the fatigue cracking phenomenon these depths include the surface of the AC layer, the strain at a depth of 0.5 inches, and at the bottom of the asphalt layer. The first two responses are used to evaluate top-down cracking while the third response is used for the bottom-up cracking prediction. For rutting predictions the relevant strain response depths include the mid-depth of each structural layer/sub-layer, the top of the subgrade, and six inches below the top of the subgrade.

4.2.2 Fatigue Cracking Prediction

Fatigue cracking is predicted based on the cumulative damage concept, e.g., Miner's Law. The damage is calculated as the ratio of predicted number of traffic repetitions to the allowable number of load repetitions (to some failure level) as shown in Equation (2).

$$D = \sum \frac{n_{i,j,k,l,m}}{N_{i,j,k,l,m}} \times 100 \tag{2}$$

Where:

D	=	Cumulative damage;
n	=	Number of load repetitions for condition indicated by subscript combination;
N	=	Number of load repetitions to failure for condition indicated by subscript combination, see Equation (3);
i	=	Month;
j	=	Quintile;
k	=	Axle type;
l	=	Axle load; and
m	=	Traffic path, assuming a normally distributed lateral wheel wander.

The number of load repetitions to failure is estimated using the classic empirical fatigue relationship given by Equation (3). The form of the model is a function of the tensile strain at the bottom of the asphalt pavement layer as well as the modulus of the asphalt layer. This model form is chosen because it directly links with the pavement response model discussed in Section 4.2.1,

$$N_f = Ck_1 \left(\frac{1}{\varepsilon_t}\right)^{k_2} \left(\frac{1}{E}\right)^{k_3} \quad . \tag{3}$$

Where:

N_f	=	Number of repetitions to fatigue cracking;
ε_t	=	Tensile strain at the bottom of the asphalt concrete layer (from the pavement response model);
E	=	Modulus of the asphalt concrete;
k_1,k_2,k_3	=	Calibrated coefficients (0.007566, 3.9492, and 1.281 respectively); and
C	=	Equation (4) with V_a as the air void content and V_b as the asphalt content.

$$C = 10^{4.84\left(\frac{V_b}{V_a + V_b - 0.69}\right)} \tag{4}$$

4.2.3 Rutting Prediction

To predict the cumulative rutting, the permanent deformation in each of the aforementioned sub-layers is first predicted using the model shown in Equation (5) for asphalt concrete and Equation (9) for aggregate base and subgrade. As seen in these equations, the vertical compressive strain from layered elastic analysis is used to link pavement response and pavement performance modeling for the case of rutting. The predicted permanent deformation is converted to rutting depth using the 1-D approximation shown in Equation (16), essentially taking the definition of strain to estimate that the change in geometry is equal to the product of permanent strain and sub-layer depth. Since the subgrade is treated as an infinitely deep layer this expression will not provide a reasonable answer and so an alternative form, shown in Equation (14) is used to estimate the subgrade rutting.

$$\varepsilon_p = \varepsilon_v \left[k_z 10^{K_1} T^{K_2} N^{K_3} \right] \tag{5}$$

$$k_z = \left(C_1 + C_2 z\right) 0.328196^z \tag{6}$$

$$C_1 = -0.1039 h_{ac}^2 + 2.4868 h_{ac} - 17.342 \tag{7}$$

$$C_2 = -0.0172 h_{ac}^2 - 1.7331 h_{ac} + 27.428 \tag{8}$$

$$\varepsilon_p = \varepsilon_v \left[\left(\frac{\varepsilon_0}{\varepsilon_r} \right) e^{\left(\frac{\rho}{N}\right)^\beta} \right] \beta_{mat} \tag{9}$$

$$\log \beta = -0.61119 - 0.017638 W_c \tag{10}$$

$$\log \left(\frac{\varepsilon_0}{\varepsilon_r} \right) = \frac{\left(0.15 e^{(\rho)^\beta} \right) + \left(20 e^{\left(\rho / 10^9\right)^\beta} \right)}{2} \tag{11}$$

$$\rho = 10^9 \left[\frac{-4.89285}{1 - \left(10^9\right)^\beta} \right]^{\frac{1}{\beta}} \tag{12}$$

$$W_c = 51.712 \left[\left(\frac{M_r}{2555} \right)^{\frac{1}{0.64}} \right]^{-0.3586 \times GWT^{0.1192}} \tag{13}$$

Where:

ε_p = Permanent strain

ε_v = Vertical compressive strain at the mid-depth of the given sub-layer (from the pavement response model);

k_z = Equation (6);

T = Temperature at mid-depth of given sub-layer (°F);

N = Number of applied loading cycles;

z = Mid-depth at sub-layer of interest (inch);

h_{ac} = Overall asphalt pavement thickness (inch);

GWT = Depth to water table (feet);

B_{mat} = 1.673 for aggregate base and 1.35 for subgrade; and

M_r = Soil modulus (psi).

$$RD_{SG} = \int_0^\infty \varepsilon_p(z)\,dz = \frac{1}{k}\varepsilon_{p,z=0} \tag{14}$$

$$k = \frac{1}{6}\ln\left(\frac{\varepsilon_{p,z=0}}{\varepsilon_{p,z=6}}\right) \tag{15}$$

$$RD_{Total} = \sum_{i=1}^{N_{sublayers}} \varepsilon_p^i h^i + RD_{SG} \tag{16}$$

Where:

RD_{SG} = Subgrade rut depth (inch);

$\varepsilon_{p,z=0}$ = Permanent deformation at the top of the subgrade, from Equation (9);

$\varepsilon_{p,z=6}$ = Permanent deformation six inches below the top of the subgrade, from Equation (9);

RD_{Total} = Total pavement rut depth (inch);

$N_{sublayers}$ = Number of sub-layers;

$\varepsilon_p{}^i$ = Total plastic strain in sub-layer i; and

h^i = Thickness of sub-layer i (inch).

The algorithm used to predict rutting over the pavement lifetime is based upon sequential damage accumulation scheme with the amount of accumulated permanent deformation from a given axle load being dependent upon the complete loading history prior to that axle. The process is briefly summarized in Figure 12.

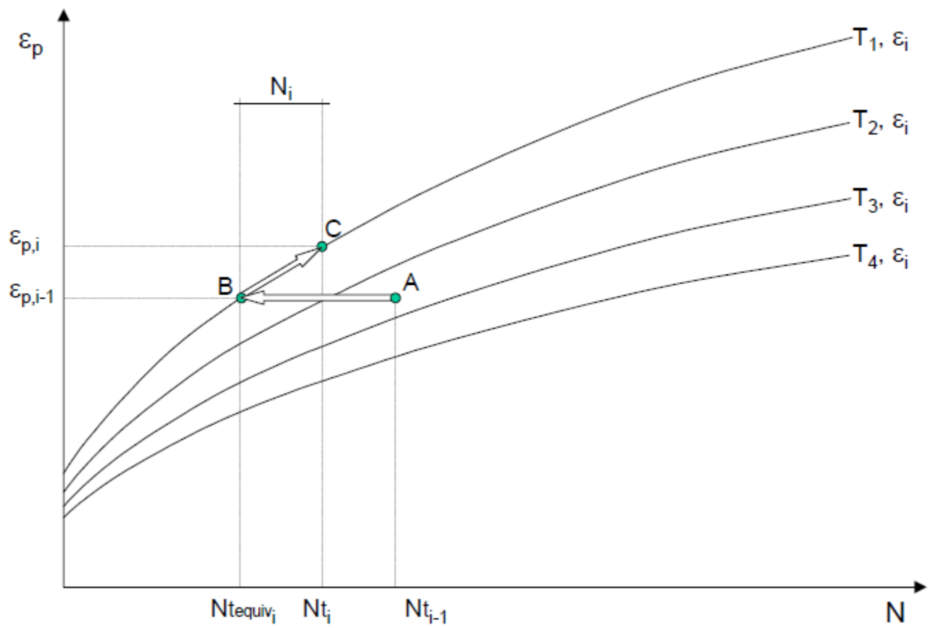


Figure 12: Permanent Deformation Accumulation.

For the purposes of this figure let $\varepsilon_{p,i\text{-}1}$ represent the permanent strain accumulated in one of the sub-layers at the end of sub-season *i*-1 (a sub-season here is a combination of month and quintile). Also, let the curve indicated as T_1 represent the value of the permanent deformation function from Equation (5) at the next sub-season, *i*. Point B is the link between the function that dictated the permanent strain accumulation in sub-season *i*-1 and the one that will control permanent strain accumulation in sub-season i. Points A and B are at an equivalent permanent strain level because the permanent strain between sub-seasons must be continuous. Finally point C represents the additional increment of permanent strain that would accumulate from the initial loading group in sub-season *i*. In reality the process is slightly more involved since both the temperature and the applied load level, indicated by the ε_v term in Equation (5), affect the permanent strain accumulation function. In this case careful attention must be given to the order of loading as well as the sub-season.

4.2.4 IRI Prediction

Ride quality is an important measure of functional performance. As shown in Figure 13, it is most often quantified by combining the measured longitudinal pavement profile with a mathematical model that simulates a single wheel on a vehicle, e.g., the International Roughness Index (IRI).

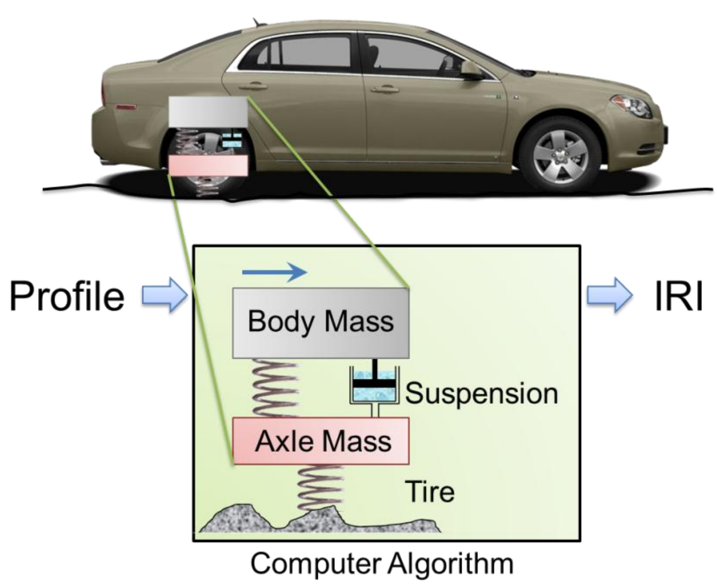


Figure 13: Schematic Diagram of IRI Parameter.

While the measurement of IRI is fairly straightforward, predicting how it evolves using mechanistic models is not so easy. In the mechanistic-empirical method used for this report, the IRI is estimated over the analysis period by using the distresses (cracking and rutting) predicted from other models. The mathematical model to accomplish this is shown in Equation (17).

$$IRI(t) = IRI_0 + \left(0.4FC + 40RD + 0.008TC + 0.015SF\right) \tag{17}$$

Where:

$IRI(t)$	=	Pavement smoothness at a specific time (inch per mile);
IRI_o	=	Initial smoothness immediately after construction (assumed = 63 in./mi);
FC	=	Total fatigue cracking (% of lane);
RD	=	Total pavement rutting (inch);
TC	=	Total transverse cracking (ft/mi); and
SF	=	Site factor, Equation (18).

$$SF = Age\left[0.02003\left(PI+1\right) + 0.007947\left(Precip+1\right)\right] + 0.000636\left(FI+1\right) \tag{18}$$

Where;

Age	=	Pavement age (year);
PI	=	Plasticity index of the soil (%);
FI	=	Average annual freezing index, (°F days); and
$Precip$	=	Average annual precipitation, (in.).

4.2.5 Transverse Cracking Prediction

Transverse cracking can initiate either at the top surface of the PCC slab and propagate downward (top-down cracking) or vice versa depending on the loading and climatic conditions at the site, as well as material properties and the conditions during construction (ARA 2004). When the truck axles are near the longitudinal edge of the slab, midway between the transverse joints, a critical tensile stress occurs at the bottom of the slab. The stress increases greatly when there is a high positive temperature gradient (top of the slab is warmer than the bottom of the slab) through the slab. Repeated loadings of heavy axles under those conditions result in fatigue damage along the bottom edge of the slab, which result in bottom-up transverse cracks that propagate to the surface of the pavement. On the other hand, repeated loading by heavy trucks that involves a combination of axles that loads the opposite ends of a slab simultaneously in the presence of a high negative gradient (top of the slab cooler than the bottom of the slab) result in fatigue damage at the top of the slab, which eventually results in top-down transverse cracks that is initiated on the surface of the pavement. Any given slab may crack either from bottom-up or top-down, but not both. Hence, the combined cracking must be determined, excluding the possibility of both modes of cracking occurring on the same slab. In the MEPDG, the input traffic and climatic data are processed to determine the equivalent number of axles and the effects of seasonal changes in moisture conditions on differential shrinkage in terms of monthly deviations in slab warping. The stress corresponding to each load configuration, load level, load position and temperature difference for each month within the design period is used to calculate the total bottom-up and top-down damage by the summation of individual damages, from which the amount of slab cracking is determined.

Cracking Model

The percentage of slabs with transverse cracks in a given traffic lane is used as the measure of transverse cracking and is predicted using the following model for both bottom-up and top-down cracking:

$$\text{Fault} = \sum_{i=1}^{m} \Delta\text{Fault} \tag{19}$$

Where,

CRK = predicted amount of bottom-up or top-down cracking (fraction)

FD = fatigue damage calculated using the procedure described in this section

The total amount of cracking is determined as follows:

$$TCRACK = \left(CRK_{Bottom-up} + CRK_{Top-down} - CRK_{Bottom-up} . CRK_{Top-down}\right)*100 \tag{20}$$

Where,

TCRACK = total cracking (percent).

$CRK_{Bottom\text{-}up}$ = predicted amount of bottom-up cracking (fraction)

$CRK_{Top\text{-}down}$ = predicted amount of top-down cracking (fraction)

The equation assumes that a slab may crack from either bottom-up or top-down and not both.

Structural Response Modeling

The following factors affect the magnitude of bending stresses in PCC slabs:

- Slab thickness
- PCC modulus of elasticity
- PCC poison's ratio
- PCC unit weight
- PCC coefficient of thermal expansion and shrinkage
- Base thickness
- Base modulus of elasticity
- Base unit weight (for bonded interface between PCC slab and base)
- Interface condition between the PCC slab and base
- Joint spacing
- Subgrade stiffness
- Lane shoulder joint LTE
- Longitudinal joint to lane LTE (for widened slab pavement)
- Temperature distribution through the slab thickness

- Moisture distribution through the slab thickness
- Magnitude of effective permanent curl/warp
- Load configuration
    - Bottom-up cracking – axle type (single, tandem, tridem and quad axle)
    - Top-down cracking – short, medium, and long wheelbase
- Axle weight
- Wheel tire pressure and wheel aspect ratio (length to width ratio)
- Axle position

While many of the parameters above remain constant throughout the design period, others vary seasonally, monthly, hourly, or with pavement age. For accurate fatigue analysis results, all cases that produce significantly different stresses must be evaluated separately. The structural model used to determine stress must be capable of accurately predicting stress considering the following:

- Temperature and wheel loads – the model must be capable of handling general nonlinear temperature distribution in the PCC layer and multiple wheel loads.
- Loss of support due to slab curling (separation of PCC slab from foundation).

- The effects of base course – the model must be able to consider bonded and unbounded cases.

- Slab to slab interaction in a multiple slab system and load transfer across both transverse and longitudinal joints.

In general, a finite element analysis program is required. The stress calculations in the design guide software is accompanied using artificial neural networks developed based on a large number of finite element analysis runs made using ISLAB2000. Step by step procedure for predicting JPCP transverse cracking is outlined below.

1. All inputs needed for predicting JPCP cracking is to be tabulated.

2. The processed traffic data needs to be further processed to determine equivalent number of single, tandem, and tridem axles produced by each passing of tandem, tridem, and quad axles.

3. The hourly pavement temperature profiles generated using EICM (nonlinear distribution) need to be converted to distribution of equivalent linear temperature differences by calendar month.

4. The effects of seasonal changes in moisture conditions on differential shrinkage is considered in terms of monthly deviations in slab warping, expressed in terms of effective temperature differences.

5. Stress corresponding to each load configuration (axle type for bottom-up and axle spacing for top-down), load level, load position, and temperature difference for each month within the design period is calculated.

6. Damage for each damage increment is calculated and sums to determine total bottom-up and top-down damage.

7. The amount of slab cracking is determined using the above two equations.

4.2.6 Faulting Prediction

Transverse joint faulting is the differential elevation across the joint measured approximately 1 ft from the slab edge (longitudinal joint for a conventional lane width), or from the rightmost lane paint stripe for a widened slab.

In the MEPDG the pavement structure is modeled as a two layered system consisting of slab and base with unbonded interface. The effects of subbase layers, as well as the shear contribution of the base layer, are accounted for through the use of effective dynamic modulus of subgrade reaction. The mean transverse faulting is predicted using an incremental approach. A faulting increment is determined each month and the current faulting level affects the magnitude of increment. The predicted faulting at any given point in time is determined as a sum of faulting increments from all previous months in the pavement life.

Since joint faulting varies significantly from joint to joint, the mean faulting of all transverse joints in a pavement section is the parameter predicted by the model. Faulting is an important deterioration mechanism of JPCP because of its impact on ride quality. Joint faulting also has a major impact on the life cycle costs of a pavement in terms of increased costs due to early rehabilitation and on vehicle operating costs as faulting becomes severe. Transverse joint faulting is the result of a combination of:

- Repeated application of moving heavy axle loads.
- Poor load transfer across the joint.
- Free moisture beneath the PCC slab.
- Erosion of the supporting base/subbase, subgrade, or shoulder base material.
- Upward curling of the slab.

The following factors affect transverse joint faulting:

- Presence of dowels and dowel diameter
- PCC slab thickness
- Joint spacing
- Use of stabilized base layers and the strength and durability of the materials
- Subgrade type
- Placement of vehicle loads near unsupported pavement edges
- Poor slab edge support (eg: lack of widened paving lanes, tied PCC shoulders, or edge beams)
- Precipitation
- Subsurface drainage, including an open graded base course

- Freezing index/number of freeze thaw cycles
- Slab curling and warping, including permanent curling and warping
- Large size and type of aggregates in the PCC
- Joint opening

<u>Faulting Model</u>

The mean transverse joint faulting is predicted using an incremental approach. A faulting increment is determined each month and the current faulting level affects the magnitude of increment. The faulting at each month is determined as a sum of faulting increments from all previous months in the pavement life since the traffic opening using the following model:

$$\text{Fault} = \sum_{i=1}^{m} \Delta\text{Fault} \qquad (21)$$

$$\Delta\text{Fault}_i = C_{34} * \left(\text{FAULTMAX}_{i-1} - \text{Fault}_{i-1}\right)^{\wedge} 2 * \text{DE}_i \qquad (22)$$

$$FAULTMAX_i = \text{FAULTMAX}_0 + C_7 \sum_{j=1}^{m} \text{DEj} * \text{Log}\left(1 + \text{C}_5 * 5.0^{\text{EROD}}\right)^{\wedge} \text{C}_6 \qquad (23)$$

$$FAULTMAX_0 = C_{12} * \delta_{Curling} * \left[Log\left(1 + C_5 * 5.0^{EROD}\right) * Log\left(\frac{P_{200} * Wetdays}{P_s}\right)\right]^{\wedge} C_6 \qquad (24)$$

Where,

Fault_m = mean joint faulting at the end of month m, in

ΔFault_i = incremental change (monthly) in mean transverse joint faulting during month i

FAULTMAX_i = maximum mean transverse joint faulting for month I, in

FAULTMAX_0 = initial maximum mean transverse joint faulting, in

EROD = base/subbase erodability factor

DE_i = differential deformation energy accumulated during month i

$\delta_{Curling}$ = Maximum mean monthly slab corner upward deflection PCC due to temperature curling and moisture warping

P_S = overburden on subgrade, lb

P_{200} = percent subgrade material passing #200 sieve

Wetdays = average annual number of wet days (greater than 0.1 in rainfall)

C_1 through C_8 and C_{12}, C_{34} are national calibration constants:

$$C_{12} = C_1 + C_2 * FR^{0.25} \quad (25)$$

$$C_{34} = C_3 + C_4 * FR^{0.25} \quad (26)$$

FR = base freezing index defined as percentage of time the top base temperature below freezing (32°F) temperature

Structural Response Modeling for Faulting

Critical truck axle loading includes a single, tandem, tridem, or quad axle located close to the approach slab corner. The closer the load is to the longitudinal lane shoulder joint, the greater the slab corner deflection. The approach corner deflects depending on the slab joint design (load transfer of transverse and longitudinal joint), base course stiffness, and subgrade stiffness. Faulting progresses non-linearly over time. The differential corner deflection is a critical factor that affects faulting. The differential corner deflection is a function of joint LTE and corner deflection. LTE across the transverse joint is modeled and varies with time (seasonal deflection and long term deterioration). The LTE at the mainline shoulder joint is assumed constant with time. The following factors affecting the magnitude of deflections at the corners of the PCC slab are directly considered by the design procedure:

- PCC thickness
- PCC modulus of elasticity
- PCC Poisson's ratio
- PCC unit weight
- PCC coefficient of thermal expansion
- PCC ultimate shrinkage
- Base thickness
- Base modulus of elasticity
- Interface condition between the PCC slab and base
- Joint spacing
- Subgrade stiffness
- LTE with shoulder
- LTE at the transverse joints
- Difference in top and bottom PCC slab surface temperature
- Variation in PCC relative humidity
- Axle type
- Axle weight
- Axle position

In general, a finite element analysis program is required. The stress calculations in the design guide software is accompanied using artificial neural networks developed based on a large number of finite element analysis runs made using ISLAB2000. The artificial neural networks were developed using the results of thousands of ISLAB2000 runs. These neural networks directly incorporate all factors listed above and closely match ISLAB2000 deflections for a wide range of input parameters. Step by step procedure for predicting faulting is outlined below.

1. All inputs needed for predicting JPCP transverse joint faulting are to be tabulated.
2. Processed traffic data needs to be further processed to determine equivalent number of single, tandem and tridem axles produced by each passing of tandem, tridem and quad axles.
3. The hourly pavement temperature profiles generated using EICM (non linear distribution) need to be converted to effective nighttime differences by calendar month.
4. The effects of seasonal changes in moisture conditions on differential shrinkage is considered in terms of monthly deviations in slab warping, expressed in terms of equivalent temperature differential.
5. Initial maximum faulting is to be calculated.
6. Joint LTE is to be evaluated.
7. Current maximum faulting to be determined.
8. Critical pavement responses for the increment to be determined.
9. Loss of shear capacity and dowel damage to be evaluated.
10. Faulting increment to be calculated.
11. Finally the cumulative faulting will be determined.

4.3 Inputs

As mentioned above, analysis with the MEPDG requires input for traffic, climate, materials, and structure. Some of these required inputs were obtained for the segmentation process, e.g., AADTT from the NHPN and state database. Other inputs were not as readily available and the sections below detail the required inputs and the process whereby they were obtained. These inputs constitute requirements of the hierarchical level 3 process in the MEPDG.

4.3.1 Traffic

For the analysis in this report the initial year traffic volumes, in terms of Average Annual Daily Truck Traffic (AADTT) were obtained from the National Highway Planning Network (NHPN 2015). In addition to AADTT, the MEPDG requires inputs to adjust the average daily traffic for monthly variations, vehicle class types, hourly usage, axle load distributions, traffic wander, number of axles per truck, axle configuration, and wheelbase. Since the analysis sections were multi-state interstates it was assumed that these factors were nearly consistent across all sections and consistent with the initial nationally calibrated default values provided in the analysis software. The factors that were taken to be section specific were the average AADTT value, number of lanes in the design direction, and the traffic growth rate. The numbers of lanes were determined from satellite images of the road segments. The percentage of trucks in the design direction was considered equal to 50% and the percentage of trucks in the design lane were 90%, 70%, and 50% for two lane, three lane, and four lanes in the design direction respectively (ARA 2004).

Figure 14 shows the map of current traffic in the form of AADTT values for various sections considered. In this map, a thicker line segment denotes a higher traffic volume. Traffic input values form the basis of this analysis, as level of traffic carried by the section is the predominant factor in determining the various distresses caused and hence the performance of the structure. As expected, the traffic levels are particularly high along;

- Interstates 5, 10, and 15 around Los Angeles, California,
- Interstates 5 and 90 around Seattle, Washington,
- Interstates 35 and 10 around San Antonio, Texas,
- Interstate 10 through Dallas, Texas,
- Interstates 80 and 90 around Chicago, Illinois,
- Interstates 75 and 94 around Detroit, Michigan, and
- Interstate 95 around Miami, Florida and New York City, New York.

It can also be seen from the map that the traffic level is relatively less in the West-North central region and the northern part of the Mountains region.

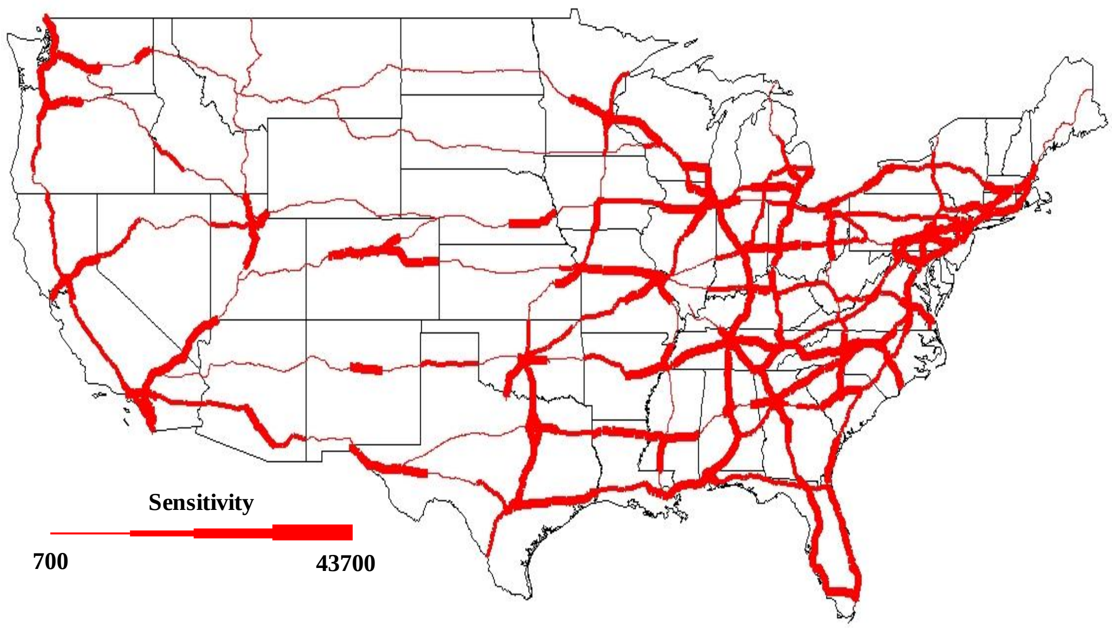


Figure 14: Interstates AADTT Map.

Within the default values there are several adjustments that are made to the initial AADTT volumes. The first adjustment is for the vehicle class distribution, which quantifies the percentage of the total AADTT attributed to each class of trucks. By default there are 17 different classifications, referred to as Truck Traffic Classifications or TTC's. These classifications along with the category of roadway that they typically apply to are summarized in Table 28. For the analysis here, TTC 1, which has a predominance of class 9 trucks (74%), has been considered for all cases. The second adjustment factor is the axle load distribution factor, which denotes the percentage of axles of each type (single, tandem, tridem, or quad), month, and vehicle class carrying a given load. It is estimated using Weigh in Motion (WIM) data from various Long Term Pavement Performance (LTPP) sites around the nation. Other traffic factors include corrections for the number of vehicles in the design direction and design lane. These were estimated by considering the pavements to have two lanes in each direction. Hence a directional split of 50 percent and a lane distribution factor of 90% have been used nationally.

Finally each segment was analyzed with respect to the traffic growth values found from the website of each Department of Transportation as well as with respect to the ATA trucking projections. These rates are summarized for each analysis section in Appendix B, but in all cases were applied based on compound growth as shown in Equation (18).

$$AADTT_t = AADTT_{BY}\left(1+GR\right)^t \tag{27}$$

Where:

$AADTT_t$	=	AADTT in t years from the base year;
$AADTT_{BY}$	=	AADTT in the base year of analysis;
t	=	Time; and
GR	=	Growth rate as a percentage.

Table 28: Summary of Available Default TTCs.

TTC	Buses	Multi-Trailer Trucks	General Categories					Description
			I	PA	MA	MjC	MC	
1	(>2%)	(<2%)	X	X				Predominantly single-trailer trucks
2	(>2%)	(<2%)	X	X				Predominantly single-trailer trucks with a low percentage of single-unit trucks
3	(<2%)	(2 - 10%)	X	X				Predominantly single-trailer trucks
4	(>2%)	(<2%)	X	X	X			Predominantly single-trailer trucks with a low to moderate amount of single-unit trucks
5	(<2%)	(>10%)	X					Predominately Single-trailer trucks.
6	(>2%)	(<2%)		X	X	X		Mixed truck traffic with a higher percentage of single-unit trucks
7	(<2%)	(2 - 10%)		X				Mixed truck traffic with a higher percentage of single-trailer trucks
8	(<2%)	(>10%)	X	X	X			High percentage of single-trailer truck with some single-unit trucks.
9	(>2%)	(<2%)		X	X	X	X	Mixed truck traffic with about equal percentages of single-unit and single-trailer trucks
10	(<2%)	(2 - 10%)		X	X			Mixed truck traffic with about equal percentages of single-unit and single-trailer trucks.
11	(<2%)	(>10%)	X	X	X			Mixed truck traffic with a higher percentage of single-trailer trucks
12	(>2%)	(<2%)		X	X	X	X	Mixed truck traffic with a higher percentage of single-unit trucks.
13	(<2%)	(>10%)	X					Mixed truck traffic with about equal percentages of single-unit and single-trailer trucks
14	(>2%)	(<2%)		X		X	X	Predominantly single-unit trucks
15	(<2%)	(2 - 10%)			X	X		Predominantly single-unit trucks.
16	(<2%)	(>10%)		X	X			Predominantly single-unit trucks.
17	(>25%)	(<2%)			X	X	X	Mixed truck traffic with about equal single-unit and single-trailer trucks

[a] I = Interstate, PA = Principle Arterial, MA = Minor Arterial, MjC = Major Collector, MC = Minor Collector

The primary goal of this project is to examine how freight trends are likely to affect the pavement infrastructure and to meet this objective a key component to the work was estimating the impacts of these trends on actual AADTT growth over a typical design period of 20 years. Such a projection is a complex process that includes various factors from the population growth of the individual regions, the predicted inter- and intraregional economic and employment growth rate, the nation's overall growth rate, and international trade occurring between nations. These types of analysis are typically done on a highly localized scale (Wittwer et al. 2005, Stone et al. 2006, Jones 2007, BITRE 2012, Wheeler et al. 2011), but one such study has examined these trends nationally and the outcomes were used extensively in this work.

The projected freight trends were developed by IHS Global Insight for the American Trucking Association (Costello 2014). The methodology adopted used a bottom-up prediction method that first examined the economic forecast of the nation and states (in terms of GDP), growth in job generation and the growth in the six key drivers of freight movement; manufacturing, mining, non-oil merchandise and merchandise import and export, construction, and farm marketing. The economic assessment as a whole examined the movement of goods and services by rail, roadway, water, air, and pipeline, but the results of primary interest here are the roadway projections. The data gathered for this forecast included industry and government freight data as well as IHS Global's own data on industries and commodities. It should be noted that due to the high fluctuations in the factors governing the economic forecasts, partially accurate predictions can be made for only a period of ten years. In this work it is assumed that these same projections hold for 20 years.

For these freight projections the country is divided into nine regions by grouping together adjacent states. For each region a cumulative projected growth has been estimated. The regions and cumulative rate are summarized in Figure 15 below. This aggregated projection alone is insufficient to project individual interstate traffic trends and so an analysis technique was devised assuming self-similar growth across all sections within a given region. First, the DOT estimated growth rates for the interstates comprising each region were compiled. Then, the growth rates on each section were cumulated by taking the averaging growth rate, $GR_{DOT,i}$, weighted by the base year AADTT of the section, Equation (28). In this equation the subscript i refers to the section and the subscript j indicates that this process was carried out on a regional basis. The third step equated this weighted average to an equivalent overall regional-wise growth rate, $GR_{DOT\ avg,j}$, as shown in Equation (29).

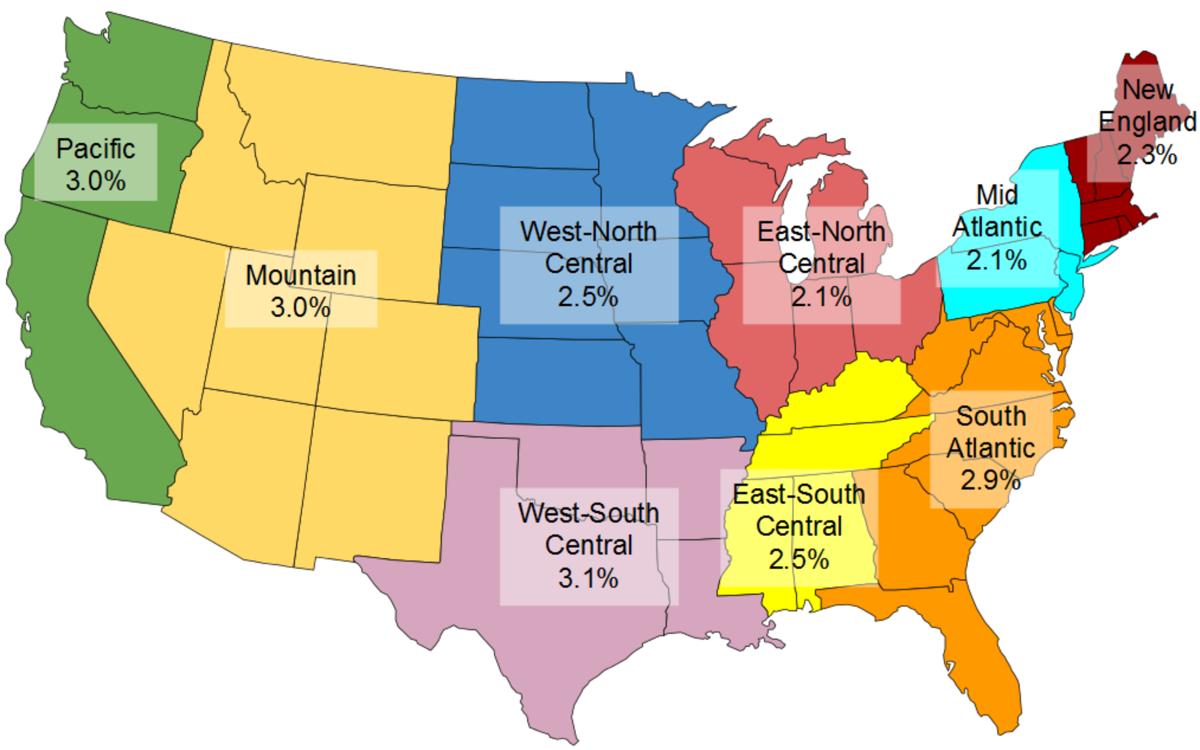


Figure 15: Regional Divisions for Freight Projects and IHS Global Projections.

