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Analysis of the Evolution of Flexible Pavement Condition Based on LTPP SPS-5 Sections

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Outline

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OBJECTIVES

Objectives

The Long-Term Pavement Performance (**LTPP**) database (http://www.infopave.com/) can be useful to derive **statistical relationships** describing the **evolution of the pavement condition** for the sections included in the database.

Main objective: create, if possible, models to assess the long-term progress of degradation of the analyzed pavements.

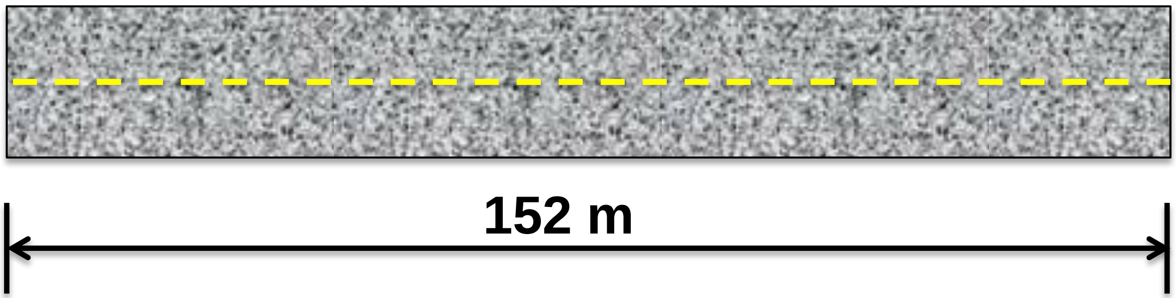
The authors have had the **supplementary objective** of evaluating whether the analysis of the USA LTPP database could be applied to the Portuguese situation.

SPS-5 Sections Characteristics

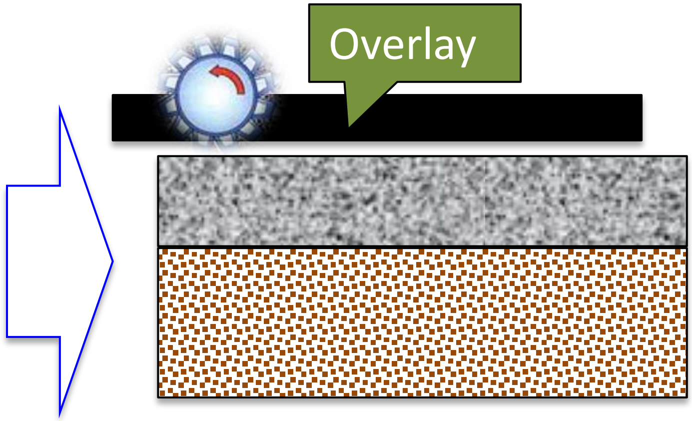
DESCRIPTION OF THE DATA SET USED

Description of the Data Set used

SPS-5 Sections Characteristics



Eight combinations of asphalt concrete (AC) **overlays** on existing AC-surfaced pavements



Variables:

- Milling / No milling
- Recycled (30 % RAP) versus virgin AC overlay
- Overlay thickness (50 or 125 mm).

Description of the Data Set used

SPS-5 Sections Characteristics

All the SPS-5 sections are numbered from 501 to 509 according to Table1.

TABLE 1 Designation of SPS-5 Sections *(5)*

Surface Preparation	50 mm of milling prior to overlay		Surface not milled	
Overlay thickness (mm)	50	125	50	125
Mix Type	SPS-5 Section Code			
RAP	509	508	502	503
Virgin	506	507	505	504

The **control section** is codified as **501** and it did not undertook any treatment.

Description of the Data Set used

SPS-5 Sections Characteristics

Table summarizes the information available and considered in the study about properties of AC overlays

TABLE 2 AC Overlay Properties Extracted from the Database

Section	Void content (%)	Binder content (%)	Penetration @ 25ºC (0.1 mm)
503	4.1	5.1	15
506	2.1	4.7	10
507	2.3	5.0	31
509	4.6	4.1	40