The outcome of these three steps was a current projected average growth rate for each region, which are summarized in Figure 16Figure 16. Comparing this figure to Figure 15 it can be seen than overall national trends suggest larger movements that currently accounted for in most regions with the exception of New England and West-South Central.

$$\bar{y}_{DOT,j} = \sum_{i=1}^{N} AADTT_{ij}\left(1 + \frac{GR_{DOT,ij}}{100}\right) \tag{28}$$

$$GR_{DOT\ avg,j} = \left(\frac{\bar{y}_{DOT,j}}{\sum_{i=1}^{N} AADTT_{ij}} - 1\right) \times 100 \tag{29}$$

To complete the sectional growth rate projections, it was assumed that the IHS Global projections for freight movement would occur across the individual sections in the same proportion that currently exists, e.g., self-similar growth. In this case the ratio of DOT growth rates, denoted as x_{ij} as it is calculated by section and region, Equation (30), was maintained. This ratio was then assumed to hold for the freight projections and used to cast all growth rates, $GR_{Proj,i}$, with respect to an estimated maximum projected growth rate, Equation (31). Thus, estimating the individual section growth rates simplifies to finding only the single maximum projected growth rate. Since the analysis assumes self-similar growth this will be the same section that showed the highest DOT based growth rate.

$$x_{ij} = \frac{GR_{DOT,ij}}{\max\left(GR_{DOT,i}\right)} \tag{30}$$

$$GR_{Proj,ij} = \left(\max\left(GR_{Proj,i}\right)_j\right) \times x_{ij} \tag{31}$$

To estimate the maximum growth rate, the same weighted average calculation procedure used to estimate the DOT based regional average growth rate was applied. Substituting Equation (22) into the basic form of Equation (19) and noting that these calculations are now being performed for projected rates leads to;

$$\bar{y}_{Proj,j} = \sum_{i=1}^{N} AADTT_{ij} \left(1 + x_{ij} \frac{\left(\max\left(GR_{Proj,i}\right)_j\right)}{100}\right) \tag{32}$$

.

Then following the same principle used with respect to Equation (29), the individual segment growth rates were related to the projected regional average growth rate via

$$GR_{Proj\ avg,j} = \left(\frac{\bar{y}_{Proj,j}}{\sum_{i=1}^{N} AADTT_i} - 1\right) \times 100 = \left(\frac{\sum_{i=1}^{N}\left(AADTT_{ij} \times x_{ij}\right)}{\sum_{i=1}^{N} AADTT_{ij}}\left(1 + x_{ij} \frac{\left(\max\left(GR_{Proj,i}\right)\right)}{100}\right)\right) \times 100 \tag{33}$$

In this equation, $GR_{Proj\ avg,j}$ was known from the IHS Global estimates and thus the equality could be solved to identify the max($GR_{Proj,i}$) value. Subsequently each section growth rate could be estimated by Equation (31).

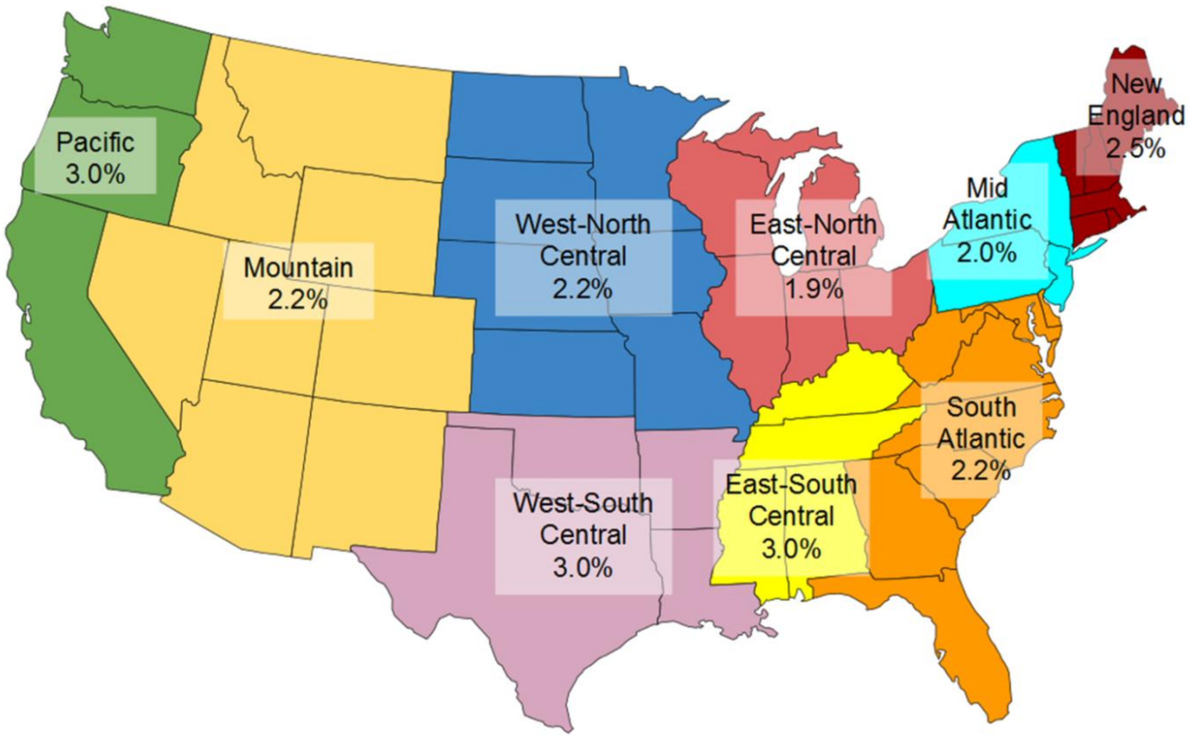


Figure 16: Estimated Regional Growth Rates from DOT Projections.

4.3.2 Climate

The local climate affects the material properties by dictating both the pavement temperature and the sub-surface moisture conditions. The relevant parameters include hourly temperature, daily precipitation, average amount of sunshine, wind speed, and latitude and longitude. As demonstrated schematically in Figure 17 each of these variables make contributions to heat and moisture flow in the pavement system. For example, the wind speed contributes to the convection process. As shown in Figure 18 the weather stations used to collect these data were distributed across the United States and provided pre-formatted files that contained a minimum of five years historical data. The MEPDG uses the EICM to model climate temperature and moisture profiles throughout the pavement layers. Default climate inputs were obtained from National Climatic Data Center climatic data from several weather stations across the US (NCDC). For the segments, a single weather station was selected when that selected station aligns closely to the segment and had no missing input details. However, in cases where these criteria could not be met a virtual weather station was created by interpolating from at least two nearby weather stations. This process was internal to the EICM and the user need only select the nearest stations. For example in the case of Tucson, which has an insufficient database, a virtual weather station was created that included Tucson, Nogales, Safford, Douglas-Bisbee and Phoenix. This approach was deemed acceptable based on the fact that climate was a determining factor in the segmentation process. Appendix C summarizes the relevant weather stations for each section. The EICM also requires water table depth and this information was obtained for all analysis segments from the US geological survey database.

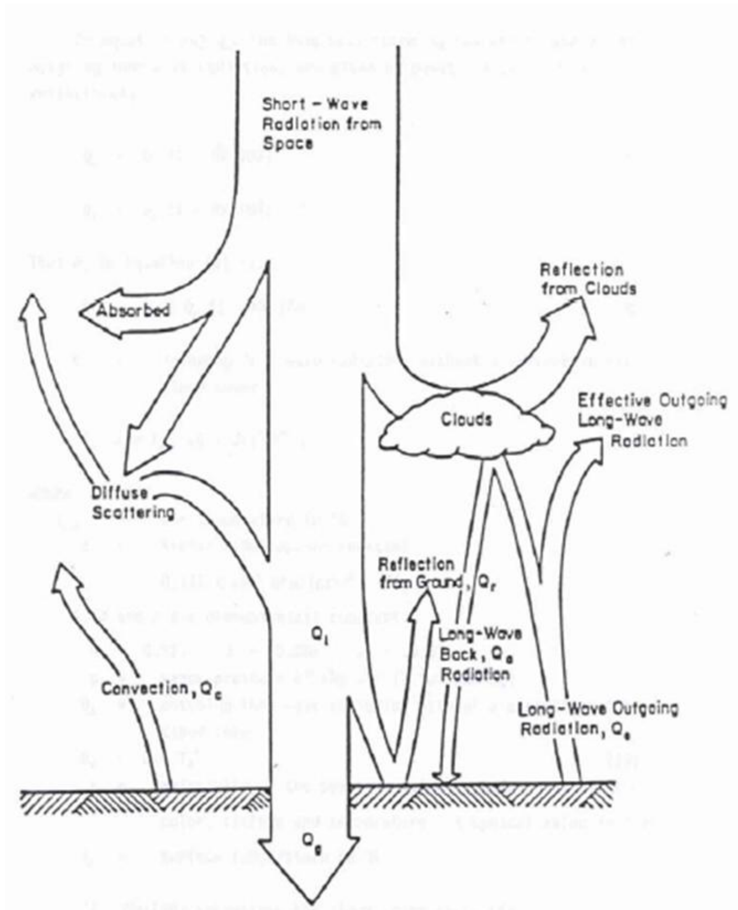


Figure 17: Relevant Energy Movements in Process of Heat Transfer in Pavement System (Lytton et al. 1990).

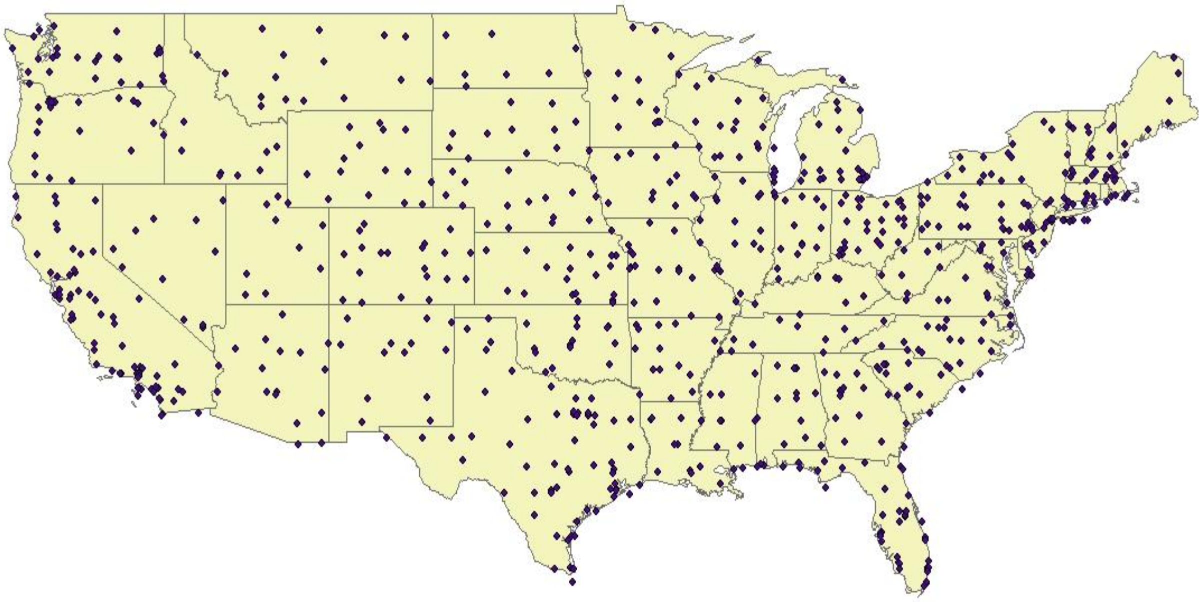


Figure 18: Weather Stations across the US.

4.3.3 Materials

The key material properties used for pavement analysis are the moduli values of each paving layer. The moduli values relate stress and strain and are necessary to perform the layered elastic analysis, which as discussed below provides the response variables for performance predictions. In the case of the asphalt concrete the relevant modulus is the temperature and frequency dependent dynamic modulus. For the purposes of this analysis the dynamic modulus was estimated using the Witczak predictive model shown in Equation (34).

$$\begin{aligned}\log|E^*| &= -1.249937 + 0.02923\rho_{200} - 0.001767(\rho_{200})^2 - \\ &0.002841\rho_4 - 0.05809V_a - 0.082208\frac{V_{beff}}{V_{beff}+V_a} + \\ &\frac{3.871977 - 0.0021\rho_4 + 0.003958\rho_{3/8} - 0.000017(\rho_{3/8})^2 + 0.00547\rho_{3/4}}{1+e^{(-0.603313-0.313351\log f - 0.393532\log h)}}\end{aligned} \tag{34}$$

Where:

ρ_{200} = Percentage of aggregate passing #200 sieve;

ρ_4 = Percentage of aggregate retained in #4 sieve;

$\rho_{3/8}$ = Percentage of aggregate retained in 3/8 - inch sieve;

$\rho_{3/4}$ = Percentage of aggregate retained in ¾ - inch sieve;

V_a = Percentage of air voids (by volume of mix);

V_{beff} = Percentage of effective asphalt content (by volume of mix);

f = Loading frequency (Hz); and

η = Binder viscosity at temperature of interest (10^6 P).

As shown in this equation the relevant material properties include gradation parameters, binder viscosity, and volumetric properties. The asphalt cement viscosity was estimated from the correlation between viscosity and specification grade of the asphalt binder. The required specification grade of the asphalt used in the pavement was obtained from either the state department of transportation or from the known climatic conditions at the site. The chosen grade is shown in the tables in Appendix D for each segment.

For unbound layers the elastic modulus at the optimum moisture content is first entered and then adjusted internally for the effects of moisture content changes over time. For sections with an aggregate base layer, the initial elastic modulus and Poisson's ratio were taken from the default model inputs for crushed stone as 30,000 psi and 0.35 respectively. In the case of the subgrade a two-step process was adopted. First, the extensive mapping effort completed under the NCHRP 9-23B project was used to determine the representative AASHTO classification for each analysis segment. The soils are denoted as A1, A2, A3, A4, A5, A6, or A7. These data which were earlier collected for the segmentation process was used here as the subgrade input for the MEPDG analysis. In the Level 3 analysis of MEPDG, the data required in the case of subgrade are the modulus, Poisson's ratio, and the coefficient of lateral pressure, k_o. The modulus values were taken to be the default MEPDG values for the corresponding AASHTO class of the soil (see Table 29), the Poisson's ratio was taken as 0.35, and k_o was taken as 0.5. Other required material parameters included the thermal conductivity and heat capacity of the asphalt as well as the gradation, soil water characteristic curve parameters, and Atterberg limits of the unbound layers. The pre-programmed default values were used for all of these parameters.

Table 29: Soil Resilient Modulus Values Entered for Analysis.

Material Classification	M_r (psi)	Material Classification	M_r (psi)	Material Classification	M_r (psi)
A-1-a	29,500	A-2-6	20,500	A-5	15,500
A-1-b	26,500	A-2-7	16,500	A-6	14,500
A-2-4	21,500	A-3	24,500	A-7-5	13,000
A-2-5	21,000	A-4	16,500	A-7-6	11,500

4.3.4 Structure

After the traffic, climate and materials input, the pavement structure is the fourth and final major input factor. This input requires knowledge of the thickness and layer types used on each interstate. These details were obtained from the Long Term Pavement Performance Program (LTPP). In some cases structure details were unavailable and so they were assumed based on the structures from the adjacent and/or close by states. The details of each section are summarized in Appendix E, where it can be seen that the majority of sections in this analysis had structures that consisted of an asphalt concrete layer.

4.4 Output

The results from the mechanistic-empirical analysis are summarized in an output file that lists the average predicted distresses along with the reliability estimate of these distresses. An example output summary from the analysis of segment I94-MT-2 is shown in the table and figures below.

Table 30: Distress Output Summary.

Distress	Distress Predicted	Reliability Predicted
Terminal IRI (in/mi)	119.2	94.81
Alligator Cracking (%)	0.2	99.99
Permanent Deformation (in)	0.46	99.95

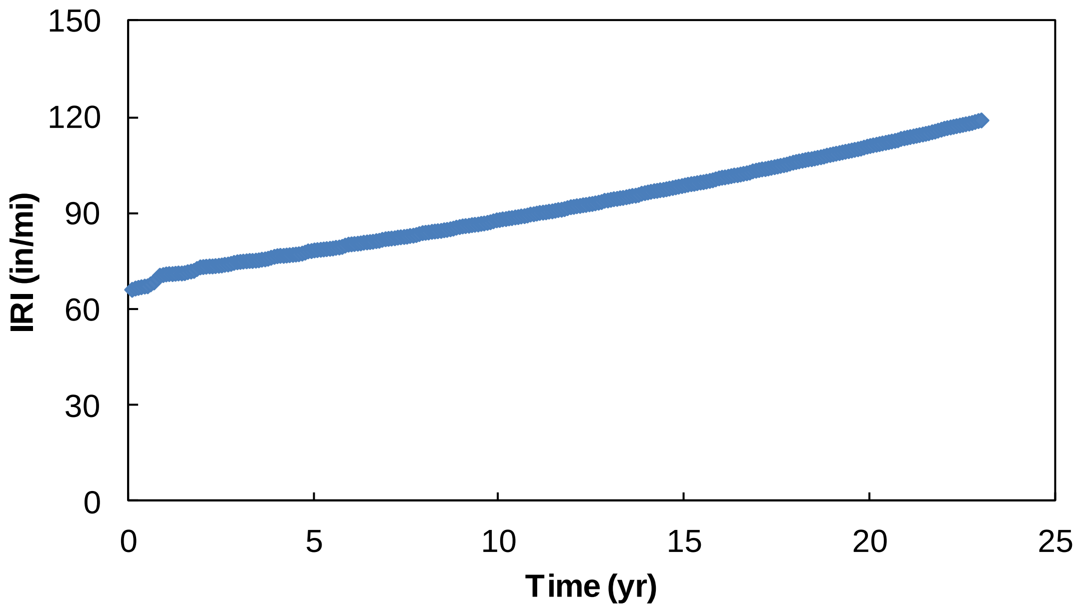


Figure 19: Example IRI Results from MEPDG Analysis.

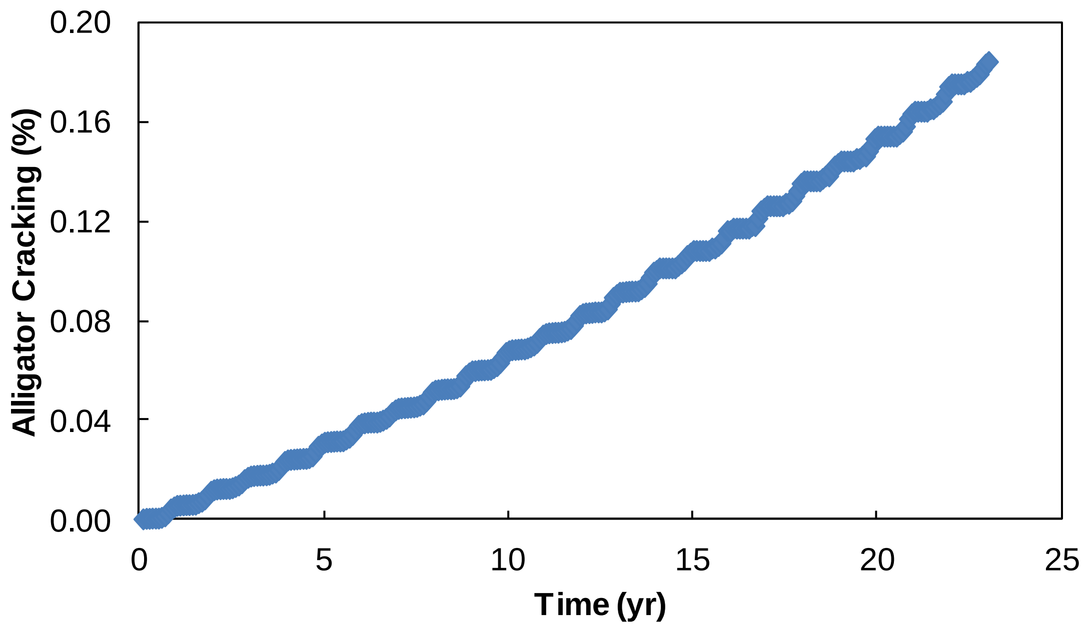


Figure 20: Example Alligator Cracking Results from MEPDG Analysis.

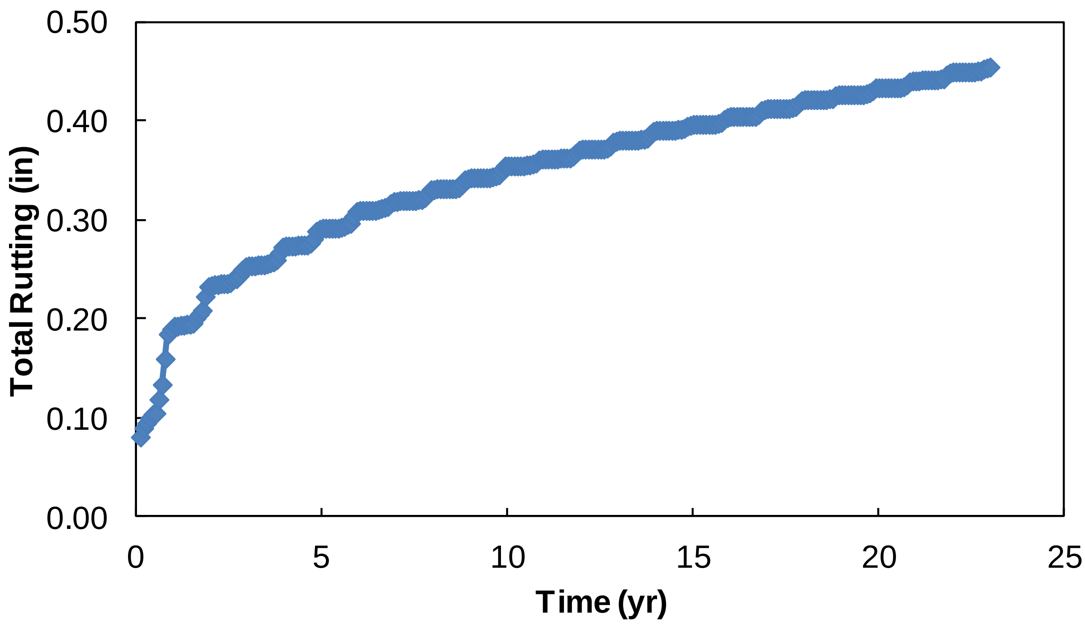


Figure 21: Example Rutting Results from MEPDG Analysis.

5.0 Results

This chapter summarizes the resultant differences in distresses (IRI, rutting, and fatigue cracking) obtained from Mechanistic-Empirical simulations. The results are shown as a series of GIS maps. All the maps represent the 26 major interstates considered for analysis. Separate distress maps were generated for IRI, Fatigue, Rutting, Transverse cracking and Rutting. The dashed lines in asphalt pavement distress maps indicate the portland cement concrete pavement sections, which do not have them as a performance metric. This pattern of using dashed lines will be repeated in the case of portland cement concrete pavements distress maps as well. The classes chosen represent low, medium, high, and very high sensitivity to changes in freight growth projections. The values of these ratios are denoted in the maps by varying the thickness of the line. A thicker line segment denotes a very high value of sensitivity. The results thus obtained are discussed below.

5.1 Pavement Performance Results and Discussion

Pavement performance was quantified for each section depending on the type of pavement structure. Inputs were obtained for the base year 2012, and it was analyzed for 2035. In all cases ride quality was predicted as a change in the International Roughness Index (IRI) over time. In the MEPDG, IRI is estimated incrementally over the analysis period by incorporating other predicted distresses. Predicted distresses specific to asphalt pavements included fatigue cracking, rutting and thermal cracking. The first two of these three distresses can be readily associated with load related phenomenon, while the third distress arises from the pavement response to temperature changes. Specific rigid pavement distresses include transverse cracking and faulting. This section discusses the distress results obtained from the MEPDG analysis. The results are shown in a GIS map. Assessment of the sensitivity to expected freight trends is made by comparing the predicted performance from the DOT based growth rate with the performance predicted using the ATA growth rate. Sections that would be considered sensitive to freight trends would have a greater difference in predicted performance. Since the scale of each performance metric is different (e.g., rutting is predicted in inches and fatigue cracking in percentage), the two predictions (ATA and DOT) are compared by taking the ratio of the predicted distress with the ATA rate to the predictions with the DOT rate., e.g., Equation (35), where the variable X represents a given distress variable of interest and the subscripts ATA and DOT indicate whether the distress is predicted using the ATA or DOT rate.

$$X_{sensitivity} = \frac{X_{ATA}}{X_{DOT}} \tag{35}$$

Maps are then developed, which graph the value of $X_{sensitivity}$ for all of the interstate sections and for different distresses (rutting, cracking, IRI, etc.). The value of $X_{sensitivity}$ is shown in the map by varying the thickness of lines, and the convention followed in these maps is that a thicker line segment represents a higher sensitivity value along the segment.

5.1.1 IRI Prediction

The distresses map of the US interstates with respect to predicted IRI is shown in Figure 22. The analysis shows highest levels of relative distress in Interstate 95 along the states of Pennsylvania, Maryland and New Jersey. It was seen from the traffic map that the traffic value along the segment is also very high, but this analysis suggests that additional traffic above that currently being designed for in this corridor is expected to have additional, and currently unaccounted for implications. The predicted IRI value is also higher in along Interstate 15 and Interstate 70 segments in the state of Utah, as the route forms the major route of transportation of goods from the ports of Los Angeles and San Diego to the northern and central part of the US. The other segments with higher value of IRI are Interstate 44 between Texas border and Oklahoma City, Interstate 75 along Georgia and Florida, and the segments of Interstate 95 around the port of Jacksonville. The distress values are higher in the central states that form the major transcontinental highway routes. The average, maximum and minimum IRI values are presented region wise in Figure 23.

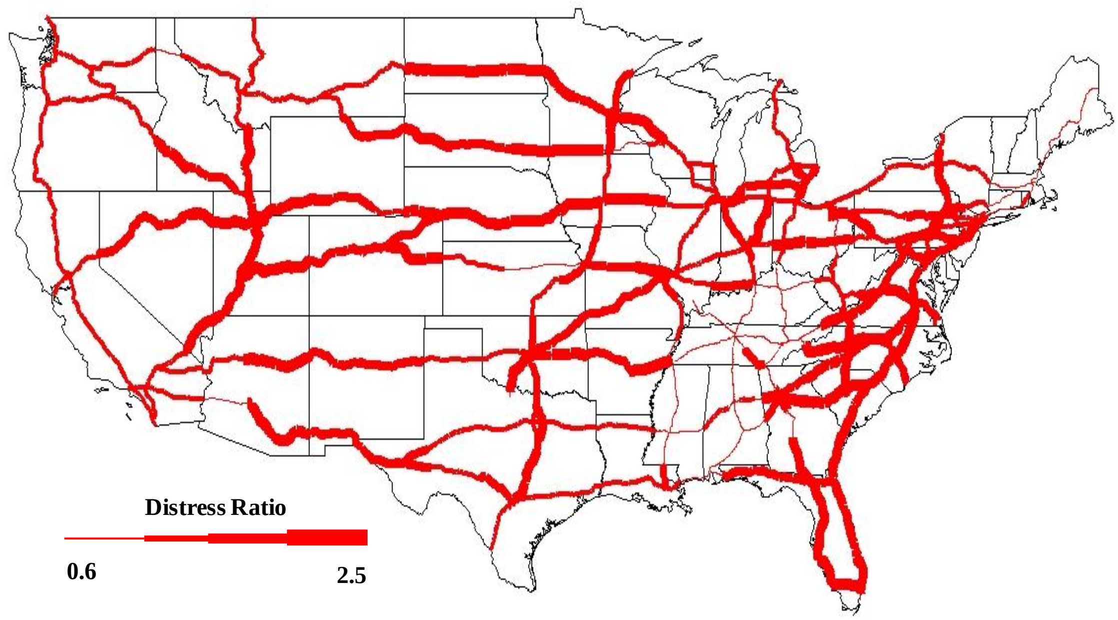


Figure 22: Interstates IRI Map.

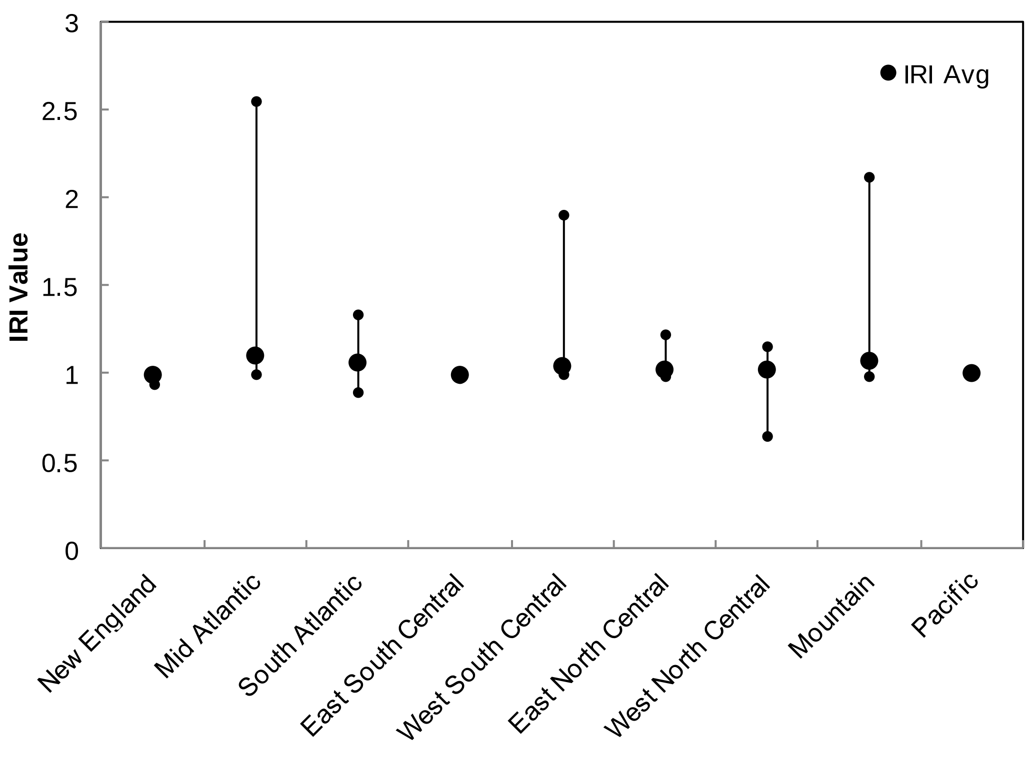


Figure 23: IRI Distress Values – Region-wise

The IRI results are presented state wise in Figure 24, which shows the maximum IRI values for each state. The figure reiterates the results drawn from IRI map, and it can be seen that the Atlantic and mountain states are projected to have the maximum pavement distresses. The IRI results are presented interstate wise in Figure 25, which shows the maximum IRI values for each interstate. It can be seen that Interstate 95 has the maximum IRI value, followed by Interstate 15 and Interstate 44.

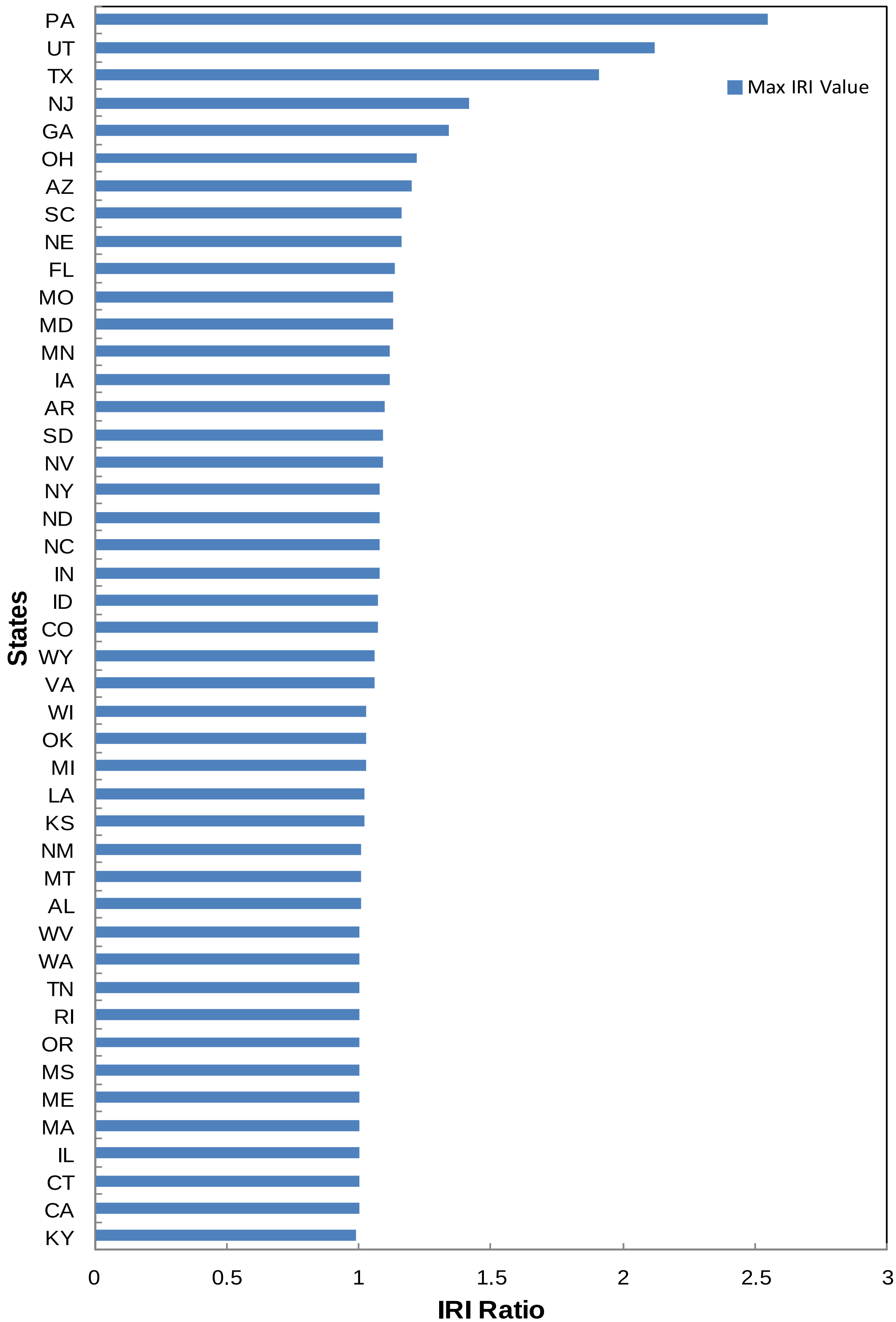


Figure 24: Maximum IRI values – State-wise

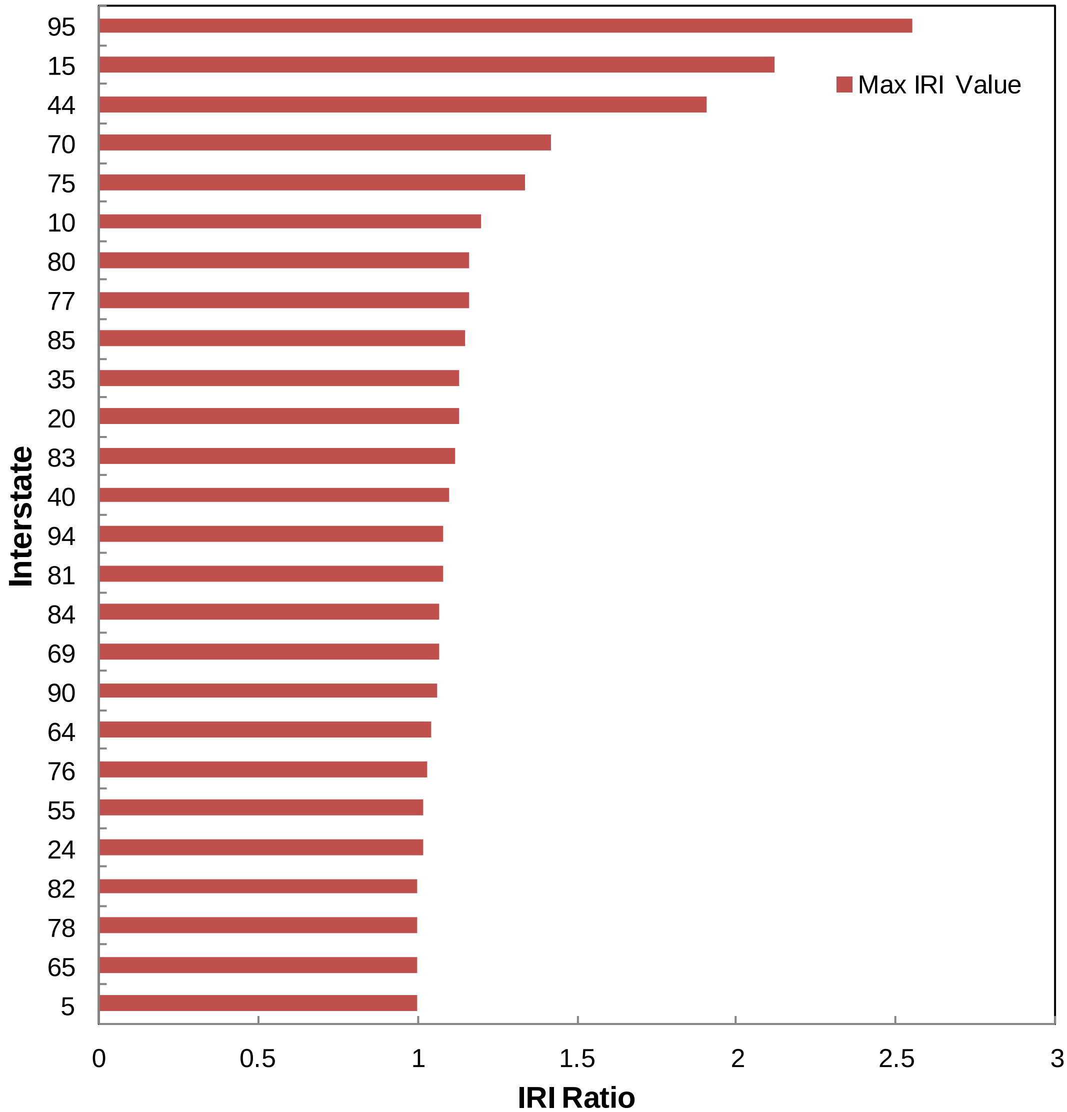


Figure 25: Maximum IRI value – Interstate-wise

5.1.2 Flexible Pavement Distress

The distress map of US interstates with respect to Fatigue is shown in Figure 26. As the fatigue cracking is directly related to the amount of load carried by the pavement, high fatigue cracking is exhibited by those segments with both a discrepancy in growth rate and that have high baseline traffic levels. It can be seen from the map that the maximum values for fatigue occurs in the Interstate 95, Interstate 81, and Interstate 64 segments in

Virginia. The Interstate 10 segment near Jacksonville, Florida also shows a higher value. The other segments with higher fatigue values are the Interstate 84 segments in Utah and Idaho, Interstate 10 segments in Louisiana, and Interstate 40 segments in North Carolina. The average, maximum and minimum fatigue values are presented region wise in Figure 27.

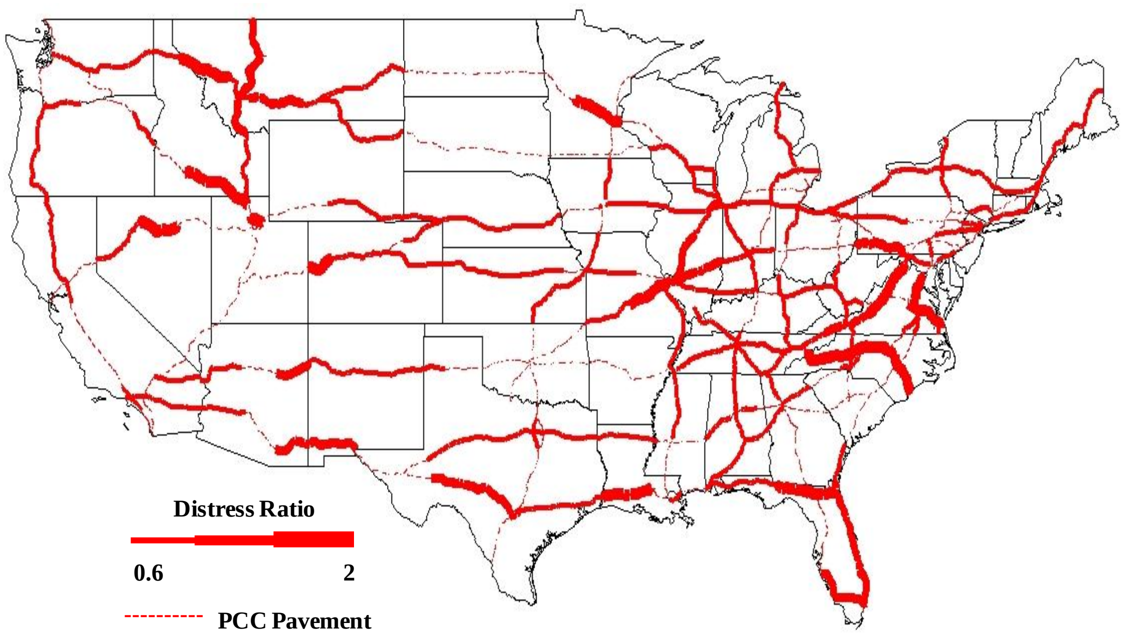


Figure 26: Interstates Fatigue Map.

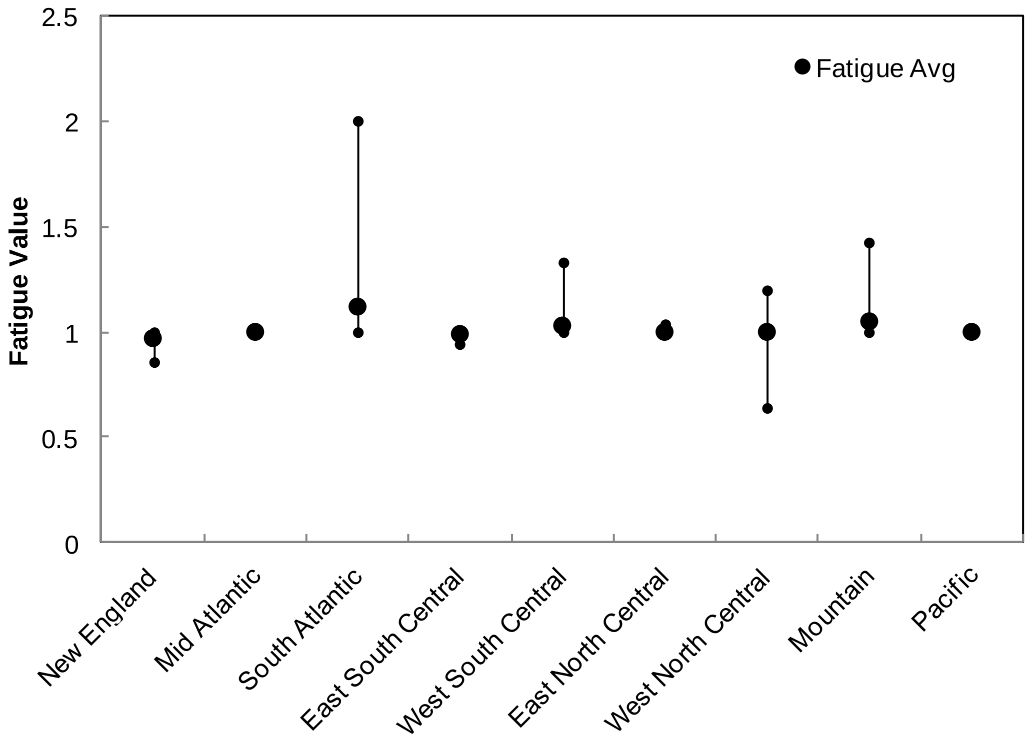


Figure 27: Fatigue Distress Values- Region-wise

The relative distress map with respect to rutting is shown in Figure 28 and it is seen that the locations with the greatest sensitivity to this distress are Interstate 10 in western Arizona, Interstate 80 segments in Nebraska, Interstate 70 sections in Kansas, Interstate 85 segment in North Carolina and Interstate 85 and 95 segments in Georgia. Taking the fatigue and rutting results together reinforces a key tenant of pavement design; segments that are weak in fatigue may not necessarily be weak in rutting and in fact these sections can demonstrate quite opposite responses to the two distresses. The average, maximum and minimum rutting values are presented region wise in Figure 29.

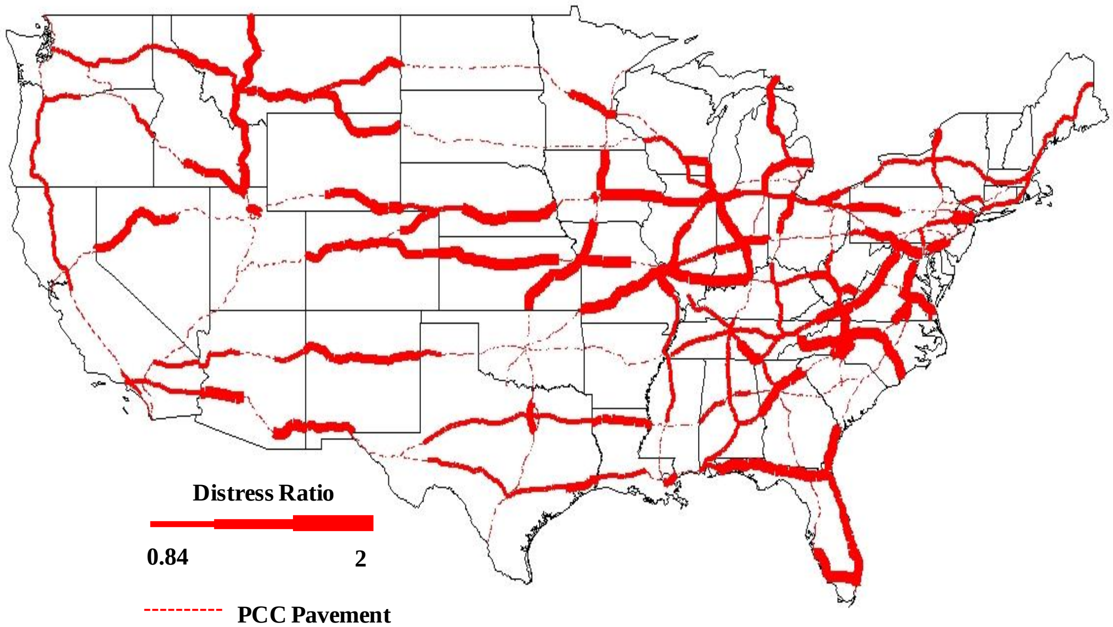


Figure 28: Interstates Rutting Map.

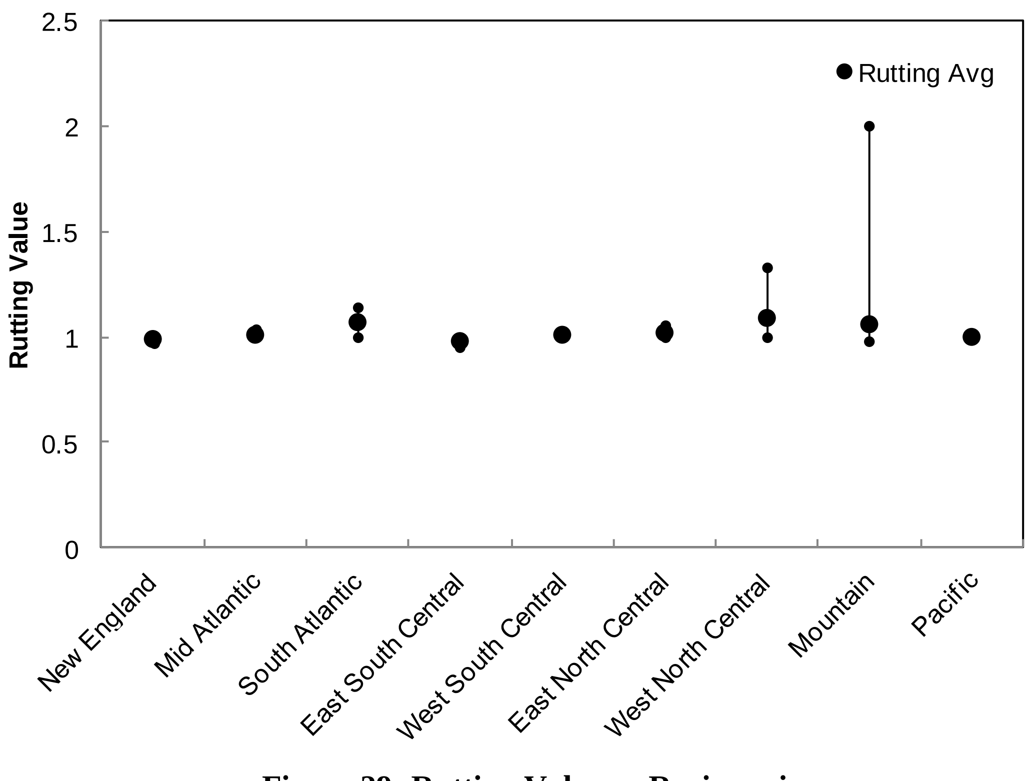


Figure 29: Rutting Values – Region-wise

5.1.3 Rigid Pavement Distress

The transverse cracking map for the various selected interstates is shown in Figure 30. The segments found to be the most affected by transverse cracking are Interstate 94 and 90 segments in North and South Dakota respectively, Interstate 80 segments in Iowa and the Interstate 75 and Interstate 20 segments in Georgia. The average, maximum and minimum transverse cracking values are presented region wise in Figure 31.

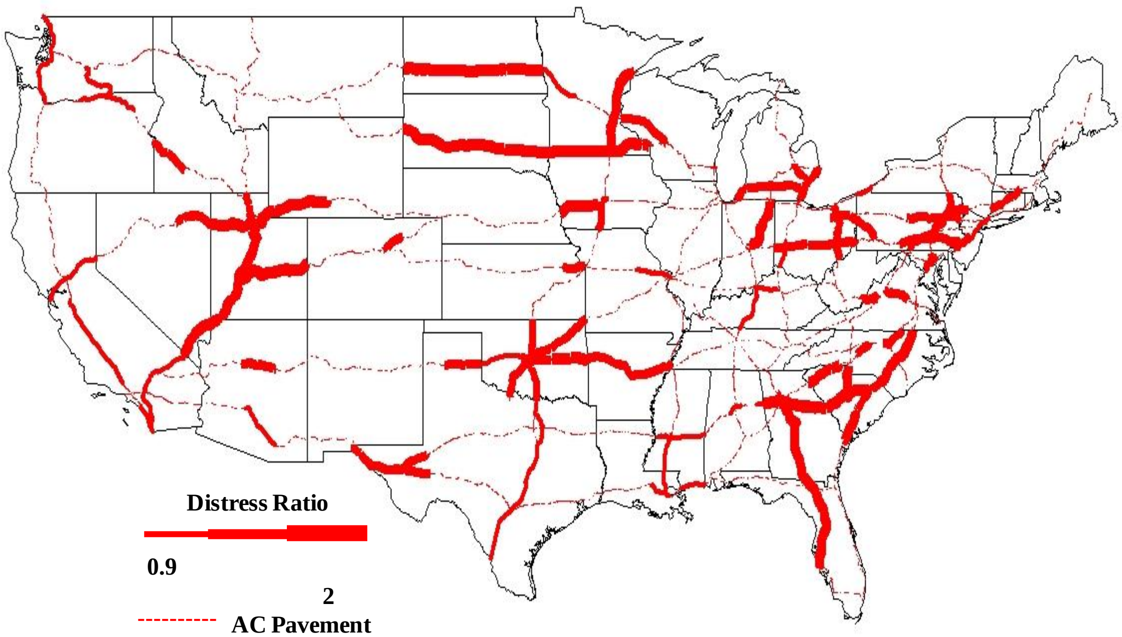


Figure 30: Interstates Transverse Cracking Map.

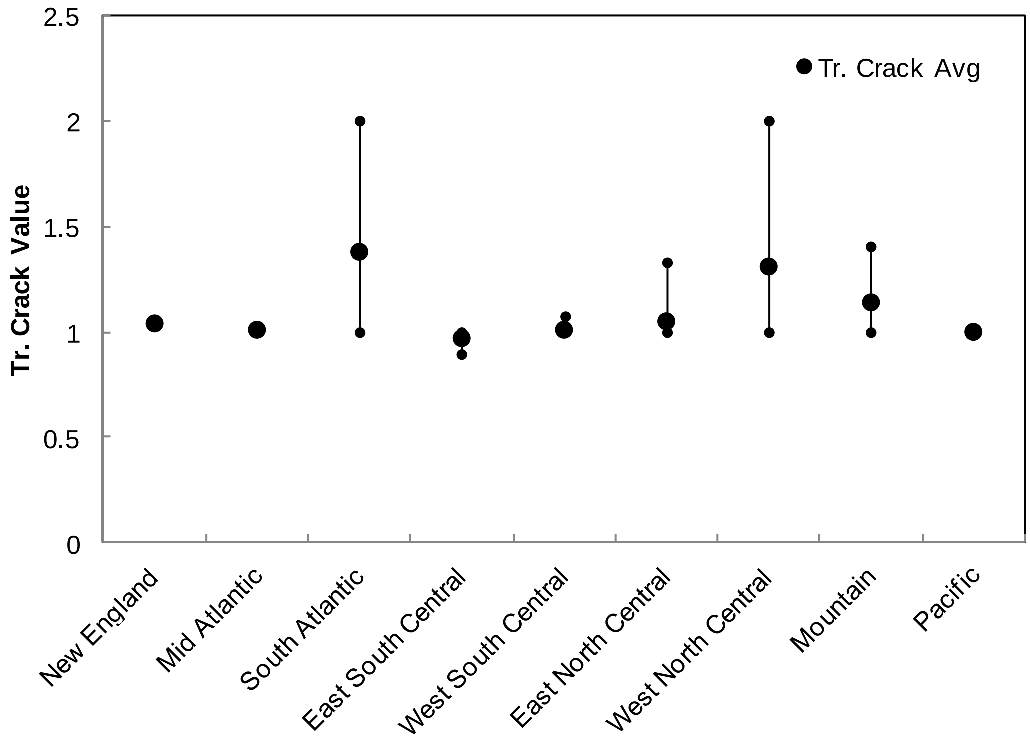


Figure 31: Transverse Cracking Values – Region-wise

Based on the faulting distress, the segments found to be mostly affected are the Interstate 75 segment in Georgia, Interstate 95 segments in the state of Pennsylvania, New Jersey and North Carolina, Interstate 94 segment in North Dakota and Interstate 15 and 70 segments in the state of Utah. The faulting distress map is shown in Figure 32. It can be seen from the transverse crack and faulting maps that the distressed segments are similar in case of both the maps. This similarity exists because in the MEPDG both the cracking and faulting models for rigid pavement involves the calculation of equivalent axles from the traffic data, temperature profiles and slab warping from the temperature data and the fatigue analysis. As cracking and faulting are the primary distresses in rigid pavement, the maps show the obviously critical sections. The average, maximum and minimum faulting values are presented region wise in Figure 33.

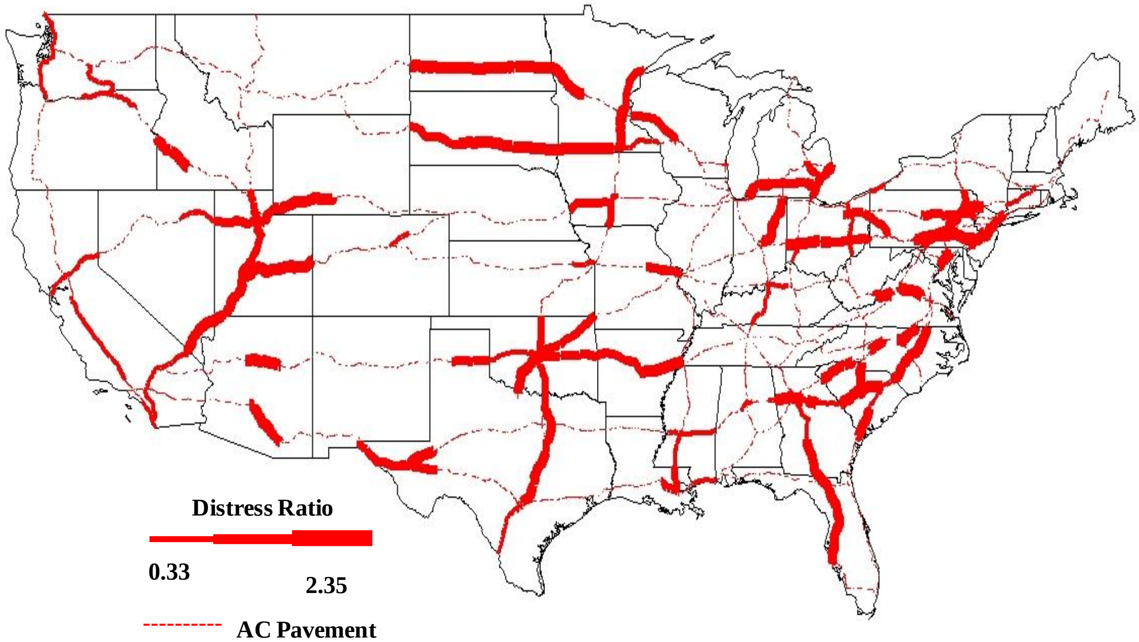


Figure 32: Interstates Faulting Map.

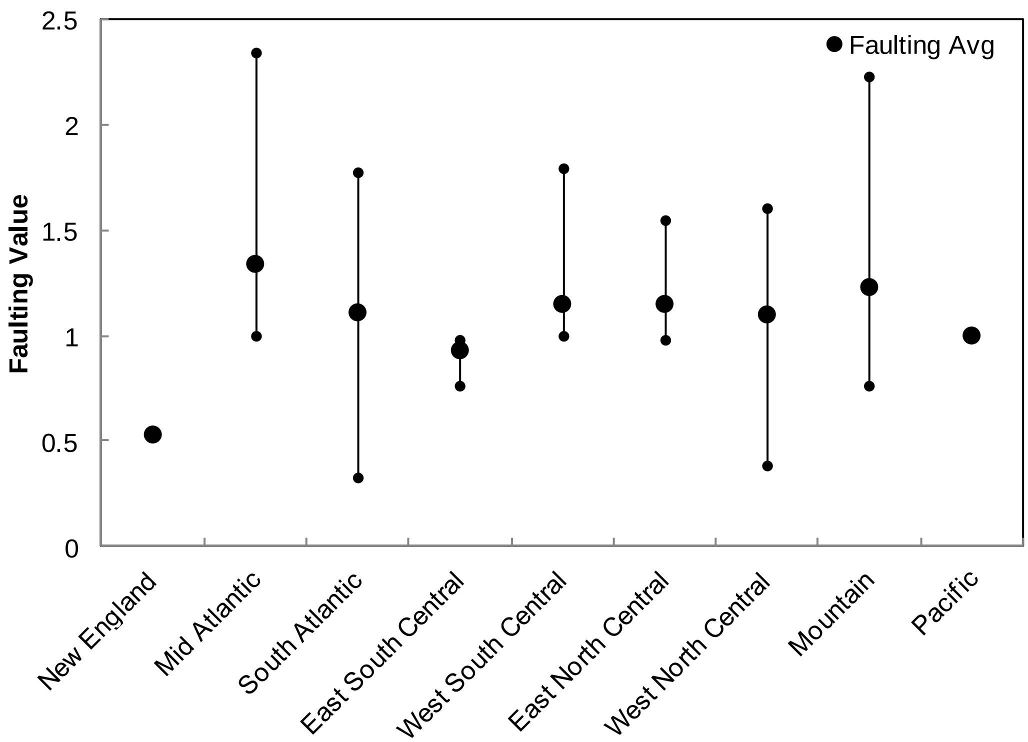


Figure 33: Faulting Values – Region-wise

5.2 Discussion of Results

Results of this study identify those places in which the difference between standard practice of assumptions and the current economic realities are large. The graphs above show locations of the effect of the difference in expected growth rate prediction coupled with the traffic, climate and material factors on the future pavement performance. The analysis identifies that the most sensitive interstates include Interstate 95 in Pennsylvania, New Jersey and Virginia, Interstate 15 and 70 in Utah, Interstate 75 and 20 in Georgia. Interestingly, the results do not mirror the traffic or congestion maps, which show that the greatest impacts are generally clustered around the busiest ports such as Los Angeles, Seattle, Dallas, New York and Chicago 0. It is also interesting that the overall sensitivity, as judged by the IRI map (Figure 22) shows no obvious differences between the Portland cement concrete and asphalt concrete sections. An additional observation from this study is the overall sensitivity in locations, such as Nevada, Utah, Nebraska, and Idaho, which themselves are not considered as freight-centric states because of the lack of a major port. However, the analysis here suggests that the critical corridors traversing their states, which are port connected, may experience impacts from incomplete planning of future freight trends. Conversely in the west, the major land and sea ports (California, Texas, and Washington) appear to have already implicitly built in processes that make their pavement infrastructure less sensitive to the growth trends or have already a saturation level in the amount of freight moved.

5.3 Life Cycle Cost Analysis

The project helps in identifying the pavement segments that are most vulnerable and prone to faster deterioration. Through the MEPDG analysis it helps to identify segments that may deteriorate (or fail) before the design period, thus enabling the agencies to take required precautionary steps in the form of rehabilitation strategies. Such precautionary rehabilitation strategies could result in huge cost savings. In this example, one such segment that fails even before its design period was considered, and the cost comparisons were made. Life cycle cost calculations were carried out on the representative segment to arrive at the cost saving implications the project would have.

5.3.1 Description of case study

An Interstate 75 segment, that runs from Miami-Dade County to Sarasota County has been considered for this life cycle cost study description. Interstate 75 travels 472 miles in Florida and has been divided into three segments. The first segment, which runs from Miami-Dade County to Sarasota County for a length of 194 miles, has been considered. The average AADTT value for this segment was found to be 11,182; the average annual precipitation as 60 inches and the soil type as A3. From section 5.1.1 it was shown that the Interstate 75 segments in Florida has one of the highest distress values, and that the pavement fails before the analysis period. Hence this section (I75-FL-1) has been considered to show the cost saving advantage out of this project work.

Two sets of analysis were carried out, one with state predicted freight growth rate and the other with ATA freight growth rate. The state predicted growth rate for this section has been considered 2%, and the ATA freight growth rate was calculated to be 3.9%. Due to the higher rate of traffic growth, the ATA scenario fails faster (9 Years) compared to the state growth scenario (13 years). Both these scenarios have the same pavement design (call it the state design).It has to be noted that the Mechanistic Empirical Pavement Analysis and Design software does not include any rehabilitation activity in its analysis process. The pavement distresses predicted are the result of continuous stresses imparted due to the traffic, climate, soil condition and the resultant pavement structure behavior. Hence in these LCA calculations, suitable periodical maintenance and rehabilitation activities were considered for each scenario, and the life cycle costs were calculated based on the average work costs.

Apart from the two cases discussed above (state rate + state design and the ATA growth rate + state design), a third case was also considered to demonstrate the cost comparisons arising out of the project. In the third case, it was assumed that the pavement has ATA rate of traffic growth, and the pavement has been designed for the predicted high traffic. (And this case will be referred to as ATA rate + ATA design).

First step in life cycle cost analysis involves the calculation of initial construction costs. The pavement structure for I75-FL-1 consists of four layers i.e: AC layer, base, subbase and subgrade. The various layer thicknesses for this section are: AC layer 3.6”, unbound granular base 10.9”, unbound granular base 10.8” and subgrade. In order to determine the pavement initial construction costs, the average cost of construction obtained from the industrial sector and given in the Table 31 has been used.

Table 31: Pavement Cost Information

Layer	Average cost per inch including cost of construction
Asphalt Concrete	$200,000
Aggregate Base	$140,000
Subbase	$90,000
Subgrade	$200,000

List of pavement rehabilitation maintenance activities considered for the analysis and their average costs are given below.

Table 32: Rehabilitation Activity and Cost

Activity	Average cost per mile
Major Rehabilitation	$1,000,000
Preventive Maintenance	$400,000
Routine Maintenance	$20,000

In the analysis procedure, suitable maintenance and rehabilitation activities were considered to keep the pavement structure functional for 50 years. As the distress values and failure periods differ in each case, different maintenance & rehabilitation schedules have been considered in each case.

5.3.2 LCCA Results

Three different cases were considered for the life cycle cost analysis and they are discussed below:

Case 1: State pavement structure with State growth rate

First case is based on the first set of analysis, which uses the state pavement design for structure and material properties with the state growth rate. It has to be noted that the state growth rate for this section is 2%, which is lower than the ATA growth rate. As a result, the traffic is under predicted and the pavement structure fails in 13 years.

As it was mentioned, First case uses the state designed pavement structure with the state growth rate. If the rate of growth of traffic over the section occurs as per the expectation of state, the pavement would sustain the traffic coming over it for a period of 13 years, after which it fails. The failure period was obtained from the MEPDG simulation outputs. Based on this output summary, rehabilitation strategy has been formulated which includes major pavement rehabilitation just before pavement failure i.e: 12^{th} year to prolong the life of pavement.

List of pavement rehabilitation activities considered in case 1 is given below in Table 33:

Table 33: Rehabilitation Activities - Case 1

Year	Activity
Every 2 Years	Routine Maintenance
7	Preventive Maintenance
12	Major Rehabilitation
18	Preventive Maintenance
24	Major Rehabilitation
30	Preventive Maintenance
36	Major Rehabilitation
42	Preventive Maintenance
48	Major Rehabilitation

Net present value for this case was calculated using the cost values in Table 31and Table 32. The total present worth cost calculated for case 1 is $5,740,968. The cash flow diagram for case 1 is given below in Figure 34.

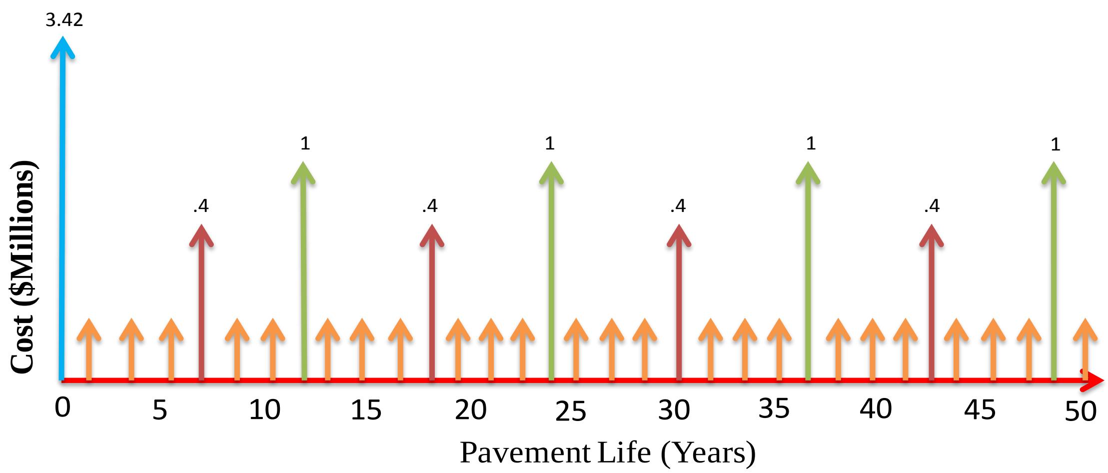


Figure 34: Cash Flow Diagram - Case 1

Case 2: State pavement structure with ATA growth rate

Second case is based on the second set of analysis, which uses the American Trucking Association's (ATA) rate of freight growth rate. The ATA growth rate is 3.9% for this section, and as a result of such a high growth rate the pavement fails in 9 years. As the failure is faster in this case, the repair and rehabilitation costs are expected to be much higher in this case.

Second case uses the state pavement structural section, but with the revised ATA growth rate. As the revised traffic growth rate is higher than the state traffic growth rate, the section fails sooner i.e: in the 9th year. Based on the MEPDG output summary rehabilitation strategy has been formulated for this section. List of pavement rehabilitation activities considered in case 2 is given below:

Table 34: Rehabilitation Activities - Case 2

Year	Activity
Every 2 Years	Routine Maintenance
5	Preventive Maintenance
8	Major Rehabilitation
12	Preventive Maintenance
16	Major Rehabilitation
20	Preventive Maintenance
24	Major Rehabilitation

28	Preventive Maintenance
32	Major Rehabilitation
36	Preventive Maintenance
40	Major Rehabilitation
44	Preventive Maintenance
48	Major Rehabilitation

It can be seen that a major rehabilitation was considered during the 8th year. The schedule also considered major rehabilitation every 8 years. Net present value for this case was calculated using the cost values in Table 31and Table 32. The total present worth cost calculated for case 2 is $6,992,113. Comparing the two cases, it is evident from the net present value that this rehabilitation program is going to cost more for the state department of transportation. The primary reason behind this cost escalation is that the state DOT does not have provisions for the increased traffic growth. The cash flow diagram for case 2 is given below in Figure 35.