Climatic Regions and Traffic

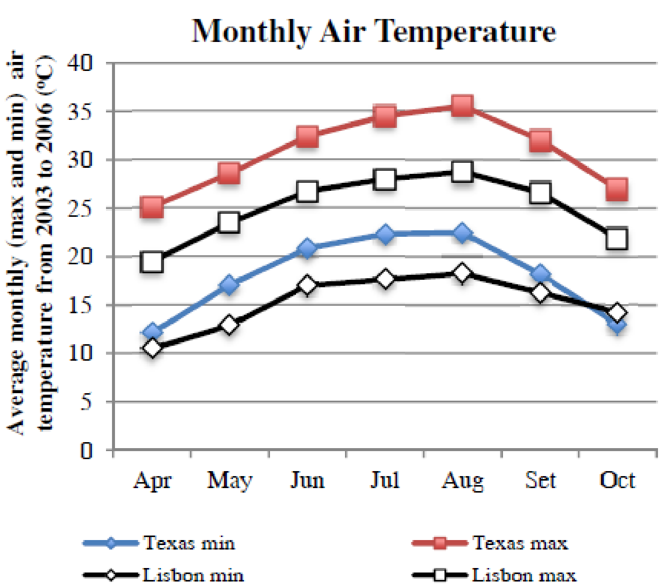
DESCRIPTION OF THE DATA SET USED

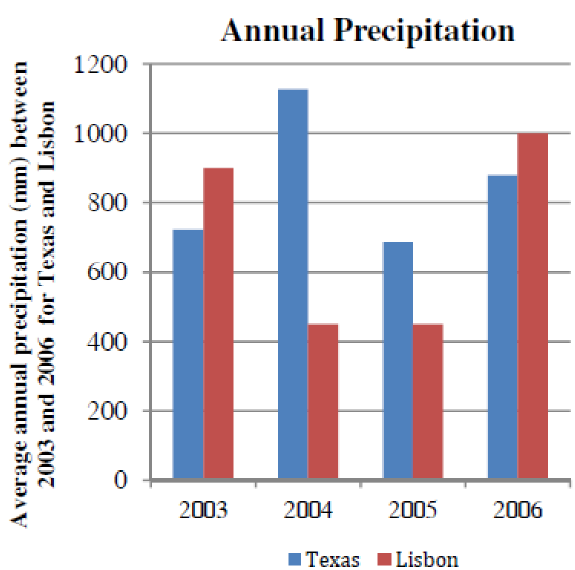
Description of the Data Set used

Climatic Regions and Traffic

The parameters used to match the climatic regions were the **average monthly minimum air temperature** and the **average annual precipitation**.

Example of the climatic matching process carried out in the study (**Texas** vs **Lisbon**)





Description of the Data Set used in the Study

Climatic Regions and Traffic

The matching with Portuguese regions with climatic zones of LTPP leading to the following pairs:

- California and Beja;
- Texas and Lisbon;
- Mississippi and Porto.

The **estimated traffic** of 80 kN Equivalent Single Axle Loads (**ESALs**) considered in the database is the following:

- California, 9.9 millions;
- Texas, 3.0 millions;
- Mississippi, 72.2 millions.

DATA ANALYSIS AND RESULTS DISCUSSION

Data Analysis and Results Discussion

The total approach of the study deals with longitudinal cracking, transverse cracking, block cracking, roughness, **fatigue cracking** and **rutting**.

This presentation addresses:

- **fatigue cracking:** series of small, jagged, interconnecting cracks caused by failure of the AC surface under repeated traffic loading;
- **Rutting**: longitudinal surface depression in the wheel-path;
- Longitudinal & transverse cracking.