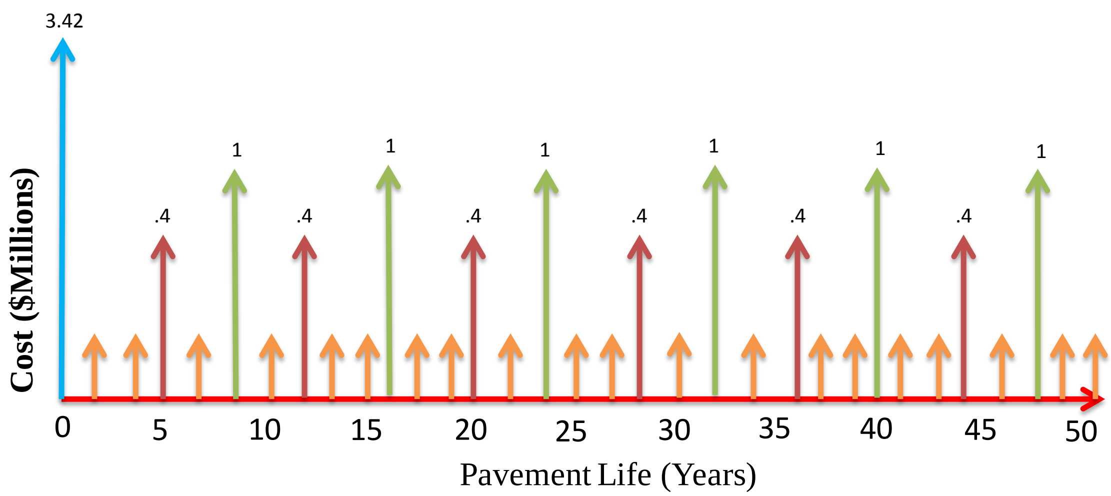


Figure 35: Cash Flow Diagram - Case 2

Case 3: ATA pavement structure with ATA growth rate

As we now have the list of critical sections, a third case is also considered assuming a thicker pavement structure for the segment under consideration. The section considered in this case consisted of 6" of AC layer, unbound granular base 12", unbound granular subbase 16" and subgrade. The pavement thickness is determined based on the MEPDG simulation results for this increased traffic. Third case uses the American Trucking Association's (ATA) rate of freight growth for this new assumed thickness (say: ATA pavement structure).

List of pavement rehabilitation activities considered in case 3 is given below:

Table 35: Rehabilitation Activities - Case 3

Year	Activity
Every 2 Years	Routine Maintenance
7	Preventive Maintenance
12	Major Rehabilitation
18	Preventive Maintenance
24	Major Rehabilitation
30	Preventive Maintenance
36	Major Rehabilitation
42	Preventive Maintenance
48	Major Rehabilitation

The total present worth cost calculated for case 3 is $6,842,968. The cash flow diagram for case 3 is given below in Figure 36.

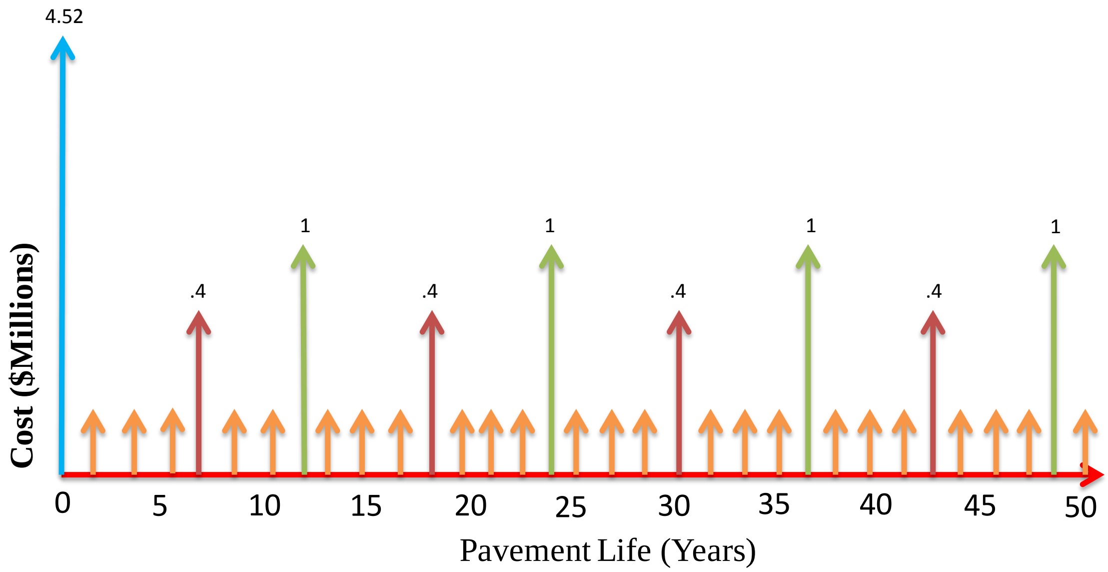


Figure 36: Cash Flow Diagram - Case 3

Due to the predicted high rate of traffic growth, a thicker pavement section has been considered in case 3. It can be seen that the overall present worth cost in the third case is $150,000 lower than case 2. As the preliminary design of the section considers ATA rate of traffic growth, the section could sustain traffic and perform better, with lesser rehabilitation activities than case 2. It is a significant cost saving because the pavement distresses were accurately predicted; critical segments were identified to provide optimum pavement thickness that required comparatively less rehabilitation & maintenance. Even though the initial pavement construction cost is higher, the third case achieved significant cost saving in terms of rehabilitation & maintenance activities. By this way, the pavement life cycle cost can be reduced.

Out of the total 272 segments considered for this study, 200 segments have an IRI ratio of greater than 1. It means that these 200 sections were under designed and are not capable of taking the additional traffic load, which is going to occur in the future. The 200 segments represent 24,000 miles out of the 32,000 miles of interstates considered. It was shown that the saving for 1 pavement segment comes out to be $150,000 on a per mile basis over a period of 50 years. Hence it can be seen that the cost saving over the entire network of interstates would be about 10 percent of the highway construction costs. Considering the volume of interstate highway network, 10 percent is a significant cost saving from an engineer's perspective. The results and outcome of the project helps in optimal resource utilization for the FHWA, national and the state agencies.

6.0 Summary and Conclusions

6.1 Challenges

This report analyzes a substantial portion of the interstate system in the United States to evaluate the impact of projected freight trends on the pavement infrastructure. During the course of the research some major challenges were encountered and some simplifications and assumptions were necessary in order to complete the analysis in as meaningful a way as possible. The first challenge for this report was gathering the input data. The pavement simulation tools require a substantial amount of detailed information, which is gathered to a different level of accuracy by different state agencies. Pavement structure characteristics such as layer type and thickness, gradation parameters, binder viscosity, and volumetric properties are not available on a mileage basis. Availability of input data on a mileage basis would improve the accuracy of this research.

Though a weather station can be selected near the analysis section under consideration, some of the weather stations have some missing data. In that case another climatic station, which is close to analysis segment, is used for interpolation. In some cases, e.g., the I10-AZ-3 in Arizona, Tucson is the nearest climatic station available, but Tucson has missing climatic data and hence the data of nearby stations are also taken. Such interpolation of climatic data over a long distance may lead to differences in the segment under analysis.

Freight traffic has been predicted for 2035 in this report. Most of the literature on economic and freight prediction does not normally extend more than 10 years because of the uncertainties in such long-term projections. For example, in the freight prediction surveys for 2015 carried out in 2005, the recession which affected the global markets in 2009 (an extreme case) was not predicted. In this report, the freight traffic growth rate predicted by the American Trucking Association for 2025 has been used with corrections for 2035. Though a lot of factors (global economy, population and employment growth rate, growth rate of ports among others) have been considered for analysis, there may be fluctuation in the predicted future truck traffic.

6.2 Future Research

The report has been developed with Level 3 input values in the analysis software. There have also been discrepancies with respect to the local calibration factors. While some of the states have their own calibration factors, the other states are in the process of developing their calibration factors. National calibration factors with Level 3 inputs have been used in this report. Errors with this approach were accounted for by examining the relative change in performance instead of the predicted performance directly.

- Future research could be carried on with the identified sections for various distresses, using the locally available calibration and possibly a Level 1 input that could accurately predict the distress values in each of the segments.
- Longer segments were taken into consideration, as the project is national in scope. Shorter segments with region specific inputs can be considered, especially at the identified critical segments.

- LTPP database has been used for pavement structure inputs. Actual field investigation can be carried out for a regional study, to obtain Level 1 inputs.
- It is assumed in this study that the truck size and weight regulations are nearly consistent across all the sections. But in reality the truck specifications and weight regulations may vary across the states.
- TTC-1, which has predominant class 9 trucks has been assumed for this study. Future research could be carried on with state specific truck and weight regulations.

6.3 Conclusion

Despite these challenges, the results provide a different, and (in the authors opinions) important perspective concerning the impacts of freight movement along United States highways. The various traffic and the distress maps generated provide a bird's eye view of corridors and states that may be most affected. It also provides an initial look that may be useful for the planning programs of the various state and the national agencies, specifically towards a more efficient pavement preservation program. The primary conclusion from this research is that pavement impacts from freight projections do not mirror congestion impacts. In fact, it is found that corridors, which are not congested, but instead feed into congested areas, are more prone to pavement impacts. Whether this correlation is due to specific design and engineering practices inherent with areas not experiencing congestion or was due to secondary factors (climate for example) was not discovered. More importantly, this research provides a first glimpse of a component of the freight question that heretofore has not been examined at a gross national level. There are many important secondary questions to answer, particularly with respect to the economic and environmental cost of these sensitivities.

7.0 References

Alam, M., Fekpe, E., and Mohammed, M. (2007) FAF2 freight traffic analysis, Report Number S7, Federal Highway Administration: Office of Operations.

American Association of State Highway Transportation Officials (AASHTO). (2007) America's freight challenge. [Online] Available from <ftp://ftp.mdt.mt.gov/research/library/TIF3-1-FREIGHT_CHALLENGE-AASHTO.PDF>. [Accessed April 2015].

American Trucking Association. *US freight transportation forecast to 2025*, 2014.

Applied Research Associates (ARA). (2004) Guide for Mechanistic-Empirical design of new and reconstructed flexible pavements: Part 2 Design Inputs Chapter 4 Traffic. Final Report. *National Cooperative Highway Research Program*. Transportation Research Board, National Research Council, Washington, D.C.

Applied Research Associates (ARA). (2004) Guide for Mechanistic-Empirical design of new and reconstructed flexible pavements: Part 3 Design Analysis. Final Report. *National Cooperative Highway Research Program.* Transportation Research Board, National Research Council, Washington, D.C.

Archondo-Callao, R. (2000). Roads Works Costs per Km.

Blanchard, O.J. and Leigh, D. (2013) Growth forecast errors and fiscal multipliers. NBER Working Paper No. 18779. *National Bureau of Economic Research*.

Bureau of Infrastructure, Transport, and Regional Economics (BITRE). (2012) *Traffic growth: modeling a global phenomenon*. Report 128, Department of Infrastructure and Transport, Canberra AU.

Costello, B. (2014) US freight transportation forecast to 2025. *American Trucking Association*.

Dr. Kamil Kaloush. (March 2016) Interview with Dr. Kamil Kaloush. Arizona State University, Tempe.

Facanha, C. and Horvath, A. (2007) Evaluation of life-cycle air emission factors of freight transportation. *Environmental Science & Technology* 41(20), pp.7138-7144.

Federal Highway Administration (FHWA). (2013) Freight facts and figures 2013. [Online] Available from: <http://ops.fhwa.dot.gov/Freight/freight_analysis/nat_freight_stats/docs/13facts figures/index.htm>. [Accessed December 2014].

Gillespie, T.D. and Karamihas, S.M. (1994) Heavy truck properties significant to pavement damage. ASTM Special Technical Publication, 1225, pp. 52-62.

Hensher, D.A. and Puckett, S.M. (2005) Refocusing the modeling of freight distribution: Development of an economic-based framework to evaluate supply chain behavior in response to congestion charging. *Transportation* 32(6), pp. 573-602.

Hoerner, T. E., Smith, K. D., Yu, H. T., Peshkin, D. G., & Wade, M. J. (2001). PCC Pavement Evaluation and Rehabilitation. *Reference Manual, NHI Training Course*, *131062*

.

Jones, C. (2007) Perspective on freight congestion. *Public Roads* 71(1). Available from < http://www.fhwa.dot.gov/publications/publicroads/07july/06.cfm>. [Accessed October 2014].

Kveiborg, O. and Fosgerau, M. (2007) Decomposing the decoupling of Danish road freight traffic growth and economic growth. *Transport policy* 14(1), pp. 39-48.

Lee, G., You, S., Ritchie, S., Saphores, J. D., Sangkapichai, M., and Jayakrishnan, R. (2009). "Environmental impacts of a major freight corridor: a study of I-710 in California". *Transportation Research Record: Journal of the Transportation Research Board*, (2123), 119-128.

Protopapas, A., Kruse, C., and Olson, L. (2013). Modal Comparison of Domestic Freight Transportation Effects on the General Public. *Transportation Research Record: Journal of the Transportation Research Board,* (2330), 55-62.

Li, Q. Xiao, D.X., Wang, K.C., Hall, K.D. and Qiu, Y. (2011) Mechanistic-Empirical Pavement Design Guide (MEPDG): a bird's-eye view. *Journal of Modern Transportation* 19(2), pp. 114-133.

Walls III, J., & Smith, M. R. (1998). *Life-cycle cost analysis in pavement design-interim technical bulletin* (No. FHWA-SA-98-079).

Lytton, R.L., Pufahl, D.E., Michalak, C.H., Liang, H.S., and Dempsey, B.J. (1993) An integrated model of the climatic effects on pavement. Final Report: FHWA-RD-90-033). *Federal Highway Administration*.

Mani, A. and Prozzi, J. (2004) State-of-the practice in freight data: a review of available freight data in the U.S (No. 0-4713-P2). *Center for Transportation Research*, The University of Texas at Austin.

McKinnon, A. (1999) The effect of traffic congestion on the efficiency of logistical operations. *International Journal of Logistics: Research and Applications* 2(2), pp. 111-128.

Miller, J.S., and Bellinger, W.Y. (2003) Distress identification manual for the long term pavement performance program. Report: FHWA-RD-03-031. *Federal Highway Administration*. Washington, DC.

Moving Ahead for Progress in the 21st Century Act (MAP 21). (2012) Public Law 112-141, Title I Federal-Aid Highways, Subtitles A, B, D, and F.

National Highway Planning Network (2015). <http://www.fhwa.dot.gov/planning/processes/tools/nhpn/>. [Accessed: March 2015)

National Climatic Data Center (NCDC). (2010) NOAA's 1981-2010 climate normals. [Online] Available from <http://www.ncdc.noaa.gov/oa/climate/normals/usnormals.html>. [Accessed: December 2014].

Piecyk, M.I. and McKinnon, A.C. (2010) Forecasting the carbon footprint of road freight transport in 2020. *International Journal of Production Economics* 128(1), pp. 31-42.

Reifschneider, D. and Tulip, P. (2007) Gauging the uncertainty of the economic outlook from historical forecasting errors. *Finance and Economic Discussion Series, Federal Reserve Board, Washington, D.C.*

Salama, H.K., Chatti, K., and Lyles, R.W. (2006) Effect of heavy multiple axle trucks on flexible pavement damage using in-service pavement performance data. *Journal of Transportation Engineering* 132(10), pp. 763-770.

Sankaran, J.K. Gore, A and Coldwell, B. (2005) The impact of road traffic congestion on supply chains: insights from Auckland, New Zealand. *International Journal of Logistics: Research and Applications* 8(2), pp. 159-180.

Strocko, E., Sprung, M., Nguyen, L., Rick, C., and Sedor, J. (2014). Freight facts and figures 2013. *Federal Highway Administration*, (No. FHWA-HOP-14-004).

United States Census Bureau. (2010) 2010 US Census Data [Online] Available from < http://www.census.gov/2010census/data/>. [Accessed: March 2015].

United States Department of Transportation. MAP-21, Sec. 1108. Surface Transportation Program.

United States Geological Survey. Active groundwater level network. http://groundwaterwatch.usgs.gov/default.asp, 2014. [Accessed: April 2015].

Wheeler, N. and Figliozzi, M. (2011) Multi criteria trucking freeway performance measures in congested corridors. *Transportation Research Board Annual Meeting.*

Witter, E., Adams, T., Gordon,T., Kawamura, K., Lindquist, P., Vonderembse, M., Kawamura, K., and McNeil, S. (2005) Upper Midwest freight corridor study. Final Report: FHWA/OH 2005-1). *Ohio Department of Transportation*. Columbus OH.

Zeitsman, J., Rilett, L.R. and Kim, S.J. (2006) Transportation corridor decision-making with multi-attribute utility theory. International Journal of Management and Decision Making 7(2), pp. 254-26.

APPENDIX A

DETAILED DESCRIPTION OF ANALYSIS SEGMENT

Interstate 5

California

Interstate 5 runs for a length of 797 miles in the state of California. The interstate has been divided into five segments for the sake of analysis. The first segment runs from the Mexico – United States border in San Diego County northward to Orange County. The average AADTT value for this segment is 27,100. The overall average annual precipitation is 10 to 15 inches and the region is made up of AASHTO A7 type of soil. The second segment runs from Orange County to Kern County for a length of 189 miles and has heavy traffic. The average AADTT value for this segment was 35,430. The average annual precipitation value was approximately 10 inches and the region is made up of A7 soil. The third segment travels from Kern County to San Joaquin County. The average AADTT value for this segment was 5,218, the annual average precipitation was 20 inches, and the soil type was AASHTO A7. The fourth segment runs from San Joaquin to Glenn County and has a total length of 132 miles. The average AADTT value for this segment was 12,380, the annual average precipitation was 30 inches, and the soil type was A7. The fifth and final segment starts at Glenn County and ends at the Oregon state boundary. The traffic volume is relatively small in the entire segment due to low commercial activities and a hilly terrain. The average AADTT value was found to be 7,925, the average annual precipitation was 40 inches, and the soil was an A7 type.

Oregon

Interstate 5 travels 322 miles in Oregon and has been divided into three segments The first segment spans from the California boundary to Douglas County with a total mileage of 98. The average AADTT value for this segment was found to be 4,380. The average annual precipitation in this segment was 30-60 inches and the soil was considered as A7. The second segment starts just beyond Douglas County and goes to Marion County. The traffic is higher with an average AADTT value of 8,465. Apart from traffic, the average annual precipitation values and the soil types are relatively similar to that of the first section. This segment has a length of about 169 miles. The third segment starts beyond Marion County and goes up to Multnomah County. The average AADTT value for this segment is 21,976. The total length of this segment is 55 miles and the terrain is generally mountainous in this region. The precipitation is between 30 and 60 inches per year, the soil was considered as A6.

Washington

Interstate 5 travels 276 miles in the state of Washington. The terrain and the climate of its entire stretch is quiet similar. Based on the factors discussed above, the interstate has been divided into three segments for the purpose of analysis. The first segment starts from the Oregon state boundary and goes north to Pierce County. The total length of this segment is 132 miles. The average AADTT in this segment is 17,754, the precipitation level is generally higher in this segment and varies from 60 to 100 inches, and the more prevalent soil type is A4. The second segment runs from Pierce County to Snohomish County. The traffic is higher than on the first segment with an average AADTT value of 43,675. The section predominantly has A4 soil type with the annual average precipitation value ranges between 30 and 60 inches. The third and final segment runs from Snohomish County to the international border with Canada. The segment carries less overall traffic than others with an average AADTT of 18,244, the average annual precipitation value is in the range of 30 to 60 inches, and is made of A6 soil type.

Interstate 10

California

Interstate 10 runs for 251 miles in the state of California from the west terminus in Santa Monica and up to the Arizona state line. It has been divided into 2 segments. The first segment runs from Los Angeles County to Riverside County for a length of 102 miles and has an average AADTT value of 31,801. It has a soil type of A4. The second segment runs from Riverside County to Arizona border for a length of 149 miles and has an average AADTT value of 6,908. It has a soil type of A2.

Arizona

I-10 travels 393 miles in the state of Arizona. From the California boundary it passes through the cities of Phoenix and then Tucson. In this state the interstate has been divided into three segments. The first segment runs from the California boundary to Maricopa County (a length of 137 miles) and has an average AADTT value of 7,089. The average annual rainfall in this region is 10 inches and the soil type is A4. The second segment runs from Maricopa County to Pima County (a length of 145 miles) and has an average AADTT value of 24,965. The average annual rainfall in this region is 10 inches and the soil type is A4. The last segment, from Pima County to the New Mexico border has a length of 111 miles and has an average AADTT value of 8,691. The average annual rainfall in this region is 10 inches and the soil type is A4.

New Mexico

The interstate travels 164 miles in New Mexico and has been considered as one segment. The segment runs throughout the state from Arizona state line to the Texas state line. The total length of this segment is 164 miles. The average AADTT in this segment is 4,436. The average annual rainfall in this region is 15 inches and the soil type is considered as A6.

Texas

Interstate 10 travels 881 miles in Texas and has been divided into seven segments for analysis. The first section runs from the New Mexico state line in El Paso County to the Hudspeth County for a length of 141 miles. The average AADTT value for this segment is 21,146. The average annual rainfall in this region is 15 inches and the soil type is A4. The second segment runs from Hudspeth County to Pecos County. It has a length of about 136 miles. The average AADTT value for this segment is 10,435. The average annual rainfall in this region is 18 inch and the soil type is A5. The third section runs from Pecos County to Sutton County. The average AADTT value for this portion of the interstate is only 1,306. The average annual rainfall is 20 inches and the soil type is A5. The fourth section runs from Sutton County to Kerr County. The traffic volume is similar to the previous section with an AADTT value of 8,706. The average annual rainfall in this region is 25 inches and the soil type is A6. The fifth section runs from Kerr County to the Bexar County. The average AADTT value for this segment is 17,536. The average annual rainfall in this region is 30 inches and the soil type is A5. The sixth segment runs from Bexar to Colorado County and it has an average AADTT value of 16,978. The average annual rainfall in this region is 35 inches and the soil type is A5. The seventh segment runs from Colorado County and goes up to Louisiana state boundary. The average AADTT in this portion of the interstate is the highest in Interstate 10 in Texas with a value of 17,801. The average annual rainfall in this region is 40 inches and the soil type is A5.

Louisiana

Interstate I5 travels 274 mile in the state of Louisiana. The interstate has been divided into three segments for the purpose of analysis. The first segment starts at the Texas state border and goes to Lafayette County. The total length of this segment is 154 miles. The average AADTT is 8,910, the average annual precipitation level is 50 inches, and the most prevalent soil type is A4. The second segment runs from Lafayette County to Jefferson County. The traffic is higher than on the first segment with an average AADTT value of 12,384. The section predominantly has A7 soil type with the annual average precipitation value of 60 inches. The third and final segment runs from Jefferson County to Mississippi state border. The segment has an average AADTT of 20,296, the average annual precipitation value 60 inches, and is made of A7 soil type.

Mississippi

The interstate runs for a length of 77 miles in the state of Mississippi and it has been considered as one segment. It starts at the Hancock County and ends at the Alabama boundary in Baldwin County. This segment has an average AADTT of 10,569. The average annual rainfall in this region is 60 inches and the soil type is A4.

Alabama

Interstate 10 covers a very short distance of 66 miles in the state of Alabama. It has been considered as one segment for analysis. The segment begins at the border with Mississippi and ends at the Florida state border in Baldwin County. The average AADTT value for this segment is 12,400. The average annual rainfall in this region is 60 inches and the soil type is A4.

Florida

Interstate 10 travels a total length of 362 miles in Florida and has been divided into two segments for analysis. The first segment starts at the Alabama border and goes until Gadsden County for a length of about 175 miles. This section has an average AADTT value of 5,876 and the soil type is A4. The average annual rainfall in this region is 60 inches. The second segment starts at Gadsden County and goes until Duval County. This section of the interstate has an average AADTT value of 7,940. The average annual rainfall in this region is 50 inches and the soil type is considered A4.

Interstate 15

California

The Interstate 15 runs for a length of 289 miles in the state of California and it has been divided into two segments. The first segment starts from San Diego and goes up to San Bernardino County. This section runs for a length of 111 miles and has an average AADTT value of 22,402. The average annual rainfall in this region is 15 inches and the soil type is A4. The second segment runs from San Bernardino County and goes to the Arizona state line. It has a total length of 178 miles and has an average AADTT value of 9,212. The average annual rainfall in this region is 10 inches and the soil type is A5.

Nevada and Arizona

The interstate runs for a length of 124 miles in the state of Nevada and for 30 miles in the state of Arizona. It has been considered as one segment for the analysis. The average AADTT value for this segment is 23,196. The average annual rainfall in this region is 15 inches and the soil type is A4.

Utah

Interstate 15 travels 401 miles in the state of Utah. Based on the factors discussed above, the interstate has been divided into three segments for the purpose of analysis. The first segment starts from the Nevada state border and goes to Iron County. The total length of this segment is 179 miles. The average AADTT in this segment is 3,853, the average annual precipitation is 15 inches, and the more prevalent soil type is A5. The second segment runs from Iron County to Utah County. The average AADTT value is 14,793. The section predominantly has A6 soil type with the annual average precipitation value of 10 inches. The third segment runs from Utah County to the Idaho state border. The segment carries an average AADTT of 21,029, the average annual precipitation value is 15 inches, and is made of A5 soil type.

Idaho

Interstate 15 travels 197 miles in the state of Idaho. The interstate has been divided into two segments for the purpose of analysis. The first segment starts at the Utah state border and goes up to Bingham County. The total length of this segment is 75 miles. The average AADTT in this segment is 3,256, the average annual precipitation level is 15 inches, and the most prevalent soil type is A3. The second segment runs from Bingham

County to the Montana state border. The segment has an average AADTT value of 2,201. The section predominantly has A5 soil type with the annual average precipitation value of 10 inches.

Montana

Interstate 15 travels 396 miles in the state of Montana. The interstate has been divided into two segments for the purpose of analysis. The first segment runs from the Idaho state border to Jefferson County. The total length of this segment is 199 miles. It has an average AADTT of 1,633, an average annual precipitation of 20 inches, and an A5 soil. The second segment runs from Jefferson County to the Canadian international border. The segment has an average AADTT value of 1,005. The soil type is A4 with the annual average precipitation value of 15 inches.

Interstate 20

Texas

Interstate 20 travels 636 miles in Texas. It has been divided into 5 segments. First segment runs from Reeves County to Ward County. Average AADTT value for this segment is 1689. Average annual rainfall in this segment is 15 inches and the soil type is A7. Second segment runs from Ward County to Taylor County. Average AADTT value for this segment is 3686. Average annual rainfall in this segment is 25 inches and the soil type is A7. Third segment runs from Taylor County to Tarrant County. Average AADTT value for this segment is 4637. Average annual rainfall in this segment is 30 inches and the soil type is A7. Fourth segment runs from Tarrant County to Van Zandt County. Average AADTT value for this segment is 24030. Average annual rainfall in this segment is 40 inches and the soil type is A7. Fifth segment runs from Van Zandt County to Harrison County. Average AADTT value for this segment is 6075. Average annual rainfall in this segment is 50 inches and the soil type is A7.

Louisiana

Interstate 20 travels 190 miles in Louisiana and is considered as one segment. The segment runs from Caddo County to Madison County. Average AADTT value for this segment is 9586. Average annual rainfall in this segment is 55 inches and the soil type is A7.

Mississippi

Interstate 20 runs for a length of 162 miles in Mississippi and is considered as a single segment. It starts at Warren County and ends at Lauderdale County. Average AADTT value for this segment is 9184. Average annual rainfall for this region is 55 inches and the soil type is A7.

Alabama

Interstate 20 travels 215 miles in Alabama. It has been divided into two segments. First segment runs from Sumtar County to St. Clair County. Average AADTT value for this segment is 4978. Average annual rainfall in this segment is 55 inches and the soil type is A6. Second segment runs from St. Clair County to Cleburne County. Average AADTT value for this segment is 12043. Average annual rainfall in this segment is 55 inches and the soil type is A6.

Georgia

Interstate 20 travels 202 miles in Georgia. It has been divided into two segments. First segment runs from Haralson County to Morgan County. Average AADTT value for this segment is 23048. Average annual rainfall in this segment is 50 inches and the soil type is A7. Second segment runs from Morgan County to Richmond County. Average AADTT value for this segment is 7744. Average annual rainfall in this segment is 50 inches and the soil type is A7.

South Carolina

Interstate 20 travels 142 miles in South Carolina. The segment runs from Aiken County to Florence County. Average AADTT value for this segment is 10797. Average annual rainfall in this segment is 50 inches and the soil type is A7.

Interstate 24

Georgia

Interstate 24 travels 89 miles in Georgia and Tennessee. It has been considered as one segment. The segment runs from Georgia state line to Rutherford. Average AADTT value for this segment is 10358. Average annual rainfall in this segment is 55 inches and the soil type is A7.

Tennessee

Interstate 24 travels 91 miles in Tennessee. The segment runs from Rutherford County to Hamilton COunty. Average AADTT value for this segment is 13262. Average annual rainfall in this segment is 50 inches and the soil type is A7.

Kentucky

Interstate 24 travels 131 miles in Kentucky and Illinois. It has been considered as one segment. The segment runs from Clarksville to Williamson County. Average AADTT value for this segment is 4894. Average annual rainfall in this segment is 60 inches and the soil type is A7.

Interstate 35

Texas

Interstate 35 runs for a length of 686 miles in Texas and it has been divided into five sections for the purpose of analysis. The first section runs from the Mexican international border at the city of Laredo to Bexar County for a length of 151 miles and has an AADTT value of 7,133. The average annual rainfall in this region is 20 inches and the soil type is considered A7. The second section runs from Bexar County to McLennan County. It has a length of 177 miles and has a relatively high AADTT value of 22,096. The average annual rainfall in this region is 25 inches with A7 soil type. The third section runs from McLennan County to Cooke County for a length of 77 miles and has an AADTT value of 12,493. The average annual rainfall in this region is 30 inches and the soil type is considered A7. In the portion between Hill County and Denton County, the Interstate 35 divided itself into two routes and they are named I35 East and I35 West and have a length of 96 miles and 85 miles respectively.

Oklahoma

Interstate 35 runs for a length of 243 miles in the state of Oklahoma and it passes through Oklahoma City. The interstate has been divided into two segments for the purpose of analysis. The first segment runs from the Texas state border to Oklahoma County, a distance of 136 miles. It has an average AADTT value of 9,946. The average annual rainfall in this region is 30 inches and the soil type in this region is A4. The second segment runs from Oklahoma County to the Kansas state border. It has a total length of 107 miles and has an average AADTT of 7,621. The average annual rainfall in this region is 30 inches and the soil type is A4.

Kansas

Interstate 35 travels 236 miles in the state of Kansas. The interstate has been divided into two segments for the purpose of analysis. The first segment starts from Oklahoma state border and goes up to Lyon County. The total length of this segment is 141 miles. The average AADTT in this segment is 2,946, the average annual precipitation level is 25 inches, and the most prevalent soil type is A6. The second segment runs from Lyon County to the Missouri state border. The segment has an average AADTT value of 13,602. The section predominantly has A7 soil type with the annual average precipitation value of 35 inches.

Missouri

Interstate 35 travels 115 miles in the state of Missouri and it has been considered as a single segment for the purpose of analysis. The segment has an average AADTT value of 8,991. The average annual precipitation in this region is 35 inches and the soil type is A7.

Iowa

Interstate 35 travels 218 miles in the state of Iowa. The interstate has been divided into two segments for the purpose of analysis. The first segment starts from at the Missouri state border and goes up to Story County. The total length of this segment is 102 miles. The average AADTT in this segment is 9,526, the average annual precipitation level is 35 inches, and the soil type is A7. The second segment runs from Story County to the Minnesota state border. The segment has an average AADTT value of 4,064. The section predominantly has A7 soil type with the annual average precipitation value of 30 inches.

Minnesota

Interstate 35 travels 260 miles in the state of Minnesota, and has been divided into four segments for the purpose of analysis. The first segment starts at the Iowa state border and goes up to Dakota County. The total length of this segment is 97 miles. The average AADTT in this segment is 7,334, the average annual precipitation level is 30 inches, and the soil type is A7. The second segment runs from Dakota County to the end of the interstate at the city of Duluth. The segment has an average AADTT value of 5,606. The section predominantly has A7 soil type with the annual average precipitation value of 25 inches. Interstate 35, between Dakota County and Anoka County divides itself into I35 East and I35 West as in the state of Texas.

Interstate 40

California

Interstate 40 travels 155 mile in the state of California, and has been considered as one segment for the purpose of analysis. The segment starts at Barstow County and goes to the Arizona state boundary. The average AADTT is 2,175, the average annual precipitation level is 10 inches, and the soil type is A6.

Arizona

I-40 travels 360 miles in the state of Arizona. In this state the interstate has been divided into three segments. The first segment runs from the California state border to Yavapai County (a length of 146 miles) and has an average AADTT value of 4,440. The average annual rainfall in this region is 10 inches and the soil type is A5. The second segment runs from Yavapai County to Navajo County (a length of 112 miles) and has an average AADTT value of 4,927. The average annual rainfall in this region is 20 inches and the soil type is A6. The last segment, from Navajo County to the New Mexico state border has a length of 102 miles and an average AADTT value of 3,783. The average annual rainfall in this region is 15 inches and the soil type is A7.

New Mexico

In the state of New Mexico, I-40 runs for a length of 374 miles and it has been divided into three segments for the purpose of analysis. The segments break at mileage length of 155 and 257 at Cibola County and Guadalupe County. The three sections have an average AADTT value of 4,705, 17,063, and 3,192 respectively. The average annual rainfall in the first two segments is 15 inches and that in the second segment is 20 inches. The soil type in first two segments is considered as A7 and for third segment it is A6.

Texas

Interstate 40 runs for a short length of 177 miles in the northern most part of Texas. It has been divided into two sections for analysis. The first section runs from the New Mexico state border to Potter County and has an AADTT value of 5,692. The average annual rainfall in this region is 15 inches with A6 soil type. The second section runs from Potter

County to the Oklahoma state border (a length of 110 miles). It has an average AADTT value of 6,921. The average annual rainfall in this region is 20 inches and the soil type is A6.

Oklahoma

I-40 travels 329 miles in the state of Oklahoma. In this state the interstate has been divided into three segments. The first segment runs from the Texas state border to Custer County for a length of 126 miles, and has an average AADTT value of 4,140. The average annual rainfall in this region is 25 inches and the soil type is A6. The second segment runs from Custer County to Okfuskee County for a length of 94 miles and has an average AADTT value of 11,879. The average annual rainfall in this region is 30 inches and the soil type is A7. The last segment, from Okfuskee County to the Arkansas state border, has an average AADTT value of 3,876 for a length of 109 miles. The average annual rainfall in this region is 40 inches and the soil type is A6.

Arkansas

Interstate 40 travels 303 miles in the state of Arkansas. The interstate has been divided into two segments for the purpose of analysis. The first segment starts at the Oklahoma state border and goes to Faulkner County. The total length of this segment is 152 miles. The average AADTT in this segment is 7,449, the average annual precipitation level is 45 inches, and the most prevalent soil type is A6. The second segment runs from Faulkner County to the Tennessee state border. The segment has an average AADTT value of 9,523. The section predominantly has A6 soil type with the annual average precipitation value of 50 inches.

Tennessee

Interstate 40 travels 455 miles in Tennessee and has been divided into four segments. The first segment spans from the Arkansas state border to Madison County (a total of 87 miles). The average AADTT value for this segment was found to be 10,273. The average annual precipitation in this segment is 50 inches and the soil type is A4. The second segment starts just beyond Madison County and goes to Davidson County. The traffic is relatively high with an average AADTT value of 14,653 and soil type is A6. This segment has a length of about 130 miles and an average annual precipitation of 55 inches. The third segment starts beyond Davidson County and goes up to Knox County. The average AADTT value for this segment is 10,882. The total length of this segment is 160 miles. The average annual precipitation is 55 inches per year, the soil is type A4. The fourth and the final segment start from Knox County and finishes at the North Carolina state boundary. The average AADTT value for this segment is 12,705, average annual precipitation is 45 inches and the soil type is A6.

North Carolina

I-40 travels 422 miles in the state of North Carolina. In this state the interstate has been divided into three segments. The first segment runs from the Tennessee state border to Iredell County (a length of 162 miles) and has an average AADTT value of 9,133. The average annual rainfall in this region is 50 inches and the soil type is A7. The second segment runs from Iredell County to Orange County (a length of 98 miles) and has an average AADTT value of 17,877. The average annual rainfall in this region is 45 inches and the soil type is A4. The last segment, from Orange County to the end of I-40 in New

Hanover County (a length of 162 miles) has an average AADTT value of 13,178. The average annual rainfall in this region is 50 inches and the soil type is A7.

Interstate 44

Texas

Interstate 44 travels 150 miles in Texas border and Oklahoma. The segment runs from Wichita Falls to Oklahoma County. Average AADTT value for this segment is 9454. Average annual rainfall in this segment is 35 inches and the soil type is A7.

Oklahoma

Remaining portion of Interstate 44 travels 191 miles in Oklahoma. The segment runs from Oklahoma County to Missouri state line. Average AADTT value for this segment is 8922. Average annual rainfall in this segment is 40 inches and the soil type is A7.

Missouri

Interstate 44 travels 290 miles in Missouri. It has been considered as two segments. First segment runs from Newton County to Pulaski County. Average AADTT value for this segment is 6920. Average annual rainfall in this segment is 45 inches and the soil type is A7. Second segment runs from Pulaski County to St. Louis. Average AADTT value for this segment is 13094. Average annual rainfall in this segment is 20 inches and the soil type is A7.

Interstate 55

Louisiana

Interstate 55 travels 66 miles in Louisiana. The segment runs from Laplace to Kentwood. Average AADTT value for this segment is 4992. Average annual rainfall in this segment is 70 inches and the soil type is A7.

Mississippi

Interstate 55 travels 289 miles in Mississippi. It has been divided into 2 segments. First segment runs from Pike County to Hinds County. Average AADTT value for this segment is 11752. Average annual rainfall in this segment is 60 inches and the soil type is A7. Second segment runs from Hinds County to Desoto County. Average AADTT value for this segment is 4948. Average annual rainfall in this segment is 60 inches and the soil type is A7.

Tennessee

Interstate 55 travels 82 miles in Tennessee and Arkansas. The segment runs from Mississippi state line to Blytheville. Average AADTT value for this segment is 10896. Average annual rainfall in this segment is 55 inches and the soil type is A7.

Missouri

Interstate 55 travels 216 miles in Missouri. It has been divided into two segments. First segment runs from Arkansas state line to Cape Girardeau. Average AADTT value for this segment is 15794. Average annual rainfall in this segment is 50 inches and the soil type is A7. Second segment runs from Cape Girardeau to Illinois state line. Average AADTT value for this segment is 4427. Average annual rainfall in this segment is 40 inches and the soil type is A7.

Illinois

Interstate 55 travels 294 miles in Illinois. It has been divided into two segments. First segment runs from East ST. Louis to McLean County. Average AADTT value for this segment is 8252. Average annual rainfall in this segment is 40 inches and the soil type is A7. Second segment runs from McLean County to Chicago. Average AADTT value for this segment is 16733. Average annual rainfall in this segment is 35 inches and the soil type is A7.

Interstate 64

Missouri

Interstate 64 travels 140 miles in Missouri and Illinois. It has been considered as one segment. The segment runs from St. Charles to Grayville. Average AADTT value for this segment is 3739. Average annual rainfall in this segment is 40 inches and the soil type is A7.

Indiana

Interstate 64 travels 124 miles in Indiana. The segment runs from Posey County to Floyd County. Average AADTT value for this segment is 5893. Average annual rainfall in this segment is 45 inches and the soil type is A7.

Kentucky

Interstate 64 travels 183 miles in Kentucky. It has been considered as two segments. First segment runs from Jefferson County to Woodford County. Average AADTT value for this segment is 13044. Average annual rainfall in this segment is 45 inches and the soil type is A7. Second segment runs from Woodford County to Boyd County. Average AADTT value for this segment is 5186. Average annual rainfall in this segment is 45 inches and the soil type is A7.

West Virginia

Interstate 64 travels 174 miles in West Virginia. The segment runs from Wayne County to Greenbrier County. Average AADTT value for this segment is 7841. Average annual rainfall in this segment is 45 inches and the soil type is A4.

Virginia

Interstate 64 travels 299 miles in Virginia. It has been considered as two segments. First segment runs from Alleghany County to Albemarle County. Average AADTT value for this segment is 7756. Average annual rainfall in this segment is 40 inches and the soil type is A4. Second segment runs from Albemarle County to City of Chesapeake. Average AADTT value for this segment is 17750. Average annual rainfall in this segment is 45 inches and the soil type is A7.

Interstate 65

Alabama

Interstate 65 travels 366 miles in Alabama and is divided into two segments. First segment runs from Mobile County to Elmore County. The average AADTT value for this segment is 9178. Average annual rainfall in this region is 55 inches and the soil type is A6. The second segment runs from Elmore County up to Limestone County. Average AADTT value for this segment is 11431. Average annual rainfall in this segment is 55 inches and the soil type is A6.

Tennessee

Interstate 65 travels 120 miles in Tennessee. It has been considered as one segment. The segment runs from Giles County to Robertson County. Average AADTT value for this segment is 12689. Average annual rainfall in this segment is 55 inches and the soil type is A7.

Kentucky

Interstate 65 travels 138 miles in Kentucky and is considered as one segment. The segment runs from Franklin to Indiana state line. Average AADTT value for this segment is 13441. Average annual rainfall in this segment is 50 inches and the soil type is A7.

Indiana

Interstate 65 travels 262 miles in Indiana and is divided into two segments. First segment runs from Jefferson to Columbus. Average AADTT value for this segment is 9842. Average annual rainfall in this segment is 45 inches and the soil type is A7. Second segment runs from Columbus to Gary. Average AADTT value for this segment is 11800. Average annual rainfall in this segment is 40 inches and the soil type is A7.

Interstate 69

Indiana

Interstate 69 travels 158 miles in Indiana. The segment runs from Indianapolis to Steuben. Average AADTT value for this segment is 8186. Average annual rainfall in this segment is 35 inches and the soil type is A7.

Michigan

Interstate 69 travels 215 miles in Michigan. It has been considered as two segments for analysis. First segment runs from Branch County to Shiawassee County. Average AADTT value for this segment is 5920. Average annual rainfall in this segment is 35 inches and the soil type is A7. Second segment runs from Shiawassee County to St. Clair. Average AADTT value for this segment is 8151. Average annual rainfall in this segment is 30 inches and the soil type is A7.

Interstate 70

Utah

Interstate 70 travels 230 miles in the state of Utah. The interstate has been divided into two segments for the purpose of analysis. The first segment starts from Millard County and goes to Emery County. The total length of this segment is 89 miles. The average AADTT in this segment is 1,409, the average annual precipitation level is 10 inches, and the most prevalent soil type is A4. The second segment runs from Emery County to the Colorado state border. The segment has an average AADTT value of 1,199. The section predominantly has A6 soil type with the annual average precipitation value of 10 inches.

Colorado

Interstate 70 travels 451 miles in Colorado and has been divided into three segments. The first segment spans from the state border with Utah to Garfield County with a total mileage of 91. The average AADTT value for this segment was found to be 3,360. The average annual precipitation in this segment was 10 inches and the soil type was A7. The second segment starts just beyond Garfield County and goes to Denver County. The segment has an average AADTT value of 10,792. The soil type is A4. This segment has a length of about 184 miles and an average annual precipitation of 20 inches. The third segment starts beyond Denver County and goes up to Kit Carson County. The traffic is relatively high with an average AADTT value for this segment is 11,462. The total length of this segment is 176 miles. The average annual precipitation is 20 inches per year, the soil is type A6.

Kansas

In Kansas I-70 travels 424 miles and has been divided into three segments The first segment spans from the Colorado state border to Russell County with a total mileage of 189. The average AADTT value for this segment was 1,924. The average annual precipitation was 20 inches and the soil type was A7. The second segment starts just beyond Russell County and goes to Shawnee County. The segment has an average AADTT value of 3,437. The soil type is A7. This segment has a length of about 167 miles and an average annual precipitation of 25 inches. The third segment starts beyond Shawnee County and goes up to Wyandotte County. The average AADTT value for this segment is 8,609. The total length of this segment is 68 miles. The average annual precipitation is 30 inches per year, the soil is type A7 .

Missouri

Interstate 70 travels 253 miles in the state of Missouri. The interstate has been divided into two segments for the purpose of this analysis. The first segment starts from the state border with Kansas and goes up Callaway County. The total length of this segment is 148 miles. The average AADTT in this segment is 13,654, the average annual precipitation level is 40 inches, and the soil type is A7. The second segment runs from Callaway County to the border with Illinois. The segment has an average AADTT value of 21,481, a predominantly A7 soil type, and an annual average precipitation value of 40 inches.

Illinois

Interstate 70 runs for a length of 138 miles in the state of Illinois and has been considered as a single segment for the analysis. This segment has an average AADTT value of 4,205. The average annual rainfall in this region is 40 inches and the soil type found in this region is A7.

Indiana

Interstate 70 runs for a length of 155 miles in the state of Indiana and has been divided into two segments. The first segment runs from the Illinois state border to Hancock County for a length of 75 miles and has an average AADTT value of 7,995. The average annual rainfall in this region is 40 inches and the soil type is A7. The second segment runs from Hancock County to the border with Ohio in Wayne County and has a length of 80 miles. It has an average AADTT value of 14,179. The average annual rainfall in this region is 35 inches and the soil type is A7.

Ohio and West Virginia

Interstate 70 runs for a length of 226 miles in Ohio and for 14 miles in West Virginia. These two states have been combined into two segments. The first segment, which is 129 miles, is wholly contained in Ohio and runs from the Indiana border to Licking County. The average AADTT value in this segment is 12,056. The average annual rainfall in this region is 40 inches and the soil type is A7. The second segment lies in both states, but is predominantly in Ohio (97 of the 111 miles). It starts at Licking County and meets the Pennsylvania state boundary at Westmoreland County. The average AADTT value in the second segment is 7,332. The average annual rainfall in this region is 10 inches and the soil type is A7.

Pennsylvania

Interstate 70 travels 169 miles in the state of Pennsylvania, and has been divided into two segments. The first segment starts from the border with West Virginia and includes the route until Westmoreland County (a total length of 54 miles). The average AADTT in this segment is 7,681, the average annual precipitation level is 40 inches, and the soil type is A7. The second segment runs from Westmoreland County to the Maryland border. The segment has an average AADTT value of 4,683. The section predominantly has A4 soil type with the annual average precipitation value of 35 inches.

Maryland

Interstate 70 runs for a length of 93 miles in the state of Maryland and has been considered as a single segment for the purpose of analysis. The section runs from

Washington to Baltimore counties and has an average AADTT value of 12,870. The average annual rainfall in this region is 40 inches and the soil type is considered A4.

Interstate 75

Florida

Interstate 75 travels 472 miles in Florida and has been divided into three segments. The first segment spans from the Miami-Dade County to Sarasota County with a total of 194 miles. The average AADTT value for this segment was found to be 11,182. The average annual precipitation was 60 inches and the soil type is A3. The second segment starts just beyond Sarasota County and goes to Alachua County. The segment has an average AADTT value of 16,175. The soil type is A3. This segment has a length of about 180 miles and an average annual precipitation of 20 inches. The third segment starts beyond Alachua County and goes north to Georgia border. The traffic is relatively high with an average AADTT value for this segment is 10,513. The total length of this segment is 98 miles. The average annual precipitation is 20 inches per year, the soil is type A7.

Georgia

Interstate 75 travels 356 miles in Georgia and has been divided into four segments. The first segment spans from the Florida state border to Crisp County with a total mileage of 110. The average AADTT value for this segment was found to be 8,646. The average annual precipitation in this segment was 50 inches and the soil type was A3. The second segment starts just beyond Crisp County and goes to Monroe County. The segment has an average AADTT value of 12,462. The soil type is A7. This segment has a length of about 92 miles and an average annual precipitation of 45 inches. The third segment starts beyond Monroe County and goes up to Fulton County. The average AADTT value for this segment is 39,017. The total length of this segment is 68 miles. The average annual precipitation is 50 inches per year, the soil is type A7. The fourth and final segment starts from Fulton County and finishes at the Tennessee state border. The average AADTT value for this segment is 15,082, average annual precipitation is 50 inches and the soil type is A7.

Tennessee

Interstate 75 runs for a length of 142 miles in the state of Tennessee and has been considered as one segment. The segment runs from the border with Georgia to the Kentucky border. It has an average AADTT value of 11,145. The average annual rainfall in this region is 50 inches and the soil type is A7.

Kentucky

Interstate 75 runs for a length of 173 miles in the state of Kentucky and has been divided into two segments. The first segment runs from the Tennessee border to Madison County for a length of 88 miles and has an average AADTT value of 7,190. The average annual rainfall in this region is 50 inches and the soil type is A4. The second segment runs from Madison County to the border with Ohio. It has a total length of 85 miles, an average AADTT value of 11,513, an average annual rainfall of 45 inches, and the soil type is A6.

Ohio

In Ohio, I-75 travels 216 miles and has been divided into two segments. The first segment is 78 miles, and travels from the border with Kentucky to Shelby County. It has an AADTT value of 18,067. The average annual rainfall in this region is 40 inches and the soil type is A7. The second segment of 138 miles runs from the Shelby County to the Michigan state border. It has an AADTT value of 9,651, an average annual rainfall of 35 inches, and A7 soil.

Michigan

Interstate 75 travels 399 miles in Michigan and has been divided into three segments. The first segment spans from the Ohio state border to Saginaw County with a total mileage of 132. The average AADTT value for this segment was found to be 19,126. The average annual precipitation was 34 inches and the soil type was A7. The second segment starts from Saginaw County and goes to Ogemaw County. The segment has an average AADTT value of 8,014. The soil type is A4. This segment has a length of about 87 miles and an average annual precipitation of 32 inches. The third segment starts beyond Ogemaw County and goes up to Chippewa County. The average AADTT value for this segment is 1,965. The total length of this segment is 180 miles. The average annual precipitation is 30 inches per year, the soil is type A3.

Interstate 76

Colorado

Interstate 76 travels 187 miles in Colorado. It has been divided into two segments. First segment runs from Arvada to Morgan County. Average AADTT value for this segment is 10077. Average annual rainfall in this segment is 15 inches and the soil type is A4. The second segment runs from Morgan County to Nebraska state line. Average AADTT value for this segment is 2140. Average annual rainfall in this segment is 20 inches and the soil type is A3.

Ohio

Interstate 76 travels 82 miles in Ohio. The segment runs from Medina County to Mahoning County. Average AADTT value for this segment is 8313. Average annual rainfall in this segment is 40 inches and the soil type is A4.

Pennsylvania

Interstate 76 travels 192 miles in Pennsylvania. The segment runs from Youngstown to New Jersey state line. Average AADTT value for this segment is 15097. Average rainfall in this segment is 45 inches and the soil type is A7.

Interstate 77

South Carolina

Interstate 77 travels 91 miles in South Carolina. The segment runs from Lexington County to York County. Average AADTT value for this segment is 12343. Average annual rainfall in this segment is 45 inches and the soil type is A7.

North Carolina

Interstate 77 travels 105 miles in North Carolina. The segment runs from Mecklenburg County to Surry County. Average AADTT value for this segment is 16755. Average annual rainfall in this segment is 50 inches and the soil type is A7.

Virginia

Interstate 77 travels 67 miles in Virginia. The segment runs from Carroll County to Bland County. Average AADTT value for this segment is 6956. Average annual rainfall in this segment is 40 inches and the soil type is A7.

West Virginia

Interstate 77 travels 187 miles in West Virginia. The segment runs from Mercer County to Wood County. Average AADTT value for this segment is 4792. Average annual rainfall in this segment is 45 inches and the soil type is A7.

Ohio

Interstate 77 travels 160 miles in Ohio. The segment runs from Washington County to Cuyahoga County. Average AADTT value for this segment is 9310. Average annual rainfall in this segment is 40 inches and the soil type is A7.

Interstate 78

Pennsylvania

Interstate 78 runs for a length of 77 miles in the state of Pennsylvania. It starts at Lebanon County and ends at the New Jersey border. The average AADTT value for this segment is 9590. The average annual rainfall in this region is 50 inches and the soil type considered is A4.

New Jersey

In New Jersey, I-78 travels 72 miles. It starts at the Town of Alpha, travels for a brief period in the state of New York and ends near the city of New York. The average AADTT value for this segment is 20009. The average annual rainfall in this region is 50 inches and the soil type is A6.

Interstate 80

California

Interstate 80 runs for a length of 207 miles in the state of California. It has been divided into two sections with the first segment running from the San Francisco County to the Placer County for a length of 89 miles. It has an average AADTT value of 21,008. The average annual rainfall in this region is 30 inches. The soil type found in this region is A6. The second segment runs from Placer County to the Nevada state boundary at Truckee County for a length of 118 miles. The average AADTT value in this segment is 14,944. The average annual rainfall in this region is 40 inches, and the soil is A4.

Nevada

Interstate 80 travels 416 miles in Nevada and has been divided into three segments. The first segment spans from the California border to Humboldt County (183 miles). The average AADTT value for this segment was found to be 8,210. The average annual precipitation in this segment was 10 inches and the soil type was A4. The second segment starts at Humboldt County and goes to Osino. The segment has an average AADTT value of 1,672. The soil type is A6. This segment has a length of about 123 miles and an average annual precipitation of 10 inches. The third segment starts beyond Osino and goes to Utah boundary. The average AADTT value for this segment is 1,422. The total length of this segment is 110 miles. The average annual precipitation is 10 inches per year, the soil is type A5.

Utah

Interstate 80 travels 193 miles in Utah and has been divided into two segments. The first segment spans from the Nevada state border to Salt Lake County for a length of 120 miles. The segment has an average AADTT value of 7,962. The average annual rainfall in this region is 10 inches and the soil type is A7. The second segment starts from Salt Lake County and ends at the border with Wyoming. The total length of the segment is 73 miles and it has an average AADTT value of 12,421. The average annual rainfall in this region is 15 inches and the soil type is A7.

Wyoming

Interstate 80 travels 404 miles in Wyoming and has been divided into 3 segments. The first segment spans from the Utah state border to Sweetwater County for a total of 173 miles. The average AADTT value for this segment was found to be 1,972. The average annual precipitation in this segment was 10 inches and the soil type was considered A7. The second segment starts from Sweetwater County and goes to Albany County. The segment has an average AADTT value of 2,508. The soil type is A4. This segment has a length of about 141 miles and an average annual precipitation of 10 inches. The third segment starts beyond Albany County and goes up to the Nebraska state boundary. The average AADTT value for this segment is 2,521. The total length of this segment is 90 miles. The average annual precipitation is 10 inches per year, the soil is type A4.

Nebraska

Interstate 80 runs for a length of 456 miles in the state of Nebraska and has been divided into three segments. The first segment starts at the Wyoming border and ends at Lincoln

County after a length of 178 miles. It has an AADTT value of 2,082. The average annual rainfall in this region is 15 inches and the soil type is considered A7. The second segment starts at the Lincoln County and ends at Hall County after a length of 134 miles. It has an average AADTT value of 3,538. The average annual rainfall in this region is 15 inches with A7 soil type. The third segment in Nebraska ends at the Iowa state border after a length of 144 miles, an AADTT value of 12,938, and an A7 soil type. The average annual rainfall in this region is 20 inches.

Iowa

Interstate 80 travels 289 miles in the state of Iowa. In this state the interstate has been divided into two segments. The first segment runs from the border with Nebraska to Dallas County (a length of 110 miles) and has an average AADTT value of 4,730. The average annual rainfall in this region is 30 inches and the soil type is A7. The second segment runs from Dallas County to the Illinois state border (a length of 179 miles) and has an average AADTT value of 6,863. The average annual rainfall in this region is 35 inches and the soil type is A7.

Illinois

Interstate 80 travels 163 miles in Illinois and has been considered as one segment. The segment spans from the Iowa state line to Indiana border. The segment has an average AADTT value of 9,581. The average annual rainfall in this region is 10 inches and the soil type is A7.

Indiana

Interstate 80 runs for a length of 150 miles in the state of Indiana and has been divided into two segments at Elkhart County. The first segment has a length of 69 miles and an AADTT value of 14,470. The average annual rainfall in this region is 40 inches and the soil type is considered A7. The second segment has a length of 81 miles and an AADTT value of 4,888. The average annual rainfall in this region is 35 inches and the soil is of type A7.

Ohio

Interstate 80 travels 239 miles in Ohio and has been divided into two segments. The first segment spans from the Indiana border to Loraine County for a length of 91 miles. The average AADTT value for this segment is 5,883. The average annual rainfall in this region is 35 inches and the soil type is A6. The second segment runs from Loraine County to Mahoning County (at the Pennsylvania state border) for a length of 148 miles. The average AADTT value for this segment is 7,137. The average annual rainfall in this region is 40 inches and the soil type is A6.

Pennsylvania

In Pennsylvania, I-80 travels 311 miles and has been divided into two segments. The first segment spans from the Ohio state border to Centre County for a length of 147 miles and has an average AADTT value of 5,115. The average annual rainfall in this region is 40 inches and the soil type is A4. The second segment spans from Centre County to the New Jersey state line and has an average AADTT value of 6,951. The average annual rainfall in this region is 45 inches and the soil type is A4.

New Jersey

Interstate 80 spans a length of 68 miles in the New Jersey and has been considered as a single segment. It starts at the Pennsylvania state border and ends at the Bergen County. The segment has an average AADTT value of 23,413. The average annual rainfall in this region is 45 inches and the soil type is A5.

Interstate 81

Tennessee

Interstate 81 travels 76 miles in Tennessee. The segment runs from Dandridge to Virginia border. Average AADTT value for this segment is 6132. Average annual rainfall in this segment is 45 inches and the soil type is A7.

Virginia

Interstate 81 travels 305 miles in Virginia. It has been considered as two segments. First segment runs from Washington to Botetourt County. Average AADTT value for this segment is 45. Average annual rainfall in this segment is inches and the soil type is A7.Second segment runs from Botetourt County to Fredrick County. Average AADTT value for this segment is 8649. Average annual rainfall in this segment is 40 inches and the soil type is A7.

West Virginia

Interstate 81 spans a short distance of 38 miles in both West Virginia and Maryland combined. The segment runs from Ridgeway to Maugansville. Average AADTT value for this segment is 12158. Average annual rainfall in this segment is 40 inches and the soil type is A7.

Pennsylvania

Interstate 81 travels 233 miles in Pennsylvania. It has been considered as two segments. First segment runs from Franklin County to Schuylkill County. Average AADTT value for this segment is 9918. Average annual rainfall in this segment is 45 inches and the soil type is A7. Second segment runs from Schuylkill County to Susquehanna County. Average AADTT value for this segment is 8842. Average annual rainfall in this segment is 40 inches and the soil type is A4.

New York

Interstate 81 travels 189 miles in New York. It has been considered as two segments for analysis. First segment runs from Broome County to Ellisburg. Average AADTT value for this segment is 8193. Average annual rainfall in this segment is 40 inches and the soil type is A4. Second segment runs from Ellisburg to Orleans. Average AADTT value for this segment is 3614. Average annual rainfall in this segment is 35 inches and the soil type is A7.

Interstate 82

Washington

Interstate 82 travels 144 miles in Washington and Oregon. It has been considered as one segment. The segment runs from Kittitas County to Umatilla County. Average AADTT value for this segment is 4486. Average annual rainfall in this segment is 10 inches and the soil type is A4.

Interstate 83

Maryland

Interstate 83 spans a short length of 34 miles in the state of Maryland and runs from Baltimore upto the Pennsylvania border. The average AADTT value for this segment is 19694. The average rainfall in this region is 45 inches and the soil type is A4.

Pennsylvania

Interstate 78 runs for a length of 60 miles in Pennsylvania and runs from Shrewsbury to Dauphin County. The average AADTT value for this segment is 13654. The average annual rainfall in this region is 40 inches and the soil type is A4.

Interstate 84

Oregon

Interstate 84 travels 394 miles in Oregon. It has been considered as three segments. First segment runs from Multnomah County to Wasco County. Average AADTT value for this segment is 11076. Average annual rainfall in this segment is 55 inches and the soil type is A4. Second segment runs from Wasco County to Morrow County. Average AADTT value for this segment is 2193. Average annual rainfall in this segment is 30 inches and the soil type is A6. Third segment runs from Morrow County to Malheur County. Average AADTT value for this segment is 1897. Average annual rainfall in this segment is 20 inches and the soil type is A7.

Idaho

Interstate 84 travels 276 miles in Idaho. It has been considered as two segments. First segment runs from Payette County to Elmore County. Average AADTT value for this segment is 7832. Average annual rainfall in this segment is 20 inches and the soil type is A7. Second segment runs from Elmore County to Oneida County. Average AADTT value for this segment is 2868. Average annual rainfall in this segment is 10 inches and the soil type is A7.

Utah

Interstate 84 travels 110 miles in Utah. The segment runs from Box Elder County to Summit County. Average AADTT for this segment is 2223. Average annual rainfall in this segment is 30 inches and the soil type is A4.

Pennsylvania

Interstate 84 travels 54 miles in Pennsylvania. The segment runs from Dunmore to New York state line. Average AADTT for this segment is 5082. Average annual rainfall in this segment is 45 inches and the soil type is A4.

New York

Interstate 84 travels 71 miles in New York. The segment runs from Port Jervis to Connecticut state line. Average AADTT for this segment is 9663. Average annual rainfall in this segment is 45 inches and the soil type is A4.

Connecticut

Interstate 84 travels 110 miles in Connecticut and Massachusetts combined. It has been considered as one segment. Average AADTT for this segment is 12695. Average annual rainfall in this segment is 50 inches and the soil type is A4.

Interstate 85

Alabama

Interstate 85 runs for a length of 80 miles in the state of Alabama and runs from Montgomery upto the Georgia state border. The average AADTT value for this segment is 8742. The average annual rainfall in this region is 55 inches and the soil type is A6.

Georgia

Interstate 85 traverses 170 miles in the state of Georgia and is divided into two segments. First segment runs from Harris County to Fulton County. The average AADTT value for this segment is 8507. The average rainfall in this region is 55 inches and the soil type is A7. The second segment starts at Fulton County and ends at the South Carolina state border. The average AADTT value for this segment is 27007. This region has an average rainfall of 55 inches and the soil type is A7.

South Carolina

Interstate 85 runs for a length of 149 miles in the state of South Carolina. It is considered as one segment, which runs from Oconee County upto the Cherokee County. The average AADTT value for this segment is 12792. Average annual rainfall in this region is 50 inches and the soil type is A7.

North Carolina

Interstate 85 travels 248 miles in North Carolina and has been divided into two segments. First segment runs from Cleveland County to Davidson County. The average AADTT value for this segment is 19200. The average rainfall in this region is 50 inches and the soil type is A7. Second segment runs from Davidson County to Warren County. The average AADTT value for this segment is 9343. Average annual rainfall in this region is 45 inches and the soil type is A7.

Virginia

Interstate 85 travels 68 miles in Virginia, which is considered as one segment. The segment runs from Mecklenburg County to the City of Petersburg. The average AADTT value for this segment is 5268. Average annual rainfall in this region is 45 inches and the soil type is A7.

Interstate 90

Washington

Interstate 90 travels 297 miles in Washington and has been divided into three segments. The first segment spans from King County to Grant County for a length of 149 miles and has an average AADTT value of 12,226. The average annual rainfall in this region is in the range of 90-120 inches and the soil type is A3. The second segment spans from Grant County to Lincoln County and has an average AADTT value of 2,646. The segment spans a length of 93 miles. The average annual rainfall in this region is in the range of 60-90 inches and the soil type is A4.The third and final segment from Lincoln County meets the Idaho state border at Spokane County after traversing a length of 55 miles. It has an average AADTT value of 12,294. The average annual rainfall in this region is 30 inch and the soil type is A4.

Idaho

Interstate 90 spans 68 miles in Idaho and has been considered as a single segment for the purpose of analysis. The average AADTT value for this segment is 3,938 and the soil type is predominantly A4. The average rainfall over this region is approximately 30 inches.

Montana

Interstate 90 spans 545 miles in Montana and has been divided into five segments. The first section runs from the Idaho state border to Missoula County for a length of 155 miles. The average AADTT value for this segment is 2,807, the average rainfall over the section is around 30-50 inches and the soil type is considered A4. The second segment runs from Missoula County to Deer Lodge County for a length of about 85 miles. The average AADTT value for this segment is equal to 1,726. The annual rainfall in this segment is similar to the first segment with a value of 30-50 inches and the soil type is considered A4. The third segment runs from Deer Lodge County to Gallatin County for a length of about 160 mile. The average AADTT value for this segment is equal to 2,543 and the average annual rainfall is about 10 inches with A7 soil type. The fourth segment runs from Gallatin County to Yellowstone County and it covers a length of about 75 miles. The average AADTT value for this segment is 3,614 and this region has an average annual rainfall of about 10 inches with A7 soil type. The fifth and final segment of I-90 in Montana runs from Yellowstone County to the Wyoming border for a length of about 97 miles. The average AADTT value for this segment is 1,188 and it has a rainfall of about 10 inches average annually and the soil type is considered A7.

Wyoming

Interstate 90 runs for a length of about 209 miles in the state of Wyoming. It has been divided into two segments. The first segment runs from the Montana border to Campbell

County for a length of about 135 miles. The average AADTT value for this segment is equal to 1,361. The average annual rainfall for this segment of the region is around 20 inches and the soil type is considered A7. The second segment runs from Campbell to the South Dakota border and it covers a length of about 74 miles. The average AADTT value for this segment is 1,052 and it receives rainfall of less than 20 inches per year. The soil type is considered A6.

South Dakota

Interstate 90 travels 413 miles in South Dakota and has been divided into three segments. The first segment spans from the Wyoming state border to Jackson County (a total distance of 151 miles). The average AADTT value for this segment was found to be 2,978. The average annual precipitation in this segment was 20 inches and the soil type was A7. The second segment starts from Jackson County and goes to Davison County. The segment has an average AADTT value of 1,341. The soil type is A7. This segment has a length of about 125 miles and an average annual precipitation of 15 inches. The third segment starts beyond Davison County and goes to the Minnesota state border. The average AADTT value for this segment is 2,460. The total length of this segment is 119 miles. The average annual precipitation is 20 inches per year and the soil is type A7.

Minnesota

Interstate 90 covers a length of 276 miles in Minnesota and has been divided into two segments. The first segment runs from the South Dakota border Freeborn County covering a length of 143 miles and has an average AADTT value of 1,670. The average annual precipitation in this segment is 25-30 inches and the soil type is A7. The second segment runs from Freeborn County to the Wisconsin border and has a total length of 133 miles, an average AADTT value of 2,528, an average annual precipitation of 30-35 inches, and A7 soil.

Wisconsin

Interstate 90 spans 185 miles in Wisconsin and has been considered as one segment for the purpose of analysis. The segment has an average AADTT value of 8,107, an average annual precipitation of 30 inches, and type A7 soil.

Illinois

Interstate 90 spans 109 miles in Illinois and has been considered as a single segment. The segment has an average AADTT value of 32,168, an average annual precipitation of 40 inches, and a type A7 soil.

Indiana

Interstate 90 runs for a length of 156 miles in the state of Indiana and it has been considered as a single segment. The segment has an average AADTT value of about 6,903, an average annual precipitation of 35 inches, and a type A7 soil.

Ohio

In Ohio, I-90 covers a length of 245 miles and has been divided into two segments. The first segment runs from the state border with Indiana to Sandusky County covering a length of 103 miles. It has an average AADTT value of 15,227, an average precipitation of 35 inches, and type A6 soil. The second segment runs from Sandusky County to the Pennsylvania border (142 miles). It has an AADTT value of 5,353, average annual precipitation of 35 inches, soil of type A4.

Pennsylvania

Interstate 90 spans 46 miles in Pennsylvania and has been considered as a single segment. The segment runs from the border with Ohio to that with New York. The average AADTT value is 6,021, the average annual precipitation is 40 inches, and the soil type is A6.

New York

Interstate 90 runs for a length of 386 miles in the state of New York and has been divided into three segments for the purpose of analysis. The first segment runs from the Pennsylvania border to Victa and it covers a length of 106 miles. It has an average AADTT value of 12,435. The average precipitation value for this segment is around 40 inches and the soil type is considered A4. The second segment runs from Victa to Utica and it covers a length of 136 miles. It has an average AADTT value of 6,986. The average precipitation value for this segment is around 35 inches with soil type A4. The third segment runs from Utica to Massachusetts and it covers a length of 144 miles. It has an average AADTT value of 8,299. The average precipitation value for this segment is around 30 inches and the soil type is considered A4.

Massachusetts

In Massachusetts, I-90 runs for a length of 136 miles and has been considered as one segment for the purpose of analysis. The segment has an average AADTT value of about 15,015, an average annual precipitation of 35 inches, and the soil type is considered A4.

Interstate 94

Montana

Interstate 94 runs for a length of 249 miles in the state of Montana and has been divided into two segments. The first segment runs from Yellowstone County to Custer County for a length of 119 miles and has an average AADTT value of 888. The average annual rainfall in this region is 10 inches and the soil type is A5. The second segment starts from Custer County and meets the North Dakota state boundary at the Wibaux County after a length of 130 miles. This segment has an average AADTT value of 721. The average annual rainfall in this region is 15 inches with A5 soil type.

North Dakota

Interstate 94 travels 352 miles in North Dakota and has been divided into two segments. The first segment spans from the Montana state border to Kidder County for a length of 193 miles and with an average AADTT value of 2094. The average annual rainfall in this region is 15 inches and the soil type is A7. The second segment spans from Kidder County to the Minnesota state border and has an average AADTT value of 3,214. The segment spans a length of 159 miles. The average annual rainfall in this region is 17 inches and the soil type is A7.

Minnesota

Interstate 94 spans 258 miles in Minnesota and has been divided into two segments. The first segment starts at the North Dakota border and ends at the Todd County covering a length of 115 miles. It has an average AADTT value of 3,253. The average annual rainfall in this region is 22 inches and the soil type is A7. The second segment starts at Todd County and goes to Washington County for a length of 143 miles. It has an average

AADTT value of 13,506. The average annual rainfall in this region is 28 inches and the soil type is A6.

Wisconsin

In Wisconsin, I-94 travels 341 miles and has been divided into two segments. The first segment spans from the Minnesota border to Juneau County for a length of 160 miles and has an average AADTT value of 9,234. The average annual rainfall in this region is 30 inches and the soil type is A7. The second segment spans from Juneau County to Illinois state boundary and has an average AADTT value of 18,067. The segment spans a length of 103 miles. The average annual rainfall in this region is 35 inches and the soil type is A7.

Illinois

Interstate 94 spans 59 miles as a single section across Illinois. The average AADTT value in this segment is 26,349. The average annual rainfall in this region is 35 inches and the soil type is A7.

Indiana

Interstate 94 spans 46 miles in Indiana and has been considered as a single section in the analysis. The average AADTT value in this segment is 9,338. The average annual rainfall in this region is 35 inches and the soil type is A6.

Michigan

Interstate 94 covers a length of 284 miles in the Michigan. It has been divided into three segments for the purpose of analysis. The first segment runs from the state border with Indiana to Calhoun County for a length of 74 miles. It has an average AADTT value of

8,016. The average annual rainfall in this region is 34 inches and the soil type is A7.The second segment starts at Calhoun County and ends at Wayne County covering a length of 112 miles. The average AADTT value in this segment is 9,780. The average annual rainfall in this region is 30 inches and the soil type is A7. The third segment ends at St. Clair County and has an average AADTT value of 22,128. The average annual rainfall in this region is 28 inches and the soil type is A6.

Interstate 95

Florida

Interstate 95 runs for a length of 383 miles in the state of Florida and it has been divided into three segments. The first segment is located in southern Florida and includes the Miami area. It is subjected to high traffic, average AADTT value of 42,842, a large average annual rainfall of 60 inches, and is built upon an A3 subgrade. The second segment begins at St. Lucie County and ends in Brevard County. This segment has an average AADTT value of 11,837. The average annual rainfall in this region is 54 inches with A3 soil. The third and final segment runs from Brevard County to the Georgia state border. This segment has an average AADTT value of 17,378, an average annual rainfall of less than 50 inches, and an A4 soil.

Georgia

There are a total of 112 miles of I-95 in the state of Georgia, and all of this is considered as one segment. The traffic is moderate with an average AADTT value of 10,922. The average annual rainfall in this region is 48 inches and the soil type is A7.

South Carolina

Interstate 95 travels a total of 199 miles in the state of South Carolina and it is divided into two sections. The first segment runs from the Georgia border to Dorchester County (a length of 82 miles). The average AADTT value for this segment is 8,479, the average annual rainfall is 50 inches, and the soil type is A7. The second segment runs from Dorchester County to the North Carolina border. It has a total length of about 117 miles. The average AADTT value for this segment is 6,765. The average annual rainfall in this region is 45 inches and the soil type is A7.

North Carolina

Interstate 95 traverses 182 miles in the state of North Carolina, and has been considered as one segment. The segment runs from the border with South Carolina to the Virginia state border. The average AADTT value for this segment is 7,543, the average annual rainfall is 48 inches, and the soil type is A5.

Virginia

Interstate 95 traverses 174 miles in the state of Virginia, and is divided into two segments. The first segment runs from the North Carolina border to Hanover County for a length of 101 miles. The average AADTT value for this segment is 14,698, the average annual rainfall is 40 inches, and the soil type is A6. The second segment runs from Hanover County to the Maryland border. It has a total length of about 73 miles. The average AADTT value for this segment is 33,343. The average annual rainfall in this region is 35 inches and the soil type is A7.

Maryland and Delaware

Interstate 95 covers 107 miles in Maryland and 23 miles in the state of Delaware. It has been divided into two segments. The first segment runs from Virginia border to Baltimore for a length of 47 miles. The average AADTT value for this segment is 29,197. The average annual rainfall in this region is 40 inches. The soil type is A7. The second segment runs from Baltimore to the Pennsylvania state boundary for a length of 83 miles. The average AADTT value for this segment is 20,687. The average annual rainfall in this region is 40 inches. The soil type is A7.

Pennsylvania

Interstate 95 covers 51 miles in the state of Pennsylvania. This segment starts at the Delaware border and runs to the New Jersey state boundary in Mercer County. The average AADTT value for this segment is 22,727. The average annual rainfall in this region is 40 inches and the soil type is A4.

New Jersey and New York

Interstate 95 covers 92 miles in the state of New Jersey and 24 miles in the state of New York. It has been considered as a single segment for analysis. The total 116 miles of this segment has an average AADTT value of 23,074. The average annual rainfall in this region is 45 inches and the soil type is A4.

Connecticut

Interstate 95 spans 111 miles in the state of Connecticut. It runs from the New York border to the Rhode Island border in New London County. The average AADTT value for this segment is 19,296. The average annual rainfall in this region is 40 inches and the soil type is A4.

Rhode Island

In Rhode Island, I-95 only travels 43 miles. It starts at the Connecticut border in Washington County and ends at the Massachusetts border in Providence County. The average AADTT value for this segment is 30,404. The average annual rainfall in this region is 46 inches and the soil type is considered A4.

Massachusetts and New Hampshire

Interstate 95 runs for a length of 91 miles in the state of Massachusetts and for a length of 16 miles in the state of New Hampshire. It has been considered as a single segment for the purpose of analysis. It starts at the Rhode Island border and ends at the Maine-New Hampshire border. The average AADTT value for this segment is equal to 22,344. The average annual rainfall in this region is 45 inches and the soil type is considered A4.

Maine

Interstate 95 spans 304 miles in the state of Maine and it has been divided into two segments. The first segment runs from York County (New Hampshire border) to Somerset County for a length of 156 miles. The segment has an average AADTT value of 4,860. The average annual rainfall in this region is 40 inches and the soil type is A4.The second segment runs from Somerset County to the Canadian border in Aroostook County (148 miles), it has an average AADTT value of 2,931, an average annual rainfall of 40 inches, a type A4 soil.

APPENDIX B

TRAFFIC GROWTH RATES BY SECTION

Table B.1 : Summary of Traffic Values for Each Analysis Section.

Route	State	Name	Length (Miles)	Initial Year AADTT	Baseline Growth Rate	Freight Trend Analysis Growth Rate
I-5	CA	I5-CA-1	85	27100	3.00	3.00
		I5-CA-2	189	35480	3.00	3.00
		I5-CA-3	194	5218	3.00	3.00
		I5-CA-4	132	12380	3.00	3.00
		I5-CA-5	197	7925	3.00	3.00
	OR	I5-OR-1	98	4380	3.00	3.00
		I5-OR-2	169	8465	3.00	3.00
		I5-OR-3	55	21976	3.00	3.00
	WA	I5-WA-1	132	17754	3.00	3.00
		I5-WA-2	46	43675	3.00	3.00
		I5-WA-3	98	18244	3.00	3.00
I-10	CA	I10-CA-1	102	31801	3.00	3.00
		I10-CA-2	149	6908	3.00	3.00
	AZ	I10-AZ-1	137	7089	2.00	2.74
		I10-AZ-2	145	24965	2.00	2.74
		I10-AZ -3	111	8691	2.00	2.74
	NM	I10-NM-1	164	4436	2.00	2.74
	TX	I10-TX-1	141	21146	3.00	3.10
		I10-TX-2	136	10435	3.00	3.10
		I10-TX-3	161	1306	3.00	3.10
		I10-TX-4	127	8706	3.00	3.10
		I10-TX-5	46	17536	3.00	3.10
		I10-TX-6	158	16978	3.00	3.10
		I10-TX-7	113	17801	3.00	3.10
	LA	I10-LA-1	154	8910	3.00	3.10
		I10-LA-2	67	12384	3.00	3.10
		I10-LA-3	53	20296	3.00	3.10
	MS	I10-MS-1	77	10569	3.00	2.50
	AL	I10-AL-1	66	12400	3.00	2.50
	FL	I10-FL-1	175	5876	2.00	3.90
		I10-FL-2	188	7940	2.00	3.90
I-15	CA	I15-CA-1	111	22402	3.00	3.00
		I15-CA-2	178	9212	3.00	3.00
	AZ, NV	I15-NV-1	154	23196	2.00	2.74
	UT	I15-UT-1	179	3853	2.00	2.74
		I15-UT-2	115	14793	2.00	2.74
		I15-UT-3	108	21029	2.00	2.74
	ID	I15-ID-1	75	3256	2.50	3.43
		I15-ID-2	122	2201	2.50	3.43
	MT	I15-MT-1	199	1633	2.00	2.74
		I15-MT-2	197	1005	2.00	2.74
I-20	TX	I20-TX-1	84	1689	3.00	3.10
		I20-TX-2	177	3686	3.00	3.10
		I20-TX-3	165	4637	3.00	3.10
		I20-TX-4	101	24030	3.00	3.10

Table B.1: Summary of Traffic Values for Each Analysis Section (continued).

Route	State	Name	Length (Miles)	Initial Year AADTT	Baseline Growth Rate	Freight Trend Analysis Growth Rate
	TX	I20-TX-5	109	6075	3.00	3.10
	LA	I20-LA-1	190	9586	3.00	3.10
	MS	I20-MS-1	162	9184	3.00	2.50
	AL	I20-AL-1	150	4978	3.00	2.50
		I20-AL-2	65	12043	3.00	2.50
	GA	I20-GA-1	110	23048	2.00	3.90
		I20-GA-2	92	7744	2.00	3.90
	SC	I20-SC-1	142	10797	2.00	3.90
I-24	GA,TN	I24-GA-1	89	10358	2.00	3.90
	TN	I24-TN-1	91	13262	3.00	2.50
	KY,IL	I24-KY-1	131	4894	3.00	2.50
I-35	TX	I35-TX-1	151	7133	3.00	3.10
		I35-TX-2	177	22096	3.00	3.10
		I35-TX-3	77	12493	3.00	3.10
		I35E-TX-1	96	23824	3.00	3.10
		I35W-TX1	85	17635	3.00	3.10
	OK	I35-OK-1	136	9946	3.00	3.10
		I35-OK-2	107	7621	3.00	3.10
	KS	I35-KS-1	141	2946	2.50	4.11
		I35-KS-2	95	13602	2.50	4.11
	MO	I35-MO-1	115	8991	2.00	3.29
	IA	I35-IA-1	102	9526	2.00	3.29
		I35-IA-2	116	4064	2.00	3.29
	MN	I35-MN-1	97	7334	2.00	3.29
		I35-MN-2	124	5606	2.00	3.29
		I35E-MN-1	136	16439	2.00	3.29
		I35W-MN2	127	19819	2.00	3.29
I-40	CA	I40-CA-1	155	2175	3.00	3.00
	AZ	I40-AZ-1	146	4440	2.00	2.74
		I40-AZ-2	112	4927	2.00	2.74
		I40-AZ-3	102	3783	2.00	2.74
	NM	I40-NM-1	155	4705	2.00	2.74
		I40-NM-2	102	17063	2.00	2.74
		I40-NM-3	117	3192	2.00	2.74
	TX	I40-TX-1	67	5692	3.00	3.10
		I40-TX-2	110	6921	3.00	3.10
	OK	I40-OK-1	126	4140	3.00	3.10
		I40-OK-2	94	11879	3.00	3.10
		I40-OK-3	109	3876	3.00	3.10
	AR	I40-AR-1	152	7449	3.00	3.10
		I40-AR-2	151	9523	3.00	3.10
	TN	I40-TN-1	87	10273	3.00	2.50
		I40-TN-2	130	14653	3.00	2.50
		I40-TN-3	160	10882	3.00	2.50
		I40-TN-4	65	12705	3.00	2.50
	NC	I40-NC-1	162	9133	2.00	3.90

Table B.1: Summary of Traffic Values for Each Analysis Section (continued).

Route	State	Name	Length (Miles)	Initial Year AADTT	Baseline Growth Rate	Freight Trend Analysis Growth Rate
I-40	NC	I40-NC-2	98	17877	2.00	3.90
		I40-NC-3	162	13178	2.00	3.90
I-44	TX,OK	I44-TX-1	150	9454	3.00	3.10
	OK	I44-OK-1	191	8922	3.00	3.10
	MO	I44-MO-1	153	6920	2.00	3.29
	MO	I44-MO-2	137	13094	2.00	3.29
I-55	LA	I55-LA-1	66	4992	3.00	3.10
	MS	I55-MS-1	103	11752	3.00	2.50
		I55-MS-2	186	4948	3.00	2.50
	TN	I55-TN-1	82	10896	3.00	2.50
	MO	I55-MO-1	96	15794	2.00	3.29
		I55-MO-2	120	4427	2.00	3.29
	IL	I55-IL-1	156	8252	2.00	2.36
		I55-IL-2	138	16733	2.00	2.36
I-64	MO	I64-MO-1	140	3739	2.00	3.29
	IN	I64-IN-1	124	5893	2.00	3.29
	KY	I64-KY-1	64	13044	3.00	2.50
		I64-KY-2	119	5186	3.00	2.50
	WV	I64-WV-1	174	7841	2.00	2.36
	VA	I64-VA-1	132	7756	2.00	3.90
		I64-VA-2	167	17750	2.00	3.90
I-65	AL	I65-AL-1	181	9178	3.00	2.50
		I65-AL-2	185	11431	3.00	2.50
	TN	I65-TN-1	120	12689	3.00	2.50
	KY	I65-KY-1	138	13441	3.00	2.50
	IA	I65-IA-1	76	9842	2.00	3.29
		I65-IA-2	186	11800	2.00	3.29
I-69	IN	I69-IN-1	158	8186	2.00	3.29
	MI	I69-MI-1	108	5920	2.00	2.36
	MI	I69-MI-2	107	8151	2.00	2.36
I-70	UT	I70-UT-1	89	1409	2.00	2.74
		I70-UT-2	141	1199	2.00	2.74
	CO	I70-CO-1	91	3360	2.80	3.84
		I70-CO-2	184	10792	2.80	3.84
		I70-CO-3	176	11462	2.80	3.84
	KS	I70-KS-1	189	1924	2.50	4.11
		I70-KS-2	167	3437	2.50	4.11
		I70-KS-3	68	8609	2.50	4.11
	MO	I70-MO-1	148	13654	2.00	3.29
		I70-MO-2	105	21481	2.00	3.29
	IL	I70-IL-1	138	4205	2.00	2.36
	IN	I70-IN-1	75	7995	2.00	2.36
		I70-IN-2	80	14179	2.00	2.36
	OH, WV	I70-OH-1	129	12056	1.50	1.77
		I70-OH-2	111	7332	1.50	1.77

Table B.1: Summary of Traffic Values for Each Analysis Section (continued).

Route	State	Name	Length (Miles)	Initial Year AADTT	Baseline Growth Rate	Freight Trend Analysis Growth Rate
I-70	PA	I70-PA-1	54	7782	2.00	2.10
	MD	I70-PA-2	115	4683	2.00	2.10
		I70-MD-1	93	12870	2.00	3.90
I-75	FL	I75-FL-1	194	11182	2.00	3.90
		I75-FL-2	180	16175	2.00	3.90
		I75-FL-3	98	10513	2.00	3.90
	GA	I75-GA-1	110	8646	2.00	3.90
		I75-GA-2	92	12462	2.00	3.90
		I75-GA-3	68	39017	2.00	3.90
		I75-GA-4	86	15082	2.00	3.90
	TN	I75-TN-1	142	11145	3.00	2.50
	KY	I75-KY-1	88	7190	3.00	2.50
		I75-KY-2	85	11513	3.00	2.50
	OH	I75-OH-1	78	18067	1.50	1.77
		I75-OH-2	138	9651	1.50	1.77
	MI	I75-MI-1	132	19126	2.00	2.36
		I75-MI-2	87	8014	2.00	2.36
		I75-MI-3	180	1965	2.00	2.36
I-76	CO	I76-CO-1	66	10077	2.80	3.84
	CO	I76-CO-2	121	2140	2.80	3.84
	OH	I76-OH-1	82	8313	1.50	1.77
	PA	I76-PA-1	190	15097	2.00	2.10
I-77	SC	I77-SC-1	91	12343	2.00	3.90
	NC	I77-NC-1	105	16755	2.00	3.90
	VA	I77-VA-1	67	6956	2.00	3.90
	WV	I77-WV-1	187	4792	2.00	2.36
	OH	I77-OH-1	160	9310	1.50	1.77
I-78	PA	I78-PA-1	77	9590	2.00	2.10
	NJ	I78-NJ-1	72	20009	2.00	2.10
I-80	CA	I80-CA-1	89	21008	3.00	3.00
		I80-CA-2	118	14944	3.00	3.00
	NV	I80-NV-1	183	8210	2.00	2.74
		I80-NV-2	123	1672	2.00	2.74
		I80-NV-3	110	1422	2.00	2.74
	UT	I80-UT-1	120	7962	2.00	2.74
		I80-UT-2	73	12421	2.00	2.74
	WY	I80-WY-1	173	1972	3.00	4.12
		I80-WY-2	141	2508	3.00	4.12
		I80-WY-3	90	2521	3.00	4.12
	NE	I80-NE-1	178	2082	2.00	3.29
		I80-NE-2	134	3538	2.00	3.29
		I80-NE-3	144	12938	2.00	3.29
	IA	I80-IA-1	110	4730	2.00	3.29
		I80-IA-2	179	6863	2.00	3.29

Table B.1: Summary of Traffic Values for Each Analysis Section (continued)

Route	State	Name	Length (Miles)	Initial Year AADTT	Baseline Growth Rate	Freight Trend Analysis Growth
I-80	IL	I80-IL-1	163	9581	2.00	2.36
	IN	I80-IN-1	69	14470	2.00	2.36
		I80-IN-2	81	4888	2.00	2.36
	OH	I80-OH-1	91	5883	1.50	1.77
		I80-OH-2	148	7137	1.50	1.77
	PA	I80-PA-1	147	5115	2.00	2.10
		I80-PA-2	164	6951	2.00	2.10
	NJ	I80-NJ-1	68	23413	2.00	2.10
I-81	TN	I81-TN-1	76	6132	3.00	2.50
	VA	I81-VA-1	161	8446	2.00	3.90
	VA	I81-VA-2	144	8649	2.00	3.90
	WV,MD	I81-WV-1	38	12158	2.00	2.36
	PA	I81-PA-1	116	9918	2.00	2.10
	PA	I81-PA-2	117	8842	2.00	2.10
	NY	I81-NY-1	130	8193	2.00	2.10
	NY	I81-NY-2	59	3614	2.00	2.10
I-82	WA	I82-WA-1	144	4486	3.00	3.00
I-83	MD	I83-MD-1	34	19694	2.00	3.90
	PA	I83-PA-1	60	13654	2.00	2.10
I-84	OR	I84-OR-1	103	11076	3.00	3.00
		I84-OR-2	178	2193	3.00	3.00
		I84-OR-3	113	1897	3.00	3.00
	ID	I84-ID-1	114	7832	2.50	3.43
		I84-ID-2	162	2868	2.50	3.43
	UT	I84-UT-1	110	2223	2.00	2.74
	PA	I84-PA-1	54	5082	2.00	2.10
	NY	I84-NY-1	71	9663	2.00	2.10
	CT,MA	I84-CT-1	110	12695	2.50	2.30
I-85	AL	I85-AL-1	80	8742	3.00	2.50
	GA	I85-GA-1	59	8507	2.00	3.90
	GA	I85-GA-2	111	27007	2.00	3.90
	SC	I85-SC-1	149	12792	2.00	3.90
	NC	I85-NC-1	93	19200	2.00	3.90
	NC	I85-NC-2	155	9343	2.00	3.90
	VA	I85-VA-1	68	5268	2.00	3.90
I-90	WA	I90-WA-1	149	12226	3.00	3.00
		I90-WA-2	93	2646	3.00	3.00
		I90-WA-3	55	12294	3.00	3.00
	ID	I90-ID-1	68	3938	2.50	3.43
	MT	I90-MT-1	155	2807	2.00	2.74
		I90-MT-2	85	1726	2.00	2.74
		I90-MT-3	160	2543	2.00	2.74
		I90-MT-4	75	3614	2.00	2.74
		I90-MT-5	70	1188	2.00	2.74
	WY	I90-WY-1	135	1361	3.00	4.12
		I90-WY-2	74	1052	3.00	4.12

Table B.1: Summary of Traffic Values for Each Analysis Section (continued).

Route	State	Name	Length (Miles)	Initial Year AADTT	Baseline Growth Rate	Freight Trend Analysis Growth Rate
I-90	SD	I90-SD-1	151	2978	3.00	4.93
		I90-SD-2	160	1341	3.00	4.93
		I90-SD-3	102	2460	3.00	4.93
	MN	I90-MN-1	143	1670	2.00	3.29
		I90-MN-2	133	2528	2.00	3.29
	WI	I90-WI-1	185	8107	2.00	2.36
	IL	I90-IL-1	109	32168	2.00	2.36
	IN	I90-IN-1	156	6903	2.00	2.36
	OH	I90-OH-1	103	15227	1.50	1.77
		I90-OH-2	142	5353	1.50	1.77
	PA	I90-PA-1	46	6021	2.00	2.10
	NY	I90-NY-1	106	12435	2.00	2.10
		I90-NY-2	136	6986	2.00	2.10
		I90-NY-3	144	8299	2.00	2.10
	MA	I90-MA-1	136	15015	2.50	2.30
I-94	MT	I94-MT-1	119	888	2.00	2.74
		I94-MT-2	130	721	2.00	2.74
	ND	I94-ND-1	193	2094	3.00	4.93
		I94-ND-2	159	3214	3.00	4.93
	MN	I94-MN-1	115	3253	2.00	3.29
		I94-MN-2	143	13506	2.00	3.29
	WI	I94-WI-1	160	9234	2.00	2.36
		I94-WI-2	103	18067	2.00	2.36
	IL	I94-IL-1	59	26349	2.00	2.36
	IN	I94-IN-1	30	9338	2.00	2.36
	MI	I94-MI-1	74	8016	2.00	2.36
		I94-MI-2	112	9780	2.00	2.36
		I94-MI-3	98	22128	2.00	2.36
I-95	FL	I95-FL-1	76	42842	2.00	3.90
		I95-FL-2	130	11837	2.00	3.90
		I95-FL-3	177	17378	2.00	3.90
	GA	I95-GA-1	112	10922	2.00	3.90
	SC	I95-SC-1	82	8479	2.00	3.90
		I95-SC-2	117	6765	2.00	3.90
	NC	I95-NC-1	182	7543	2.00	3.90
	VA	I95-VA-1	101	14698	2.00	3.90
		I95-VA-2	73	33343	2.00	3.90
	MD, DE	I95-MD-1	47	29197	2.00	3.90
		I95-MD-2	60	20687	2.00	3.90
	PA	I95-PA-1	51	22727	2.00	2.10
	NJ, NY	I95-NJ-1	116	23074	2.00	2.10
	CT	I95-CT-1	111	19296	2.50	2.30
	RI	I95-RI-1	43	30404	2.50	2.30
	MA, NH	I95-MA-1	107	22344	2.50	2.30
	ME	I95-ME-1	156	4860	2.50	2.30
		I95-ME-2	148	2931	2.50	2.30

APPENDIX C

CLIMATE STATIONS BY SECTION

Table C.2: Summary of Climate Files Chosen by Analysis Section.

Route	State	Name	Length (Miles)	Climate Station
I-5	CA	I5-CA-1	85	San Diego
		I5-CA-2	189	Los Angeles
		I5-CA-3	194	Stockton
		I5-CA-4	132	Sacramento
		I5-CA-5	197	Redding
	OR	I5-OR-1	98	Medford, Sexton summit/Montagne CA-Siskiyou county airport/Klamath falls Klamath Falls airport/Roseburg OR-Roseburg regional airport/Mount Shasta CA
		I5-OR-2	169	Roseburg
		I5-OR-3	55	Portland
	WA	I5-WA-1	132	Portland
		I5-WA-2	46	Tacoma
		I5-WA-3	98	Seattle
I-10	CA	I10-CA-1	102	Los Angeles
		I10-CA-2	149	Blythe
	AZ	I10-AZ-1	137	Phoenix, Blythe
		I10-AZ-2	145	Phoenix
		I10-AZ -3	111	Tucson, Nogales, Safford, Douglas, Phoenix
	NM	I10-NM-1	164	Deming
	TX	I10-TX-1	141	El paso
		I10-TX-2	136	El paso
		I10-TX-3	161	Fort Stockton
		I10-TX-4	127	Fort Stockton
		I10-TX-5	46	San Antonio
		I10-TX-6	158	San Antonio
		I10-TX-7	113	Houston
	LA	I10-LA-1	154	lake Charles
		I10-LA-2	67	Baton Rouge
		I10-LA-3	53	Baton Rouge
	MS	I10-MS-1	77	Gulfport
	AL	I10-AL-1	66	Mobile
	FL	I10-FL-1	175	Crestview, Destin Walton beach airport
		I10-FL-2	188	Jacksonville
I-15	CA	I15-CA-1	111	Sandiego
		I15-CA-2	178	Las Vegas
	AZ, NV	I15-NV-1	154	Las Vegas
	UT	I15-UT-1	179	Cedar City
		I15-UT-2	115	Cedar City
		I15-UT-3	108	Salt Lake City
	ID	I15-ID-1	75	Pocatello
		I15-ID-2	122	Idaho Falls
	MT	I15-MT-1	199	Butte
		I15-MT-2	197	Great Falls

Table C.2: Summary of Climate Files Chosen by Analysis Section (continued).

Route	State	Name	Length (Miles)	Climate Station
I-20	TX	I20-TX-1	84	Odessa
		I20-TX-2	177	Midland
		I20-TX-3	165	Abilene
		I20-TX-4	101	Dallas
		I20-TX-5	109	McKinney
	LA	I20-LA-1	190	Shrevport
	MS	I20-MS-1	162	Jacksonville
	AL	I20-AL-1	150	Gainsville
		I20-AL-2	65	Birmingham
	GA	I20-GA-1	110	Atlantaa
		I20-GA-2	92	Augusta
	SC	I20-SC-1	142	Columbia
I-24	GA,TN	I24-GA-1	89	Nashville
	TN	I24-TN-1	91	Nashville
	KY,IL	I24-KY-1	131	Paducah
I-35	TX	I35-TX-1	151	Cotulla
		I35-TX-2	177	Fort Worth, Arlington TX-Arlington municipal airport
		I35-TX-3	77	Oklahoma City
		I35E-TX-1	96	Dallas
		I35W-TX1	85	Dallas
	OK	I35-OK-1	136	Oklahoma City
		I35-OK-2	107	Wichita
	KS	I35-KS-1	141	Olathe
		I35-KS-2	95	Kansas City
	MO	I35-MO-1	115	Des Moines
	IA	I35-IA-1	102	Des Moines
		I35-IA-2	116	Minneapolis
	MN	I35-MN-1	97	Duluth
		I35-MN-2	124	Duluth
		I35E-MN-1	136	St Paul, Minneapolis St Paul INTL ARPT
		I35W-MN2	127	Minneapolis
I-40	CA	I40-CA-1	155	Needles
	AZ	I40-AZ-1	146	Kingman, Needles, Las Vegas
		I40-AZ-2	112	Flagstaff
		I40-AZ-3	102	Winslow, Flagstaff
	NM	I40-NM-1	155	Gallup
		I40-NM-2	102	Albuquerque
		I40-NM-3	117	Albuquerque
	TX	I40-TX-1	67	Amarillo
		I40-TX-2	110	Amarillo
	OK	I40-OK-1	126	Oklahoma City
		I40-OK-2	94	Oklahoma City
		I40-OK-3	109	Muskogee

Table C.2: Summary of Climate Files Chosen by Analysis Section (continued).

Route	State	Name	Length (Miles)	Climate Station
I-40	AR	I40-AR-1	152	Fort Smith
		I40-AR-2	151	Little Rock
	TN	I40-TN-1	87	Memphis
		I40-TN-2	130	Nashville
		I40-TN-3	160	Knoxville, Oak ridge, Crossville, Asheville
		I40-TN-4	65	Knoxville, Oak ridge, Crossville, Asheville
	NC	I40-NC-1	162	Asheville
		I40-NC-2	98	Winston Salem
		I40-NC-3	162	Raleigh
I-44	TX,OK	I44-TX-1	150	Oklahoma City
	OK	I44-OK-1	191	Tulsa, Tulsa OK- Richard Lloyd Jones JR APT/Muskogee OK-Davis Field Airport
	MO	I44-MO-1	153	Springfield
	MO	I44-MO-2	137	St Louis
I-55	LA	I55-LA-1	66	New Orleans
	MS	I55-MS-1	103	Jacksonville
		I55-MS-2	186	Greenwood
	TN	I55-TN-1	82	Memphis
	MO	I55-MO-1	96	Poplar Bluff
		I55-MO-2	120	St Louis
	IL	I55-IL-1	156	Springfield, Decatur airport/Peoria Greater Peoria regional arpt
		I55-IL-2	138	Chicago
I-64	MO	I64-MO-1	140	St Louis
	IN	I64-IN-1	124	Evansville
	KY	I64-KY-1	64	Louisville
		I64-KY-2	119	Lexington
	WV	I64-WV-1	174	Huntington, Charleston, Jackson, Lancaster
	VA	I64-VA-1	132	Charlottesville
		I64-VA-2	167	Richmond
I-65	AL	I65-AL-1	181	Montgomery
		I65-AL-2	185	Birmingham
	TN	I65-TN-1	120	Nashville
	KY	I65-KY-1	138	Louisville
	IA	I65-IA-1	76	Indianapolis
		I65-IA-2	186	Lafayette, Indianapolis Eagle creek airpark arpt
I-69	IN	I69-IN-1	158	Fort Wayne
	MI	I69-MI-1	108	Lansing
	MI	I69-MI-2	107	Flint
I-70	UT	I70-UT-1	89	Price
		I70-UT-2	141	Price
	CO	I70-CO-1	91	Grand Junction
		I70-CO-2	184	Denver
		I70-CO-3	176	Burlington

Table C.2: Summary of Climate Files Chosen by Analysis Section (continued).

Route	State	Name	Length (Miles)	Climate Station
I-70	KS	I70-KS-1	189	Goodland
		I70-KS-2	167	Salina
		I70-KS-3	68	Topeka, Lawrence
	MO	I70-MO-1	148	Kansas City
		I70-MO-2	105	Columbia
	IL	I70-IL-1	138	Springfield, Decatur airport, Peoria
	IN	I70-IN-1	75	Terre Haute
		I70-IN-2	80	Indianapolis
	OH	I70-OH-1	129	Dayton
		I70-OH-2	111	Columbus
	PA	I70-PA-1	54	Harrisburg
		I70-PA-2	115	Harrisburg
	MD	I70-MD-1	93	Baltimore, Washington DC
I-75	FL	I75-FL-1	194	Miami
		I75-FL-2	180	Naples
		I75-FL-3	98	Gainsville
	GA	I75-GA-1	110	Valdosta, Alma
		I75-GA-2	92	Macon
		I75-GA-3	68	Atlanta
		I75-GA-4	86	Atlanta
	TN	I75-TN-1	142	Chattanooga
	KY	I75-KY-1	88	London
		I75-KY-2	85	Lexington
	OH	I75-OH-1	78	Cincinnati
		I75-OH-2	138	Toledo
	MI	I75-MI-1	132	Detroit
		I75-MI-2	87	Pontiac
		I75-MI-3	180	Gaylord
I-76	CO	I76-CO-1	66	Denver
	CO	I76-CO-2	121	Akron
	OH	I76-OH-1	82	Akron
	PA	I76-PA-1	190	Pittsburgh
I-77	SC	I77-SC-1	91	Columbia
	NC	I77-NC-1	105	Charlotte
	VA	I77-VA-1	67	Lynchburg
	WV	I77-WV-1	187	Charleston
	OH	I77-OH-1	160	Akron
I-78	PA	I78-PA-1	77	Harrisburg
	NJ	I78-NJ-1	72	Newark
I-80	CA	I80-CA-1	89	San Franciscco
		I80-CA-2	118	Sacramento
	NV	I80-NV-1	183	Reno
		I80-NV-2	123	Lovelock
		I80-NV-3	110	Elko

Table C.2: Summary of Climate Files Chosen by Analysis Section (continued).

Route	State	Name	Length (Miles)	Climate Station
I-80	UT	I80-UT-1	120	Salt Lake City
		I80-UT-2	73	Salt Lake City
	WY	I80-WY-1	173	Buffalo
		I80-WY-2	141	Rock Spring
		I80-WY-3	90	Cheyenne
	NE	I80-NE-1	178	Imperial
		I80-NE-2	134	Broken Bow, ORD Evelyn sharp field airport
		I80-NE-3	144	Lincoln
	IA	I80-IA-1	110	Des Moines
		I80-IA-2	179	Iowa City
	IL	I80-IL-1	163	Moline
	IN	I80-IN-1	69	South bend
		I80-IN-2	81	South bend
	OH	I80-OH-1	91	Toledo
		I80-OH-2	148	Cleveland
	PA	I80-PA-1	147	Harrisburg
		I80-PA-2	164	Mount Pocono
	NJ	I80-NJ-1	68	Newark
I-81	TN	I81-TN-1	76	Bristol, Asheville NC-Asheville regional airport
	VA	I81-VA-1	161	Lynchburg
	VA	I81-VA-2	144	Charlottesville
	WV,MD	I81-WV-1	38	Martinsburg
	PA	I81-PA-1	116	Harrisburg
	PA	I81-PA-2	117	Wilkes Barre
	NY	I81-NY-1	130	Binghamton, Elmira, Corning
	NY	I81-NY-2	59	Watertown
I-82	WA	I82-WA-1	144	Yakima, Ellensburg, Bowers Field airport
I-83	MD	I83-MD-1	34	Baltimore, Washington DC
	PA	I83-PA-1	60	Harrisburg
I-84	OR	I84-OR-1	103	Portland
		I84-OR-2	178	Hermiston
		I84-OR-3	113	Baker City
	ID	I84-ID-1	114	Boise
		I84-ID-2	162	Burley
	UT	I84-UT-1	110	Salt Lake City
	PA	I84-PA-1	54	Wilkes Barre
	NY	I84-NY-1	71	Newyork
	CT,MA	I84-CT-1	110	Hartford
I-85	AL	I85-AL-1	80	Montgomery
	GA	I85-GA-1	59	Columbus
	GA	I85-GA-2	111	Atlanta
	SC	I85-SC-1	149	Greenville
	NC	I85-NC-1	93	Charlotte
	NC	I85-NC-2	155	Chapel Hill
	VA	I85-VA-1	68	Richmond

Table C.2: Summary of Climate Files Chosen by Analysis Section (continued).

Route	State	Name	Length (Miles)	Climate Station
	WA	I90-WA-1	149	Seattle
		I90-WA-2	93	Ellensburg, Pangborn airport, Stampede Pass
		I90-WA-3	55	Spokane
	ID	I90-ID-1	68	Lewiston
	MT	I90-MT-1	155	Missoula
		I90-MT-2	85	Butte
		I90-MT-3	160	Billings
		I90-MT-4	75	Billings
		I90-MT-5	70	Miles City
	WY	I90-WY-1	135	Buffalo
		I90-WY-2	74	Gillette
	SD	I90-SD-1	151	Rapid city
		I90-SD-2	160	Pierre
		I90-SD-3	102	Sioux Falls
	MN	I90-MN-1	143	Minneapolis
		I90-MN-2	133	St Paul, Minneapolis st paul INTL ARPT
	WI	I90-WI-1	185	La crosse
	IL	I90-IL-1	109	Chicago
	IN	I90-IN-1	156	South bend
	OH	I90-OH-1	103	Toledo
		I90-OH-2	142	Cleveland
	PA	I90-PA-1	46	Erie
	NY	I90-NY-1	106	Buffalo
I-90		I90-NY-2	136	Syracuse
		I90-NY-3	144	Albany
	MA	I90-MA-1	136	Boston
I-94	MT	I94-MT-1	119	Miles City
		I94-MT-2	130	Miles City
	ND	I94-ND-1	193	Dickinson
		I94-ND-2	159	Fargo
	MN	I94-MN-1	115	Minneapolis
		I94-MN-2	143	St Paul, Minneapolis st paul INTL ARPT
	WI	I94-WI-1	160	Eau Claire
		I94-WI-2	103	Milwaukee
	IL	I94-IL-1	59	Chicago
	IN	I94-IN-1	30	South bend
	MI	I94-MI-1	74	Kalamazoo
		I94-MI-2	112	Jacksonville, Adrian Adrian Lenawee county ARPT
		I94-MI-3	98	Detroit
I-95	FL	I95-FL-1	76	Miami
		I95-FL-2	130	Daytona Beach
		I95-FL-3	177	Jacksonville
	GA	I95-GA-1	112	Savannah
	SC	I95-SC-1	82	Charleston
		I95-SC-2	117	Florence

Table C.2: Summary of Climate Files Chosen by Analysis Section (continued).

Route	State	Name	Length (Miles)	Climate Station
I-95	NC	I95-NC-1	182	Fayetteville
	VA	I95-VA-1	101	Richmond
		I95-VA-2	73	Richmond
	MD, DE	I95-MD-1	47	Baltimore, Washington DC
		I95-MD-2	60	Baltimore, Washington DC
	PA	I95-PA-1	51	Philadelphia
	NJ, NY	I95-NJ-1	116	Trenton, Doylestown PA, Doylestown airport
	CT	I95-CT-1	111	Bridgeport
	RI	I95-RI-1	43	Providence
	MA, NH	I95-MA-1	107	Boston
	ME	I95-ME-1	156	Portland
		I95-ME-2	148	Banger

APPENDIX D

ASPHALT BINDER GRADE BY SECTION

Table D.3: Summary of Asphalt Grade Used for Each Analysis Section.

Route	State	Name	Length (Miles)	PCC Properties	AC Properties
I-5	CA	I5-CA-1	85	4340	-
		I5-CA-2	189	2975	AR-4000
		I5-CA-3	194	3240	PG 70-10
		I5-CA-4	132	3650	PG 70-10
		I5-CA-5	197	3650	AR-4000
	OR	I5-OR-1	98	5224	AR-4000
		I5-OR-2	169	5224	AR-4000
		I5-OR-3	55	5224	AR-4000
	WA	I5-WA-1	132	4268	-
		I5-WA-2	46	4268	-
		I5-WA-3	98	4700	-
I-10	CA	I10-CA-1	102	-	AR-4000
		I10-CA-2	149	-	PG 76-10
	AZ	I10-AZ-1	137	-	AC-40
		I10-AZ-2	145	4105	-
		I10-AZ -3	111	-	AR-4000
	NM	I10-NM-1	164	-	AC-20
	TX	I10-TX-1	141	5668	AC-10
		I10-TX-2	136	5668	PG 70-10
		I10-TX-3	161	-	AC-10
		I10-TX-4	127	-	PG 76-10
		I10-TX-5	46	-	PG 76-10
		I10-TX-6	158	5668	PG 76-22
		I10-TX-7	113	5668	PG 70-10
	LA	I10-LA-1	154	-	PG 70-10
		I10-LA-2	67	6280	-
		I10-LA-3	53	-	PG 70-10
	MS	I10-MS-1	77	5139	-
	AL	I10-AL-1	66	-	PG 70-10
	FL	I10-FL-1	175	-	AC-20
		I10-FL-2	188	-	PG 70-10
I-15	CA	I15-CA-1	111	2975	-
		I15-CA-2	178	2975	-
	AZ, NV	I15-NV-1	154	4500	-
	UT	I15-UT-1	179	4138	-
		I15-UT-2	115	4991	-
		I15-UT-3	108	4560	-
	ID	I15-ID-1	75	4130	PG 64-22
		I15-ID-2	122	-	85-100 pen
	MT	I15-MT-1	199	-	PG 64-28
		I15-MT-2	197	-	PG 64-28
I-20	TX	I20-TX-1	84	5668	-
		I20-TX-2	177	-	AC-20
		I20-TX-3	165	5668	AC-20
		I20-TX-4	101	-	AC-20
		I20-TX-5	109	-	AC-20

Table D.3: Summary of Asphalt Grade Used for Each Analysis Section (continued).

Route	State	Name	Length (Miles)	PCC Properties	AC Properties
	LA	I20-LA-1	190	-	PG 70-10
	MS	I20-MS-1	162	5889	AC-40
	AL	I20-AL-1	150	-	AC-20
		I20-AL-2	65	2625	-
	GA	I20-GA-1	110	5774	-
		I20-GA-2	92	5774	-
	SC	I20-SC-1	142	5204	-
I-24	GA,TN	I24-GA-1	89	-	AC-20
	TN	I24-TN-1	91	-	AC-20
	KY,IL	I24-KY-1	131	-	AC-20
I-35	TX	I35-TX-1	151	5668	PG 76-10
		I35-TX-2	177	5668	PG 76-10
		I35-TX-3	77	5668	AC-10
		I35E-TX-1	96	5668	AC-20
		I35W-TX1	85	5668	PG 76 - 22
	OK	I35-OK-1	136	5245	-
		I35-OK-2	107	5245	-
	KS	I35-KS-1	141	4500	PG 70-16
		I35-KS-2	95	4500	PG 70-16
	MO	I35-MO-1	115	4510	PG 64-22
	IA	I35-IA-1	102	4719	-
		I35-IA-2	116	4803	AC-20
	MN	I35-MN-1	97	5682	-
		I35-MN-2	124	5682	-
		I35E-MN-1	136	5682	-
		I35W-MN2	127	5682	-
I-40	CA	I40-CA-1	155	-	PG 70-10
	AZ	I40-AZ-1	146	-	AR-2000
		I40-AZ-2	112	4105	-
		I40-AZ-3	102	-	PG 70-16
	NM	I40-NM-1	155	-	85-100 pen
		I40-NM-2	102	-	PG 64-16
		I40-NM-3	117	-	120-150 pen
	TX	I40-TX-1	67	-	AC-10
		I40-TX-2	110	3939	-
	OK	I40-OK-1	126	5192	-
		I40-OK-2	94	5192	-
		I40-OK-3	109	5192	-
	AR	I40-AR-1	152	4015	-
		I40-AR-2	151	4490	-
	TN	I40-TN-1	87	4200	PG 70-10
		I40-TN-2	130	4200	PG 70-16
		I40-TN-3	160	-	85-100 pen
		I40-TN-4	65	-	PG 70-16
	NC	I40-NC-1	162	-	AC-20
		I40-NC-2	98	-	AC-20
		I40-NC-3	162	-	AC-20

Table D.3: Summary of Asphalt Grade Used for Each Analysis Section (continued).

Route	State	Name	Length (Miles)	PCC Properties	AC Properties
I-44	TX,OK	I44-TX-1	150	5668	-
	OK	I44-OK-1	191	5192	-
	MO	I44-MO-1	153	5078	60-70 pen
	MO	I44-MO-2	137	-	AC-20
I-55	LA	I55-LA-1	66	6280	-
	MS	I55-MS-1	103	3148	-
		I55-MS-2	186	-	AC-20
	TN	I55-TN-1	82	-	AC-20
	MO	I55-MO-1	96	-	AC 70-85
		I55-MO-2	120	-	AC 70-85
	IL	I55-IL-1	156	-	70-85 PEN
		I55-IL-2	138	-	AC-20
I-64	MO	I64-MO-1	140	4510	AC-20
	IN	I64-IN-1	124	-	AC-20
	KY	I64-KY-1	64	4878	-
		I64-KY-2	119	-	AC-20
	WV	I64-WV-1	174	4200	AC-20
	VA	I64-VA-1	132	4200	-
		I64-VA-2	167	-	AC-20
I-65	AL	I65-AL-1	181	-	70-85 PEN
		I65-AL-2	185	-	AC-20
	TN	I65-TN-1	120	-	AC-20
	KY	I65-KY-1	138	4878	-
	IA	I65-IA-1	76	4460	AC-20
		I65-IA-2	186	4460	AC-20
I-69	IN	I69-IN-1	158	4460	AC-20
	MI	I69-MI-1	108	-	85-100 pen
	MI	I69-MI-2	107	-	85-100 pen
I-70	UT	I70-UT-1	89	4800	-
		I70-UT-2	141	4800	-
	CO	I70-CO-1	91	-	AC-10
		I70-CO-2	184	-	AC-10
		I70-CO-3	176	-	AC-10
	KS	I70-KS-1	189	4500	PG 70-16
		I70-KS-2	167	4500	PG 70-16
		I70-KS-3	68	4500	PG 70-16
	MO	I70-MO-1	148	4510	AC-20
		I70-MO-2	105	4755	-
	IL	I70-IL-1	138	-	70-85 PEN
	IN	I70-IN-1	75	4460	AC-20
		I70-IN-2	80	4460	AC-20
	OH, WV	I70-OH-1	129	4270	-
		I70-OH-2	111	4270	-
	PA	I70-PA-1	54	-	AC-20
		I70-PA-2	115	-	AC-20
	MD	I70-MD-1	93	-	85-100 pen

Table D.3: Summary of Asphalt Grade Used for Each Analysis Section (continued).

Route	State	Name	Length (Miles)	PCC Properties	AC Properties
I-75	FL	I75-FL-1	194	-	AC-20
		I75-FL-2	180	5063	-
		I75-FL-3	98	5063	-
	GA	I75-GA-1	110	5774	-
		I75-GA-2	92	5774	-
		I75-GA-3	68	5774	-
		I75-GA-4	86	-	AC-20
	TN	I75-TN-1	142	-	AC-20
	KY	I75-KY-1	88	-	AC-20
		I75-KY-2	85	-	AC-20
	OH	I75-OH-1	78	4270	-
		I75-OH-2	138	4695	AC-20
	MI	I75-MI-1	132	3500	-
		I75-MI-2	87	3500	85-100 pen
		I75-MI-3	180	-	85-100 pen
I-76	CO	I76-CO-1	66	4200	-
	CO	I76-CO-2	121	-	85-100 pen
	OH	I76-OH-1	82	4270	-
	PA	I76-PA-1	190	3750	-
I-77	SC	I77-SC-1	91	5204	-
	NC	I77-NC-1	105	3838	AC-20
	VA	I77-VA-1	67	-	AC-20
	WV	I77-WV-1	187	4200	AC-20
	OH	I77-OH-1	160	4270	-
I-78	PA	I78-PA-1	77	3750	AC-20
	NJ	I78-NJ-1	72	-	AC-20
I-80	CA	I80-CA-1	89	3240	-
		I80-CA-2	118	3240	-
	NV	I80-NV-1	183	-	AC-20
		I80-NV-2	123	-	AC-20
		I80-NV-3	110	4500	-
	UT	I80-UT-1	120	4800	-
		I80-UT-2	73	4800	-
	WY	I80-WY-1	173	4587	-
		I80-WY-2	141	-	AC-20
		I80-WY-3	90	-	AC-20
	NE	I80-NE-1	178	5440	AC-10
		I80-NE-2	134	5592	AC-10
		I80-NE-3	144	5051	AC-10
	IA	I80-IA-1	110	4276	-
		I80-IA-2	179	5757	AC-20
	IL	I80-IL-1	163	4460	AC-20
	IN	I80-IN-1	69	4460	AC-20
		I80-IN-2	81	4460	AC-20
	OH	I80-OH-1	91	4695	AC-20
		I80-OH-2	148	4695	AC-20

Table D.3: Summary of Asphalt Grade Used for Each Analysis Section (continued).

Route	State	Name	Length (Miles)	PCC Properties	AC Properties
	PA	I80-PA-1	147	3750	AC-20
		I80-PA-2	164	4200	-
	NJ	I80-NJ-1	68	-	AC-20
I-81	TN	I81-TN-1	76	-	AC-20
	VA	I81-VA-1	161	-	PG 70-22
	VA	I81-VA-2	144	-	PG 70-22
	WV,MD	I81-WV-1	38	4200	AC-20
	PA	I81-PA-1	116	3750	-
	PA	I81-PA-2	117	3750	-
	NY	I81-NY-1	130	-	AC-20
	NY	I81-NY-2	59	-	AC-20
I-82	WA	I82-WA-1	144	4700	-
I-83	MD	I83-MD-1	34	3500	-
	PA	I83-PA-1	60	3750	AC-20
I-84	OR	I84-OR-1	103	4520	AR-20
		I84-OR-2	178	4934	-
		I84-OR-3	113	4340	AR-20
	ID	I84-ID-1	114	4130	-
		I84-ID-2	162	-	PG 70-28
	UT	I84-UT-1	110	-	AC-20
	PA	I84-PA-1	54	3750	-
	NY	I84-NY-1	71	-	AC-20
	CT,MA	I84-CT-1	110	4200	-
I-85	AL	I85-AL-1	80	-	AC 20
	GA	I85-GA-1	59	-	AC-20
	GA	I85-GA-2	111	-	AC-20
	SC	I85-SC-1	149	5204	-
	NC	I85-NC-1	93	-	AC-20
	NC	I85-NC-2	155	4626	AC-20
	VA	I85-VA-1	68	-	AC-20
I-90	WA	I90-WA-1	149	-	PG64-28
		I90-WA-2	93	-	PG64-28
		I90-WA-3	55	-	PG64-28
	ID	I90-ID-1	68	-	85-100 pen
	MT	I90-MT-1	155	-	PG 70-28
		I90-MT-2	85	-	PG 70-28
		I90-MT-3	160	-	PG 70-28
		I90-MT-4	75	-	AC-30
		I90-MT-5	70	-	AC-30
	WY	I90-WY-1	135	-	AC-20
		I90-WY-2	74	-	AC-20
	SD	I90-SD-1	151	5416	-
		I90-SD-2	160	5665	-
		I90-SD-3	102	5771	-
	MN	I90-MN-1	143	4926	PG 64-28
		I90-MN-2	133	4926	-

Table D.3: Summary of Asphalt Grade Used for Each Analysis Section (continued).

Route	State	Name	Length (Miles)	PCC Properties	AC Properties
I-90	WI	I90-WI-1	185	4030	PG 64-28
	IL	I90-IL-1	109	4460	PG 76-22
	IN	I90-IN-1	156	4460	AC-20
	OH	I90-OH-1	103	4695	AC-20
		I90-OH-2	142	4695	AC-20
	PA	I90-PA-1	46	4200	-
	NY	I90-NY-1	106	-	AC-20
	NY	I90-NY-2	136	-	AC-20
		I90-NY-3	144	-	AC-20
	MA	I90-MA-1	136	-	AC-20
I-94	MT	I94-MT-1	119	-	120-150 pen
		I94-MT-2	130	-	120-150 pen
	ND	I94-ND-1	193	4466	-
		I94-ND-2	159	4466	-
	MN	I94-MN-1	115	4926	-
		I94-MN-2	143	-	120-150 pen
	WI	I94-WI-1	160	4030	-
		I94-WI-2	103	5190	PG 64-28
	IL	I94-IL-1	59	4460	PG 76-22
	IN	I94-IN-1	30	4460	AC-20
	MI	I94-MI-1	74	3500	-
		I94-MI-2	112	3500	-
		I94-MI-3	98	3500	-
I-95	FL	I95-FL-1	76	-	AC-20
		I95-FL-2	130	-	AC-30
		I95-FL-3	177	-	AC-20
	GA	I95-GA-1	112	-	AC-20
	SC	I95-SC-1	82	5204	-
		I95-SC-2	117	5204	-
	NC	I95-NC-1	182	3838	AC-20
	VA	I95-VA-1	101	-	PG-76-22
		I95-VA-2	73	-	PG-76-22
	MD, DE	I95-MD-1	47	3500	-
		I95-MD-2	60	-	85-100 pen
	PA	I95-PA-1	51	4200	-
	NJ, NY	I95-NJ-1	116	4500	-
	CT	I95-CT-1	111	-	AC-20
	RI	I95-RI-1	43	4200	120-150 pen
	MA, NH	I95-MA-1	107	-	AC-20
	ME	I95-ME-1	156	-	AC-20
		I95-ME-2	148	-	AC-20

APPENDIX E

PAVEMENT STRUCTURE BY SECTION

Table E.4: Summary of Structure Used for Each Analysis Section.

Route	Name	Structural Section
I-5	I5-CA-1	Available: PCC 8.5", Bound Base 3.3", Unbound subbase 6", Subgrade
I-5	I5-CA-2	Available: ACOverlay 4.10"PCC 8.9", Bound treated base 4.6", Unbound granular base 35", Subgrade
I-5	I5-CA-3	AV Nearby: PCC 15", Bound treated base 3.4", unbound granular base 13.9", Subgrade
I-5	I5-CA-4	Old: (2004): AC Overlay 4.6", PCC 8.4", Bound treated base 4.6", Subgrade
I-5	I5-CA-5	Old: (2004): AC Overlay 4.6", PCC 8.4", Bound treated base 4.6", Subgrade
I-5	I5-OR-1	Old :AC layer 2.1", PCC 7.6", Unbound granular base 6.4", Subgrade
I-5	I5-OR-2	Old: AC layer: 4.4", PCC 7.8", Subgrade
I-5	I5-OR-3	Old: AC Layer 5", PCC 7.7", Unbound granular base 10.6", Subgrade
I-5	I5-WA-1	Old: PCC 8.5", Unbound granular base 2.8", Unbound granular subbase 4.2", Subgrade
I-5	I5-WA-2	Old: PCC 8.5", Unbound granular base 2.8", Unbound granular subbase 4.2", Subgrade
I-5	I5-WA-3	PCC 9.6", Unbound granular base 14", Subgrade
I-10	I10-CA-1	Available: AC layer 5.4", Bound treated base 6", Unbound Granular Base 8" Subgrade
I-10	I10-CA-2	Available: AC layer 5.4", Bound treated base 6", Unbound Granular Base 8" Subgrade
I-10	I10-AZ-1	Old: AC Layer: 13.9", Unbound granular base 6", Subgrade
I-10	I10-AZ-2	Old: PCC 9.7", Bound treated base 5.2", Subgrade
I-10	I10-AZ -3	Old: AC Layer: 8", Unbound granular base 11.4", Subgrade
I-10	I10-NM-1	Old: AC Layer: 7", Unbound granular base 12.7", Subgrade
I-10	I10-TX-1	Old,Nearby: PCC 8.4", Bound treated base 2", Unbound granular subbase 3.9", Subgrade
I-10	I10-TX-2	Old,Nearby: PCC 8.4", Bound treated base 2", Unbound granular subbase 3.9", Subgrade
I-10	I10-TX-3	Old: AC Layer 4.5", Unbound granular base 16.5", Subgrade
I-10	I10-TX-4	Old: AC Layer 4.5", Unbound granular base 16.5", Subgrade
I-10	I10-TX-5	Old: AC Layer 4.5", Unbound granular base 16.5", Subgrade
I-10	I10-TX-6	Old: AC Layer: 3.7", PCC 8.2", Bound treated base 4.4", Bound treated subbase 6", Subgrade
I-10	I10-TX-7	Old: AC Layer: 3.7", PCC 8.2", Bound treated base 4.4", Bound treated subbase 6", Subgrade
I-10	I10-LA-1	AC Layer 4.9", UG Base 8", Bound treated base 6", UG subbase 12", Subgrade
I-10	I10-LA-2	Old: PCC 12", Bound treated base 3.3", Bound treated subbase 6.3", Unbound granular subbase 2", Subgrade
I-10	I10-LA-3	AC Layer 4.9", UG Base 8", Bound treated base 6", UG subbase 12", Subgrade
I-10	I10-MS-1	Old: PCC 8.1", Bound treated base 4.1", Unbound granular subbase 6.9", Subgrade
I-10	I10-AL-1	Old: AC Layer: 7.4", PCC 8.2", UG Subbase 6", Bound treated base 5.4", UB Granular subbase 6", Bound treated subbase 6", Subgrade
I-10	I10-FL-1	Old: AC layer 7.7", Bound treated base 6.3", Bound treated subbase 6.3", Subgrade
I-10	I10-FL-2	Old: AC Layer 7.6", Unbound granular base 12.8", Unbound granular subbase 37.8", Subgrade
I-15	I15-CA-1	Old (2002): PCC 8.8", Bound treated base 5.3", Granualar subbase 7.4", Subgrade
I-15	I15-CA-2	Old (2002): PCC 8.8", Bound treated base 5.3", Granualar subbase 7.4", Subgrade
I-15	I15-NV-1	Old: PCC 11", Bound treated base 5", UBD subbase 29.8", Subgrade
I-15	I15-UT-1	Old: PCC 9.4", Bound treated base 4.8", Unbound granular subbase 14.2", Subgrade
I-15	I15-UT-2	Old: PCC 10.2", Bound treated base 4", Unbound granular base 3.2", Subgrade

Table E.4: Summary of Structure Used for Each Analysis Section (continued).

Route	Name	Structural Section
I-15	I15-UT-3	Old: PCC 9.8", Bound treated base 4.2", Unbound granular subbase 4", Unbound granular subbase 18", Subgrade
	I15-ID-1	Old: AC overlay: 5", PCC 8.3", Bound treated base 4", Unbound granular subbase 6.6", Subgrade
	I15-ID-2	AC Layer: 10.9", Unbound granular base 5.4", Subgrade
	I15-MT-1	AC Layer 6", Unbound granular base 8.4", Subgrade
	I15-MT-2	AC Layer 6", Unbound granular base 8.4", Subgrade
I-20	I20-TX-1	Old: PCC 6.2", Bound treated base 4.1", Subgrade
	I20-TX-2	Old: AC Layer: 12", Bound treated base 6.8", UG subbase 8.8", Subgrade
	I20-TX-3	AC Layer: 5", PCC 8.3", Bound treateed base 3.7", Bound treated subbase 9.5", Subgrade
	I20-TX-4	Nearby old: AC Layer9.5", Bound treated base 21.7", Subgrade
	I20-TX-5	AC Layer 9", UG Base 7.2", Subgrade
	I20-LA-1	AC Layer 4.9", UG Base 8", Bound treated base 6", UG subbase 12", Subgrade
	I20-MS-1	Old: PCC 10.3", AC Layer5.3", PCC 8.3", Boudtreated base 6.7", Bound treated subbase 5.9", Subgrade
	I20-AL-1	Old: AC Layer: 7.4", PCC 8.2", UG Subbase 6", Bound treated base 5.4", UB Granular subbase 6", Bound treated subbase 6", Subgrade
	I20-AL-2	Old: PCC 9.3", bound treated base 6.1", UG subbase 7.8", Subgrade
	I20-GA-1	Old: PCC 11.1", Bound treated base 1.4", UG subbase 5", Subgrade
	I20-GA-2	Old: PCC 9.9", Bound treated base 6.1", Subgrade
	I20-SC-1	PCC 8.3", Bound treated base 4.8", Subgrade
I-24	I24-GA-1	Old: AC Layer 5", Bound treated base 8.9", Bound treated subbase 4", Unbound granular subbase 6.1", Subgrade
	I24-TN-1	AC Layer: 14", Bound base 4.5", Subgrade
	I24-KY-1	Old: AC Layer 7.7", Unbound granular base 14", Subgrade
I-35	I35-TX-1	Old: PCC 10.4", AC layer 3.1", PCC 9.8", Subgrade
	I35-TX-2	Old: PCC 10.4", AC layer 3.1", PCC 9.8", Subgrade
	I35-TX-3	Old: PCC 10.4", AC layer 3.1", PCC 9.8", Subgrade
	I35E-TX-1	Old: PCC 10.3", AC Layer 1.4", PCC 9.9", Unbound granular base 7.8", Subgrade
	I35W-TX1	Old: AC Layer 2.3", PCC 8.3", Bound treated base 3.6", Bound treated subbase 6.1", Subgrade
	I35-OK-1	Old: PCC 9", Unbound granular base 14.8", Subgrade
	I35-OK-2	Old: PCC 9", Unbound granular base 14.8", Subgrade
	I35-KS-1	Old: AC Layer 4", PCC 9", UG base 4", Bound subbase 4.7", Subgrade
	I35-KS-2	Old: AC Layer 4", PCC 9", UG base 4", Bound subbase 4.7", Subgrade
	I35-MO-1	Pold: AC Layer 4.5", PCC 9.3", Unbound granular 4.2", Subgrade
	I35-IA-1	Old: PCC 7.4", Unbound granular base 4.5", Unbound granular subbase 24", Subgrade
	I35-IA-2	Old: AC Layer 5.1", PCC 7.8", Bound treated base 4.8", Subgrade
	I35-MN-1	Old: PCC 9.3", Unbound granular base 7.2", Subgrade
	I35-MN-2	Old: PCC 10", unbound granular base 3.6", Subgrade
	I35E-MN-1	Old: PCC 9.3", UG Base 7.2", Subgrade
	I35W-MN2	Old: PCC 10", UG base 3.6", Subgrade

Table E.4: Summary of Structure Used for Each Analysis Section (continued).

Route	Name	Structural Section
I-40	I40-CA-1	Old: AC Layer: 7", Bound treated base 5", Unbound granular subbase 16.6", SG
	I40-AZ-1	Old: AC Layer: 9.8", Unbound granular base 8.4", Subgrade
	I40-AZ-2	PCC 8", Bound treated base 3.6", Unbound granular subbase 30", Subgrade
	I40-AZ-3	Old: AC Layer: 9.8", Unbound granular base 8.4", Subgrade
	I40-NM-1	Old: AC Layer 8.2", Unbound granular base 5.9", Bound treated base 6", Subgrade
	I40-NM-2	AC Layer 8.2", Unbound granular base 5.9", Bound treated base 6", Subgrade
	I40-NM-3	Old: AC Layer: 10.1", Bound treated base 6.4", Unbound granular subbase 19", Subgrade
	I40-TX-1	Old: AC Layer 9", Unbound granular base 4.8", Subgrade
	I40-TX-2	Old: PCC 9.3", Bound treated base 6.1", Bound treated subbase 7.8", Subgrade
	I40-OK-1	Old: PCC 8.9", Bound treated base 3.6", Bound treated subbase 6.1", Subgrade
	I40-OK-2	Old: PCC 8.9", Bound treated base 3.6", Bound treated subbase 6.1", Subgrade
	I40-OK-3	Old: PCC 8.9", Bound treated base 3.6", Bound treated subbase 6.1", Subgrade
	I40-AR-1	Old: PCC 9.3", Bound treated base 8.3", Subgrade
	I40-AR-2	Old: PCC 10.1", Bound treated base 6.1", Subgrade
	I40-TN-1	Old: AC Layer 9.3", PCC 9", Bound treated base 6.6", Subgrade
	I40-TN-2	Old: AC Layer 9.3", PCC 9", Bound treated base 6.6", Subgrade
	I40-TN-3	Old: AC layer 6.7", Bound treated base 6.2", Unbound granular subbase 6.9", Subgrade
	I40-TN-4	Old: AC layer 6.7", Bound treated base 6.2", Unbound granular subbase 6.9", Subgrade
	I40-NC-1	AC Layer:11.9", Unbound granular base 12", Subgrade
	I40-NC-2	Nearby,old: AC Layer 10.9", Unbound granular base 12", Subgrade
	I40-NC-3	Old: AC Layer 10.8", Unbound granular base 9.4", Subgrade
I-44	I44-TX-1	Old: PCC 9", Bound treated base 2.9", Subgrade
	I44-OK-1	Old: PCC 8.9", Bound treated base 3.6", Bound treated subbase 6.1", Subgrade
	I44-MO-1	Old: AC Layer:6.8", PCC layer 10.1", UG base 4", Subgrade
	I44-MO-2	Old: AC Layer 18", UG Base 4.2", Subgrade
I-55	I55-LA-1	Nearby: PCC 9.8", Bound trteated base 6.7", UG Subbase 3.4", Subgrade
	I55-MS-1	Old: PCC 8.2", Bound treated base 4.3", UG subbase 6.8", Subgrade
	I55-MS-2	Old: AC Layer:14", UG Base 20.5", Bound treated subbase 6", Subgrade
	I55-TN-1	AC Layer: 14", Bound base 4.5", Subgrade
	I55-MO-1	Old: AC Layer: 7.3", Bound tretaed base 5", Subgrade
	I55-MO-2	Old: AC Layer: 7.3", Bound tretaed base 5", Subgrade
	I55-IL-1	Old: AC Layer:7", UG Base 8", UG subbase 6", Subgrade
	I55-IL-2	Old: AC layer:3", PCC 10.7", UG Base 5.9", Subgrade
I-64	I64-MO-1	AC Layer 5.2", PCC 8.4", Bound treated base 4.3", Subgrade
	I64-IN-1	AC Layer 21", Subgrade
	I64-KY-1	Old: PCC 9.8", UG base 6", Subgrade
	I64-KY-2	Old: AC Layer 3.2", UG base 14", Subgrade
	I64-WV-1	AC Layer 6", PCC 10.2", UG Base 9", Subgrade
	I64-VA-1	PCC 8.3", Bound treated base 6", Subgrade
	I64-VA-2	Old: AC layer 8.5", UG Base 5.1", Bound treated subbase 5.4", Subgrade
I-65	I65-AL-1	AC Layer: 12.3", Bound treated base 1.9", UG subbase 4.8", Subgrade
	I65-AL-2	AC Layer 13.1", UG Base 18.4", Subgrade
	I65-TN-1	Old: AC Layer 7", Bound treated base 4.3", UG Subbase 4.5", Subgrade

Table E.4: Summary of Structure Used for Each Analysis Section (continued).

Route	Name	Structural Section
	I65-KY-1	PCC 11.8", UG Base 4", Bound treated subbase 12.8", subgrade
	I65-IA-1	AC Layer: 3.4", PCC 9.8", Bound treated base 4", UG subbase 4.6", Subgrade
	I65-IA-2	AC Layer: 3.4", PCC 9.8", Bound treated base 4", UG subbase 4.6", Subgrade
I-69	I69-IN-1	Old: PCC 10.2", AC Layer 4.9", PCC 10.2", UG Base 6", Subgrade
	I69-MI-1	Old nearby: AC Layer6.5",Bound treated base 9.3", Subgrade
	I69-MI-2	Old nearby: AC Layer6.5",Bound treated base 9.3", Subgrade
I-70	I70-UT-1	Old: PCC 10.2", Bound treated base 4.4", Unbound granular subbase 14", sg
	I70-UT-2	Old: PCC 10.2", Bound treated base 4.4", Unbound granular subbase 14", sg
	I70-CO-1	Old: AC layer: 9.7", Unbound granular base: 5.9", Unbound granular subbase: 16.3", Subgrade
	I70-CO-2	Old: AC Layer: 13.3", Bound treated base 3.7". Subgrade
	I70-CO-3	Old: AC Layer: 13.3", Bound treated base 3.7". Subgrade
	I70-KS-1	Old: AC Layer 6.1", PCC Layer 9", Unbound granular layer 4", Subgrade
	I70-KS-2	Old: AC Layer 6.1", PCC Layer 9", Unbound granular layer 4", Subgrade
	I70-KS-3	Old: PCC 10.4", Bound treated base 6", Bound treated subbase 6", Subgrade
	I70-MO-1	Old: AC Layer 4.1", PCC 7.9", Unbound granular base 4.1", Subgrade
	I70-MO-2	Nearby, Old: PCC 8.3", Unbound base 3.5", Subgrade
	I70-IL-1	Old: Nearby: AC Layer 7", UG Base 8", UG Subbase 6", Subgrade
	I70-IN-1	AC Layer: 3.4", PCC 9.8", Bound treated base 4", UG subbase 4.6", Subgrade
	I70-IN-2	Old: AC Layer 6.8", PCC layer 10.1", Unbound subbase 8', Subgrade
	I70-OH-1	Old: PCC 9.2", Unbound granular base 6.1", Subgrade
	I70-OH-2	Old: PCC 9.2", Unbound granular base 6.1", Subgrade
	I70-PA-1	Old: AC Layer 5", Unbound granular base 10.5", Subgrade
	I70-PA-2	Old: AC Layer 5", Unbound granular base 10.5", Subgrade
	I70-MD-1	Old: AC Layer11.2", Bound treated base 5.3", Unbound granular base 6", sg
I-75	I75-FL-1	Old: AC Layer 3.6", Unbound granular base 10.9", Unbound granular subbase 10.8", Subgrade
	I75-FL-2	Old: PCC 13.2", Unbound granular base 7.8", Subgrade
	I75-FL-3	Old: PCC 13.2", Unbound granular base 7.8", Subgrade
	I75-GA-1	Av: PCC 10", Bound treated base 5.4", Subgrade
	I75-GA-2	Av: PCC 10", Bound treated base 5.4", Subgrade
	I75-GA-3	Old: PCC 8.4", PCC 7.8", Subgrade
	I75-GA-4	Old: AC Layer 8.3", Bound treated base 11.8", Unbound granular subbase 13, Subgrade
	I75-TN-1	AC Layer 8.2", Bound treated base 6.7", Unbound granular subbase 6.1", sg
	I75-KY-1	Old: AC Layer 7.7", Unbound granular base 14", Subgrade
	I75-KY-2	Old: AC Layer 7.7", Unbound granular base 14", Subgrade
	I75-OH-1	Old: PCC 10.3", Bound treated base 3.6", Subgrade
	I75-OH-2	Old: AC Layer 4.7", PCC layer 9", Unbound granular base 6", Subgrade
	I75-MI-1	Old nearby: PCC Layer 10", Unbound granular base 2.8", Unbound granular subbase 11.5", Subgrade
	I75-MI-2	Old: AC Layer 5.5", PCC 9.2", Unbound granular base 6", Unbound granular subbase 13.5", Subgrade
	I75-MI-3	Old: AC Layer 4.6", Unbound granualr base 12.4", Unbound granular subbase 13.8", Subgrade
I-76	I76-CO-1	PCC 7.6", Bound treated base 6.2", Subgrade
	I76-CO-2	Old: AC Layer 4.2", Bound treated base 4.6", UG subbase 19.5", Subgrade

Table E.4: Summary of Structure Used for Each Analysis Section (continued).

Route	Name	Structural Section
I-76	I76-OH-1	PCC 10.8", UG base 6.2", Subgrade
	I76-PA-1	Old: PCC 9.4", UG subbase 10.8", Subgrade
I-77	I77-SC-1	Old: PCC 8.9", Bound treated base 5.9", Subgrade
	I77-NC-1	Old: AC Layer 4.1", PCC 8", Bound treated base 1.8", UG Subbase 3.6", sg
	I77-VA-1	Old: AC Layer 3", Bound treated base 6.2", UG subbase 3.6", Subgrade
	I77-WV-1	AC Layer 6", PCC 10.2", UG Base 9", Subgrade
	I77-OH-1	PCC 10.8", UG base 6.2", Subgrade
I-78	I78-PA-1	AC Layer 3.7", PCC 20.2"", UG Base 6.5", Subgrade
	I78-NJ-1	Old: AC Layer: 5.7", Bound treated base 6.7", UG subbase 10", Subgrade
I-80	I80-CA-1	Available: PCC 15", Bound treated base 3.4", unbound granular base 13.9", Subgrade
	I80-CA-2	Av old: PCC 15", bound treated base 3.2", Unbound granular base 11.6", Subgrade
	I80-NV-1	Available: AC layer 7", Bound treated base 4.5", Unbound granular base 7.7", Unbound granular subbase 17.1", Bound treated subbase 12", Subgrade
	I80-NV-2	Old: AC Layer 4.3", Unbound granular base 11.7", Unbound granular subbase 21.4", Bound treated subbase 12", Subgrade
	I80-NV-3	Old: PCC 8.3", Bound treated base 3.6", Unbound granular subbase 1.8", Subgrade
	I80-UT-1	Old: PCC 10.2", Bound treated base 4.4", Unbound granular subbase 14", Subgrade
	I80-UT-2	PCC 10.2", Bound treated base 4.4", Unbound granular subbase 14", Subgrade
	I80-WY-1	Old: PCC 10.6", Unbound granular base 6.6", Subgrade
	I80-WY-2	Old: AC Layer 3.7", Bound treated base 16.4", Subgrade
	I80-WY-3	Old: AC Layer 3.7", Bound treated base 16.4", Subgrade
	I80-NE-1	Old: AC Layer 5", PCC 8", Bound treated base 3.2", Subgrade
	I80-NE-2	New: AC Layer 4", PCC Layer 14.3", Unbound granular base 3.5", Subgrade
	I80-NE-3	Old: AC Layer 5.3", PCC Layer 9.6", Unbound granular base 4", Subgrade
	I80-IA-1	Old: PCC 9.6", Bound treated base 4.2", Subgrade
	I80-IA-2	Old: AC Layer:5.2", PCC 10.1", Unbound granular base 5", Unbound granular subbase 22", Subgrade
	I80-IN-1	AC Layer 9", PCC 9", Unbound granular base 6.5", Subgrade
	I80-IN-2	Old: AC Layer 9", PCC 9", Unbound granular base 6.5", Subgrade
	I80-OH-1	Old: AC Layer 9", PCC 9", Unbound granular base 6.5", Subgrade
	I80-OH-2	Old: AC Layer 3.3", PCC 8.8", Bound treated base 5", Subgrade
	I80-PA-1	Old: AC Layer 3.3", PCC 8.8", Bound treated base 5", Subgrade
	I80-PA-2	Old: AC Layer 4.8", PCC 10.3", AC Layer 3.3", PCC 9.7", Unbound granular base 24",subgrade
	I80-NJ-1	Old: PCC 10.2", Unbound granular base 12", Subgrade
I-81	I81-TN-1	AC Layer: 10.5", Bound treated base 5.1", UG subbase 3.8", Subgrade
	I81-VA-1	Near Old: Ac layer 9", UG Base 7.7", Subgrade
	I81-VA-2	Near Old: Ac layer 9", UG Base 7.7", Subgrade
	I81-WV-1	AC Layer 6", PCC 10.2", UG Base 9", Subgrade
	I81-PA-1	Old: PCC 9.4", UG Base 10.8", Subgrade
	I81-PA-2	Old: PCC 9.4", UG Base 10.8", Subgrade
	I81-NY-1	Old: AC Layer: 14.2", UB Granular base 15.1", Subgrade
	I81-NY-2	Old: AC Layer: 14.2", UB Granular base 15.1", Subgrade

Table E.4: Summary of Structure Used for Each Analysis Section (continued).

Route	Name	Structural Section
I-82	I82-WA-1	Old: PCC 10.4", UG base 5.4", Subgrade
I-83	I83-MD-1	Nearby old: PCC 9", Bound treated base 4.8", UG Subbase 21.6", Subgrade
	I83-PA-1	Old: AC Layer 4.5", PCC 9.8", UG Base 3.6", Subgrade
I-84	I84-OR-1	Old: AC Layer: 11.7", UG Base 3.5", UG Subbase 14", Subgrade
	I84-OR-2	Old: PCC 10.4", Bound treated base 7.8", Subgrade
	I84-OR-3	AC layer: 5.2", PCC 8", Bound treated base 3.5", UG Subbase 26.2", Subgrade
	I84-ID-1	PCC 9",UBG Base 4.4", UBG subbase 14.3", Subgrade
	I84-ID-2	Old: AC Layer: 11.2", UB Base 9.2", Subgrade
	I84-UT-1	Old: AC Layer 9.7", UG Base 6.2", UG Subbase 7.8", Subgrade
	I84-PA-1	Old: PCC 9.4", UG Base 10.8", Subgrade
	I84-NY-1	Old: AC Layer 3.4", Bound treated base 8", UG subbase 7.2", Subgrade
	I84-CT-1	PCC 10.3", UG Base 9.7", Subgrade
I-85	I85-AL-1	Old: AC Layer: 4.1", Bound treated base 5.7", UG Base 6", Subgrade
	I85-GA-1	Old: AC Layer 4.5", PCC 9.1", Bound treated base 3.1", UG Subbase 3.9", Subgrade
	I85-GA-2	Old: AC Layer 4.5", PCC 9.1", Bound treated base 3.1", UG Subbase 3.9", Subgrade
	I85-SC-1	Old: PCC 8.9", Bound treated base 5.9", Subgrade
	I85-NC-1	Nearby: AC Layer 10.2", Bound treated base 8.2", UG Subbase 8.8", Subgrade
	I85-NC-2	Old: PCC 9", UG base 4.8", Subgrade
	I85-VA-1	Old: AC Layer 3", Bound treated base 6.2", UG subbase 3.6", Subgrade
I-90	I90-WA-1	AC Layer 11.6", Unbound granular base 3", Unbound granular subbase 6.5", Subgrade
	I90-WA-2	AC Layer 11.6", Unbound granular base 3", Unbound granular subbase 6.5", Subgrade
	I90-WA-3	AC Layer 11.6", Unbound granular base 3", Unbound granular subbase 6.5", Subgrade
	I90-ID-1	AC Layer: 10.9", Unbound granular base 5.4", Subgrade
	I90-MT-1	AC Layer 9.8", Unbound granualr base 3.6", Unbound granular subbase 14.4", Subgrade
	I90-MT-2	AC Layer 9.8", Unbound granualr base 3.6", Unbound granular subbase 14.4", Subgrade
	I90-MT-3	AC Layer 7.8", Unbound granular base 11.2", Unbound granular subbase 20.8", Subgrade
	I90-MT-4	AC Layer 8", Unbound granular subbase 26", Subgrade
	I90-MT-5	AC Layer 8", Unbound granular subbase 26", Subgrade
	I90-WY-1	Old: AC layer 6.5", Bound treated base 12.6", Subgrade
	I90-WY-2	Old: AC Layer 7", Bound treated base 10.6", Unbound granular subbase 31", Subgrade
	I90-SD-1	Old: PCC 10.1", Unbound granular base 4.8", Subgrade
	I90-SD-2	Old: PCC 8.1", Unbound granular base 4", Subgrade
	I90-SD-3	Old: PCC 8", Unbound granular base 3.5", Unbound granular subbase 5", Subgrade
	I90-MN-1	Old: PCC 8.1", AC Layer 2.4", PCC layer 8", Unbound granular layer 6", Subgrade
	I90-MN-2	Old: PCC 9.4", Unbound granular base 6", Subgrade
	I90-WI-1	AC Layer 4", PCC 9.1", Bound base 5.5", UG subbase 13.5", Subgrade
	I90-IL-1	Nearby: AC Layer 5.1", PCC 10.4", Bound treated base 4.5", Subgrade
	I90-IN-1	Old: AC Layer 9", PCC 9", Unbound granular base 6.5", Subgrade

Table E.4: Summary of Structure Used for Each Analysis Section (continued).

Route	Name	Structural Section
I-90	I90-OH-1	Old: AC Layer 3.3", PCC 8.8", Bound treated base 5", Subgrade
	I90-OH-2	Old: AC Layer 3.3", PCC 8.8", Bound treated base 5", Subgrade
	I90-PA-1	Old: PCC 10.2", Unbound granular base 12", Subgrade
	I90-NY-1	Old: AC Layer 14.2, Unbound granular 15.1", Subgrade
	I90-NY-2	Old: AC Layer 14.2, Unbound granular 15.1", Subgrade
	I90-NY-3	Old: AC Layer 14.2, Unbound granular 15.1", Subgrade
	I90-MA-1	Old: AC Layer 8", UBG Base 4", UBG subbase 8.4", Subgrade
I-94	I94-MT-1	AC Layer 13", Unbound granular base 11.4", Unbound granular subbase 9.6", Subgrade
	I94-MT-2	AC Layer 13", Unbound granular base 11.4", Unbound granular subbase 9.6", Subgrade
	I94-ND-1	New:PCC 11", Bound treated base 6.5", Unbound granular subbase 18", Subgrade
	I94-ND-2	New:PCC 11", Bound treated base 6.5", Unbound granular subbase 18", Subgrade
	I94-MN-1	Old: PCC 12", Unbound granular base 5", Unbound granular subbase 17", Subgrade
	I94-MN-2	Old: AC layer 9.5", Unbound granular base 28", Subgrade
	I94-WI-1	PCC:7.1", UG Base 6", UG subbase 5.6", Subgrade
	I94-WI-2	Old: AC Layer: 3", PCC Layer 9.1", Bound treated base 0.5", Bound treated subbase 5", Unbound granular subbase 13.5", Subgrade
	I94-IL-1	Nearby: AC Layer 5.1", PCC 10.4", Bound treated base 4.5", Subgrade
	I94-IN-1	Old mearby: AC Layer 7.2", PCC 9", UG Base 10", Subgrade
	I94-MI-1	Old: PCC 9.7", UG Base 3.4", UG subbase 9.8", Subgrade
	I94-MI-2	Old: PCC 9.7", UG Base 3.4", UG subbase 9.8", Subgrade
	I94-MI-3	Old nearby: PCC Layer 10", Unbound granular base 2.8", Unbound granular subbase 11.5", Subgrade
I-95	I95-FL-1	Old: AC Layer 5", Unbound granular base 12.8", Unbound granular subbase 12", Subgrade
	I95-FL-2	Old: AC Layer 3.1", Unbound granular base 10.7", Unbound granular subbase 14.8", Subgrade
	I95-FL-3	Old: AC Layer2.3", Unbound granular base 10.1", Unbound granular subbase 13.3", Subgrade
	I95-GA-1	Old: AC Layer 5.5", Bound treated base 11.5", Subgrade
	I95-SC-1	Old: PCC 7.7", Bound treated base 5.2", Subgrade
	I95-SC-2	Old: PCC 7.7", Bound treated base 5.2", Subgrade
	I95-NC-1	Old: PCC 10.1", Bound treated base 4, Subgrade
	I95-VA-1	Old: AC Layer: 10.4", Unbound granular base 5.6", Bound treated subbase 8.4", Subgrade
	I95-VA-2	Old: AC Layer: 10.4", Unbound granular base 5.6", Bound treated subbase 8.4", Subgrade
	I95-MD-1	Old: PCC 9", Bound treated base 4.8", Unbound granular subbase 21.6", Subgrade
	I95-MD-2	Old: AC layer:8.3", Bound treated base 3.9", UG Subbase 5.8", Bound treated subbase 5.9", Subgrade
	I95-PA-1	Old: PCC 10.2", Unbound granular base 12", Subgrade
	I95-NJ-1	Old: PCC 8.9", UBG base 12.2", Subgrade
	I95-CT-1	Old: AC Layer 8.9", Unbound granular 12", Subgrade
	I95-RI-1	AC Layer:5.2", PCC 8.2", Subgrade

Table E.4: Summary of Structure Used for Each Analysis Section (continued).

Route	Name	Structural Section
I-95	I95-MA-1	Old: AC Layer 8", UBG Base 4", UBG subbase 8.4", Subgrade
	I95-ME-1	Old: AC Layer 9.3", UBG base 13.2", UBG subbase 19.8", subgrade
	I95-ME-2	Old AC Layer11", UBG base 12", subgrade

APPENDIX F

PAVEMENT DISTRESS RATIO BY SECTION

Table F.5: Summary of Pavement Distress Ratio for Each Analysis Section.

Route	Name	IRI Ratio	Fatigue Ratio	Rutting Ratio	Transverse Crack Ratio	Faulting Ratio
I-5	I5-CA-1	1.00	0.00	0.00	1.00	1.00
	I5-CA-2	1.00	1.00	1.00	0.00	0.00
	I5-CA-3	1.00	0.00	0.00	1.00	1.00
	I5-CA-4	1.00	1.00	1.00	0.00	0.00
	I5-CA-5	1.00	1.00	1.00	0.00	0.00
	I5-OR-1	1.00	1.00	1.00	0.00	0.00
	I5-OR-2	1.00	1.00	1.00	0.00	0.00
	I5-OR-3	1.00	1.00	1.00	0.00	0.00
	I5-WA-1	1.00	0.00	0.00	1.00	1.00
	I5-WA-2	1.00	0.00	0.00	1.00	1.00
	I5-WA-3	1.00	0.00	0.00	1.00	1.00
I-10	I10-CA-1	1.00	1.00	1.00	0.00	0.00
	I10-CA-2	1.00	1.00	1.00	0.00	0.00
	I10-AZ-1	0.98	1.00	2.00	0.00	0.00
	I10-AZ-2	1.20	0.00	0.00	1.00	1.10
	I10-AZ -3	1.06	1.10	1.06	0.00	0.00
	I10-NM-1	1.01	1.09	1.03	0.00	0.00
	I10-TX-1	1.02	0.00	0.00	1.00	1.03
	I10-TX-2	1.01	0.00	0.00	1.02	1.01
	I10-TX-3	1.00	1.02	1.00	0.00	0.00
	I10-TX-4	1.01	1.02	1.00	0.00	0.00
	I10-TX-5	1.00	1.01	1.00	0.00	0.00
	I10-TX-6	1.00	1.00	1.00	0.00	0.00
	I10-TX-7	1.00	1.00	1.03	0.00	0.00
	I10-LA-1	1.00	1.33	1.00	0.00	0.00
	I10-LA-2	1.00	0.00	0.00	1.00	1.01
	I10-LA-3	1.00	1.00	1.01	0.00	0.00
	I10-MS-1	0.97	0.00	0.00	1.00	0.76
	I10-AL-1	1.00	1.00	0.97	0.00	0.00
	I10-FL-1	1.02	1.00	1.10	0.00	0.00
	I10-FL-2	1.02	1.25	1.06	0.00	0.00
I-15	I15-CA-1	1.00	0.00	0.00	1.00	1.00
	I15-CA-2	1.00	0.00	0.00	1.00	1.00
	I15-NV-1	1.09	0.00	0.00	1.21	1.11
	I15-UT-1	2.12	0.00	0.00	1.13	2.23
	I15-UT-2	1.06	0.00	0.00	1.09	1.08
	I15-UT-3	1.04	0.00	0.00	1.04	1.06
	I15-ID-1	1.01	1.00	1.07	0.00	0.00
	I15-ID-2	1.06	1.00	1.05	0.00	0.00
	I15-MT-1	1.00	1.08	1.02	0.00	0.00
	I15-MT-2	1.00	1.08	1.02	0.00	0.00
I-20	I20-TX-1	1.02	0.00	0.00	1.00	1.11
	I20-TX-2	1.00	1.00	1.00	0.00	0.00
	I20-TX-3	1.00	1.00	1.00	0.00	0.00
	I20-TX-4	1.00	1.00	1.00	0.00	0.00
	I20-TX-5	1.00	1.00	1.00	0.00	0.00

Table F.5: Pavement Distress Ratio for Each Analysis section (continued).

Route	Name	IRI Ratio	Fatigue Ratio	Rutting Ratio	Tr. Crack Ratio	Faulting Ratio
	I20-LA-1	1.00	1.00	1.01	0.00	0.00
	I20-MS-1	0.97	0.00	0.00	0.90	0.96
	I20-AL-1	1.01	1.00	0.95	0.00	0.00
	I20-AL-2	0.99	0.00	0.00	0.99	0.97
	I20-GA-1	1.12	0.00	0.00	2.00	1.18
	I20-GA-2	1.08	0.00	0.00	1.88	0.33
	I20-SC-1	1.13	0.00	0.00	1.20	1.19
I-24	I24-GA-1	1.02	1.00	1.10	0.00	0.00
	I24-TN-1	1.00	1.00	0.97	0.00	0.00
	I24-KY-1	0.99	0.95	0.98	0.00	0.00
I-35	I35-TX-1	1.00	0.00	0.00	1.00	1.00
	I35-TX-2	1.13	0.00	0.00	1.00	1.55
	I35-TX-3	1.01	0.00	0.00	1.00	1.09
	I35E-TX-1	1.13	0.00	0.00	1.00	1.70
	I35W-TX1	1.00	1.00	1.02	0.00	0.00
	I35-OK-1	1.02	0.00	0.00	1.02	1.03
	I35-OK-2	1.01	0.00	0.00	1.02	1.01
	I35-KS-1	1.00	1.00	1.09	0.00	0.00
	I35-KS-2	1.02	1.00	1.07	0.00	0.00
	I35-MO-1	1.01	0.64	1.08	0.00	0.00
	I35-IA-1	1.00	0.00	0.00	1.00	1.03
	I35-IA-2	1.00	1.00	1.07	0.00	0.00
	I35-MN-1	1.05	0.00	0.00	1.33	1.10
	I35-MN-2	1.02	0.00	0.00	1.22	1.05
	I35E-MN-1	1.12	0.00	0.00	1.12	1.04
	I35W-MN2	1.11	0.00	0.00	1.00	1.16
I-40	I40-CA-1	1.01	0.00	0.00	1.03	1.11
	I40-AZ-1	1.11	0.00	0.00	1.00	1.16
	I40-AZ-2	1.00	0.00	0.00	1.00	1.03
	I40-AZ-3	1.09	0.00	0.00	1.21	1.11
	I40-NM-1	0.98	0.00	0.00	0.92	0.98
	I40-NM-2	1.00	0.00	0.00	1.00	1.00
	I40-NM-3	1.01	0.00	0.00	1.26	1.13
	I40-TX-1	1.07	0.00	0.00	1.01	1.00
	I40-TX-2	1.07	0.00	0.00	1.06	0.86
	I40-OK-1	2.12	0.00	0.00	1.13	2.23
	I40-OK-2	1.09	0.00	0.00	1.12	1.13
	I40-OK-3	1.02	0.00	0.00	1.05	1.04
	I40-AR-1	1.01	0.00	0.00	1.03	1.01
	I40-AR-2	1.91	0.00	0.00	1.02	1.32
	I40-TN-1	1.20	0.00	0.00	1.00	1.10
	I40-TN-2	1.01	0.00	0.00	1.02	1.01
	I40-TN-3	1.05	0.00	0.00	1.25	1.08
	I40-TN-4	1.05	0.00	0.00	1.33	1.10
	I40-NC-1	1.03	0.00	0.00	1.00	1.05
	I40-NC-2	1.12	0.00	0.00	2.00	1.18
	I40-NC-3	1.07	0.00	0.00	1.33	1.11

Table F.5: Pavement Distress Ratio for Each Analysis Section (continued).

Route	Name	IRI Ratio	Fatigue Ratio	Rutting Ratio	Transverse Crack Ratio	Faulting Ratio
I-44	I44-TX-1	1.91	0.00	0.00	1.02	1.32
	I44-OK-1	1.01	0.00	0.00	1.03	1.01
	I44-MO-1	1.01	1.00	1.07	0.00	0.00
	I44-MO-2	1.01	1.13	1.07	0.00	0.00
I-55	I55-LA-1	1.02	0.00	0.00	1.00	1.04
	I55-MS-1	0.98	0.00	0.00	1.00	0.97
	I55-MS-2	1.00	1.00	0.97	0.00	0.00
	I55-TN-1	1.00	1.00	0.98	0.00	0.00
	I55-MO-1	1.01	1.00	1.06	0.00	0.00
	I55-MO-2	1.00	1.00	1.00	0.00	0.00
	I55-IL-1	1.00	1.04	1.01	0.00	0.00
	I55-IL-2	1.00	1.00	1.00	0.00	0.00
I-64	I64-MO-1	1.00	1.00	1.10	0.00	0.00
	I64-IN-1	1.01	1.00	1.06	0.00	0.00
	I64-KY-1	0.98	0.00	0.00	0.92	0.98
	I64-KY-2	0.97	0.99	0.98	0.00	0.00
	I64-WV-1	1.00	1.00	1.03	0.00	0.00
	I64-VA-1	1.04	0.00	0.00	1.02	1.12
	I64-VA-2	1.02	1.67	1.08	0.00	0.00
I-65	I65-AL-1	1.00	1.00	0.98	0.00	0.00
	I65-AL-2	1.00	1.00	0.98	0.00	0.00
	I65-TN-1	0.99	1.00	0.97	0.00	0.00
	I65-KY-1	0.98	0.00	0.00	1.00	0.97
	I65-IA-1	1.01	1.00	1.04	0.00	0.00
	I65-IA-2	1.01	1.00	1.06	0.00	0.00
I-69	I69-IN-1	1.07	0.00	0.00	1.33	1.11
	I69-MI-1	1.00	1.00	1.02	0.00	0.00
	I69-MI-2	1.00	1.00	1.02	0.00	0.00
I-70	I70-UT-1	1.39	0.00	0.00	1.27	1.89
	I70-UT-2	1.42	0.00	0.00	1.33	1.24
	I70-CO-1	1.01	1.14	1.05	0.00	0.00
	I70-CO-2	1.01	1.00	1.04	0.00	0.00
	I70-CO-3	1.07	1.00	1.04	0.00	0.00
	I70-KS-1	1.00	1.00	1.11	0.00	0.00
	I70-KS-2	0.99	1.00	1.23	0.00	0.00
	I70-KS-3	0.64	0.00	0.00	1.01	0.39
	I70-MO-1	1.01	1.00	1.07	0.00	0.00
	I70-MO-2	1.04	0.00	0.00	1.00	1.05
	I70-IL-1	1.00	1.03	1.00	0.00	0.00
	I70-IN-1	1.00	1.00	1.03	0.00	0.00
	I70-IN-2	1.00	1.00	1.03	0.00	0.00
	I70-OH-1	1.22	0.00	0.00	1.03	1.25
	I70-OH-2	1.02	0.00	0.00	1.05	1.04
	I70-PA-1	1.00	1.02	1.00	0.00	0.00
	I70-PA-2	1.00	1.01	1.01	0.00	0.00
	I70-MD-1	1.01	1.00	1.07	0.00	0.00

Table F.5: Pavement Distress Ratio for Each Analysis Section (continued).

Route	Name	IRI Ratio	Fatigue Ratio	Rutting Ratio	Transverse Crack Ratio	Faulting Ratio
I-75	I75-FL-1	1.14	1.04	1.08	0.00	0.00
	I75-FL-2	1.11	0.00	0.00	1.60	1.20
	I75-FL-3	1.09	0.00	0.00	1.50	1.17
	I75-GA-1	1.34	0.00	0.00	1.75	1.78
	I75-GA-2	0.89	0.00	0.00	1.78	0.77
	I75-GA-3	1.11	0.00	0.00	1.60	1.00
	I75-GA-4	0.95	0.00	0.85	0.00	0.00
	I75-TN-1	0.99	1.00	0.98	0.00	0.00
	I75-KY-1	0.99	0.94	0.98	0.00	0.00
	I75-KY-2	0.99	0.95	0.99	0.00	0.00
	I75-OH-1	1.00	0.00	0.00	1.00	1.00
	I75-OH-2	1.00	1.00	1.03	0.00	0.00
	I75-MI-1	1.03	0.00	0.00	1.03	1.05
	I75-MI-2	1.00	1.00	1.00	0.00	0.00
	I75-MI-3	1.00	1.00	1.02	0.00	0.00
I-76	I76-CO-1	1.03	0.00	0.00	1.01	0.76
	I76-CO-2	1.01	1.00	1.05	0.00	0.00
	I76-OH-1	1.03	0.00	0.00	1.06	1.04
	I76-PA-1	1.01	0.00	0.00	1.01	1.19
I-77	I77-SC-1	1.16	0.00	0.00	1.47	1.17
	I77-NC-1	1.08	1.00	1.06	0.00	0.00
	I77-VA-1	1.02	1.00	1.09	0.00	0.00
	I77-WV-1	1.00	1.00	1.00	0.00	0.00
	I77-OH-1	0.98	0.00	0.00	1.06	0.98
I-78	I78-PA-1	1.00	1.00	1.00	0.00	0.00
	I78-NJ-1	1.00	1.00	1.01	0.00	0.00
I-80	I80-CA-1	1.00	0.00	0.00	1.00	1.00
	I80-CA-2	1.00	0.00	0.00	1.00	1.00
	I80-NV-1	1.01	1.00	1.03	0.00	0.00
	I80-NV-2	1.01	1.14	1.02	0.00	0.00
	I80-NV-3	1.07	0.00	0.00	1.01	1.00
	I80-UT-1	1.05	0.00	0.00	1.28	1.08
	I80-UT-2	1.05	0.00	0.00	1.25	1.08
	I80-WY-1	1.06	0.00	0.00	1.41	1.13
	I80-WY-2	1.01	1.00	1.03	0.00	0.00
	I80-WY-3	1.00	1.00	1.07	0.00	0.00
	I80-NE-1	1.04	1.00	1.00	0.00	0.00
	I80-NE-2	1.05	1.00	1.33	0.00	0.00
	I80-NE-3	1.16	1.00	1.10	0.00	0.00
	I80-IA-1	1.06	0.00	0.00	1.52	1.10
	I80-IA-2	1.12	1.00	1.07	0.00	0.00
	I80-IL-1	1.00	1.00	1.04	0.00	0.00
	I80-IN-1	1.08	1.00	1.03	0.00	0.00
	I80-IN-2	1.00	1.00	1.00	0.00	0.00

Table F.5: Pavement Distress Ratio for Each Analysis Section (continued).

Route	Name	IRI Ratio	Fatigue Ratio	Rutting Ratio	Tr. Crack Ratio	Faulting Ratio
I-80	I80-OH-1	1.00	1.00	1.00	0.00	0.00
	I80-OH-2	1.00	1.00	1.00	0.00	0.00
	I80-PA-1	1.00	1.00	1.03	0.00	0.00
	I80-PA-2	1.02	0.00	0.00	1.03	1.04
	I80-NJ-1	1.00	1.00	1.00	0.00	0.00
I-81	I81-TN-1	0.99	1.00	0.98	0.00	0.00
	I81-VA-1	1.03	1.07	1.14	0.00	0.00
	I81-VA-2	1.02	1.26	1.07	0.00	0.00
	I81-WV-1	1.01	1.00	1.00	0.00	0.00
	I81-PA-1	1.02	0.00	0.00	1.01	1.33
	I81-PA-2	1.02	0.00	0.00	1.01	1.04
	I81-NY-1	1.08	1.00	1.00	0.00	0.00
	I81-NY-2	1.00	1.00	1.04	0.00	0.00
I-82	I82-WA-1	1.00	0.00	0.00	1.00	1.00
I-83	I83-MD-1	1.12	0.00	0.00	1.06	1.19
	I83-PA-1	1.00	1.00	1.00	0.00	0.00
I-84	I84-OR-1	1.00	1.00	1.00	0.00	0.00
	I84-OR-2	1.00	0.00	0.00	1.00	1.00
	I84-OR-3	1.00	1.00	1.00	0.00	0.00
	I84-ID-1	1.07	0.00	0.00	1.00	1.13
	I84-ID-2	1.01	1.33	1.02	0.00	0.00
	I84-UT-1	1.00	1.43	1.03	0.00	0.00
	I84-PA-1	1.01	0.00	0.00	1.03	1.11
	I84-NY-1	1.00	1.00	1.00	0.00	0.00
	I84-CT-1	0.94	0.00	0.00	1.04	0.53
I-85	I85-AL-1	1.00	1.00	0.98	0.00	0.00
	I85-GA-1	1.02	1.00	1.13	0.00	0.00
	I85-GA-2	1.03	1.00	1.11	0.00	0.00
	I85-SC-1	1.15	0.00	0.00	1.31	1.18
	I85-NC-1	1.03	1.00	1.10	0.00	0.00
	I85-NC-2	1.08	0.00	0.00	1.00	1.15
	I85-VA-1	1.01	1.00	1.06	0.00	0.00
I-90	I90-WA-1	1.00	1.00	1.00	0.00	0.00
	I90-WA-2	1.00	1.00	1.00	0.00	0.00
	I90-WA-3	1.00	1.00	1.00	0.00	0.00
	I90-ID-1	1.00	1.00	0.98	0.00	0.00
	I90-MT-1	1.00	1.13	1.02	0.00	0.00
	I90-MT-2	1.00	1.00	1.00	0.00	0.00
	I90-MT-3	1.00	1.12	1.03	0.00	0.00
	I90-MT-4	1.00	1.00	1.02	0.00	0.00
	I90-MT-5	1.01	1.00	1.03	0.00	0.00
	I90-WY-1	1.01	1.00	1.03	0.00	0.00
	I90-WY-2	1.01	1.00	1.04	0.00	0.00
	I90-SD-1	1.04	0.00	0.00	1.51	1.07
	I90-SD-2	1.01	0.00	0.00	1.26	1.13

Table F.5: Pavement Distress Ratio for Each Analysis Section (continued).

Route	Name	IRI Ratio	Fatigue Ratio	Rutting Ratio	Transverse Crack Ratio	Faulting Ratio
I-90	I90-SD-3	1.09	0.00	0.00	1.19	1.13
	I90-MN-1	1.06	0.00	0.00	1.50	1.61
	I90-MN-2	0.85	0.00	0.00	1.31	0.82
	I90-WI-1	1.00	1.00	1.00	0.00	0.00
	I90-IL-1	1.00	1.00	1.00	0.00	0.00
	I90-IN-1	1.00	1.00	1.04	0.00	0.00
	I90-OH-1	1.00	1.00	1.03	0.00	0.00
	I90-OH-2	1.00	1.00	1.00	0.00	0.00
	I90-PA-1	1.00	0.00	0.00	1.00	1.00
	I90-NY-1	1.00	1.00	1.00	0.00	0.00
	I90-NY-2	1.00	1.00	1.00	0.00	0.00
	I90-NY-3	1.00	1.00	1.00	0.00	0.00
	I90-MA-1	1.00	0.98	1.00	0.00	0.00
I-94	I94-MT-1	1.00	1.00	1.00	0.00	0.00
	I94-MT-2	1.00	1.00	1.04	0.00	0.00
	I94-ND-1	1.08	0.00	0.00	2.00	1.31
	I94-ND-2	1.05	0.00	0.00	2.00	1.41
	I94-MN-1	1.05	0.00	0.00	1.00	1.15
	I94-MN-2	1.01	1.20	1.04	0.00	0.00
	I94-WI-1	1.03	0.00	0.00	1.00	1.05
	I94-WI-2	1.00	1.00	1.05	0.00	0.00
	I94-IL-1	1.00	1.00	1.04	0.00	0.00
	I94-IN-1	1.00	1.00	1.00	0.00	0.00
	I94-MI-1	1.03	0.00	0.00	1.02	1.55
	I94-MI-2	1.01	0.00	0.00	1.01	1.07
	I94-MI-3	1.02	0.00	0.00	1.02	1.47
I-95	I95-FL-1	1.11	1.07	1.09	0.00	0.00
	I95-FL-2	1.13	1.05	1.08	0.00	0.00
	I95-FL-3	1.08	1.08	1.02	0.00	0.00
	I95-GA-1	1.03	1.00	1.10	0.00	0.00
	I95-SC-1	1.09	0.00	0.00	1.12	1.13
	I95-SC-2	1.07	0.00	0.00	1.06	0.86
	I95-NC-1	1.03	0.00	0.00	1.17	1.33
	I95-VA-1	1.06	1.00	1.00	0.00	0.00
	I95-VA-2	1.01	2.00	1.07	0.00	0.00
	I95-MD-1	1.13	0.00	0.00	1.02	1.20
	I95-MD-2	1.02	1.00	1.08	0.00	0.00
	I95-PA-1	2.55	0.00	0.00	1.02	2.35
	I95-NJ-1	1.42	0.00	0.00	1.00	1.69
	I95-CT-1	1.00	1.00	0.99	0.00	0.00
	I95-RI-1	1.00	1.00	1.00	0.00	0.00
	I95-MA-1	1.00	0.98	1.00	0.00	0.00
	I95-ME-1	1.00	1.00	0.98	0.00	0.00
	I95-ME-2	1.00	0.86	0.97	0.00	0.00