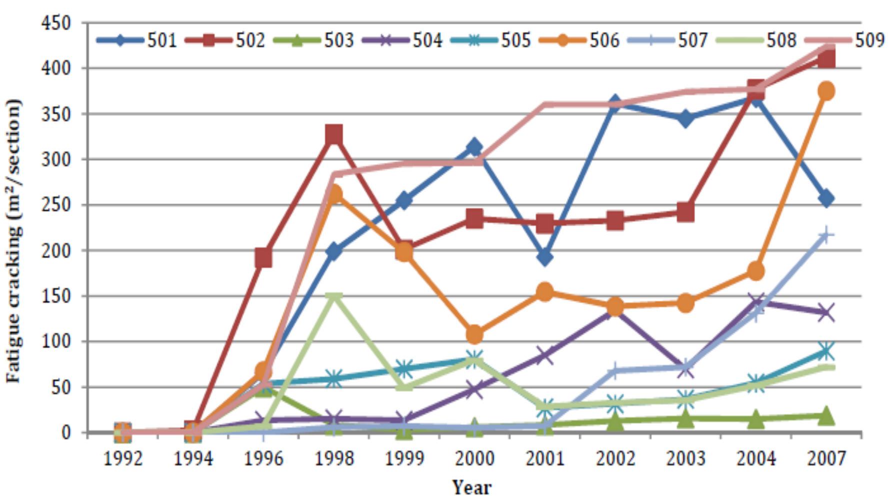
Fatigue Cracking

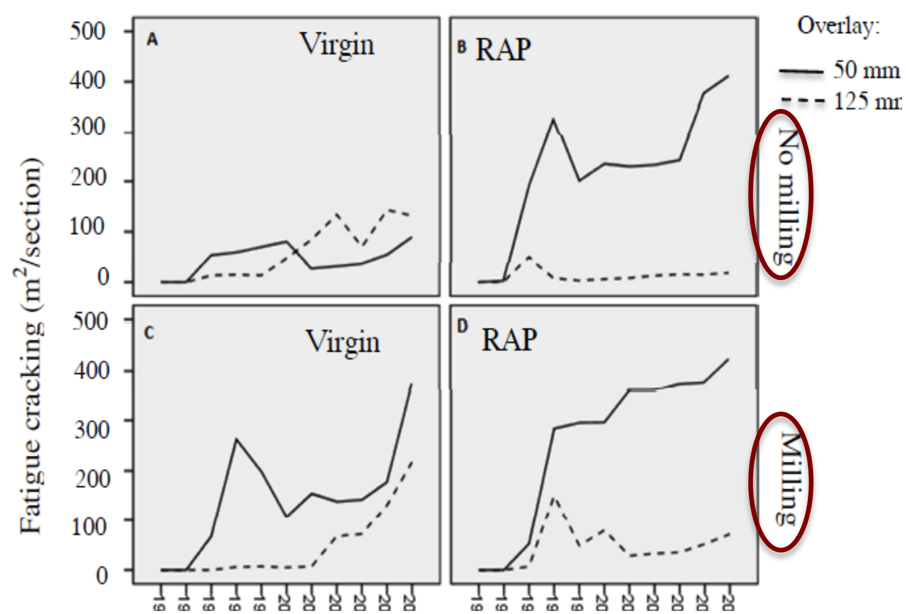
DATA ANALYSIS AND RESULTS DISCUSSION

Data Analysis and Results Discussion

Fatigue Cracking

Figures below illustrate the example of data recorded for **California** for all test sections. It is clear that test sections perform differently along time, the same occurred for other sections under analysis located in other States.





Data Analysis and Results Discussion

Fatigue Cracking

Based on the data recorded for California, including some characteristics of the overlay, expression shown was obtained by **regression analysis**. This model rejected void content and binder penetration at 25 ºC (5% significant level)

$$y = -102.446 \times x_1 + 0.012 \times x_2 + 112.354 \times x_3 - 3.695 \times x_4$$

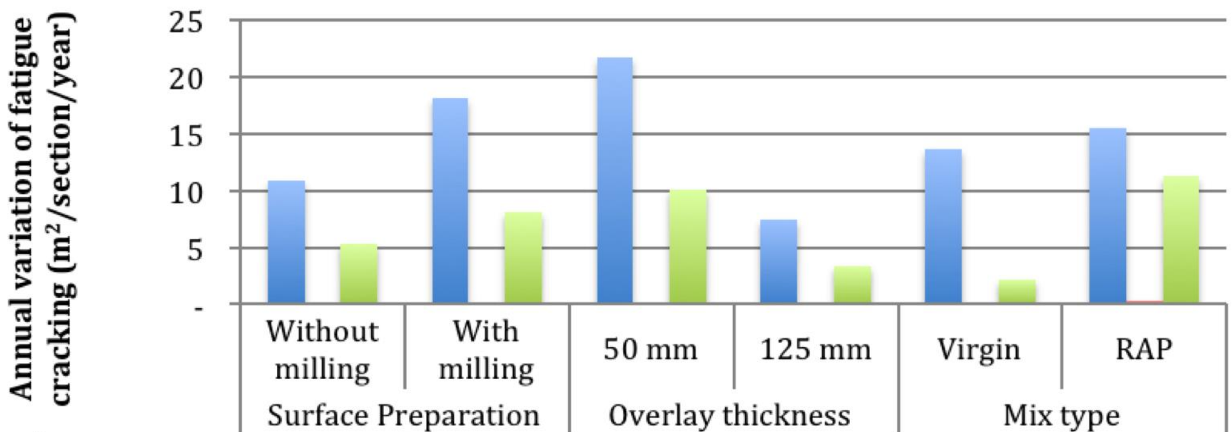
[R^2=96.4%]

y: prediction of fatigue cracking, m2/section;
x1: mix type, 0 for virgin and 1 for RAP;
x2: traffic, equivalent 80 kN single axle loads, thousands (from 2458 to 9911);
x3: binder content (from 4.4 to 4.7 %);
x4: overlay thickness (50 or 125 mm).

Fatigue Cracking

A **global analysis** was also carried out to emphasize the influence in performance of the different factors involved in this study.

Evaluation parameter shown: **Annual Variation of fatigue cracking [Annual variation = (End value – Starting value)/Number of years**]. Higher values denote lower performance of pavement overlays.



	Without milling	With milling	50 mm	125 mm	Virgin	RAP
California	10.86	18.13	21.67	7.33	13.56	15.43
Texas	0.08	0.14	0.08	0.14	0.03	0.20
Mississippi	5.24	8.11	10.08	3.27	2.08	11.28

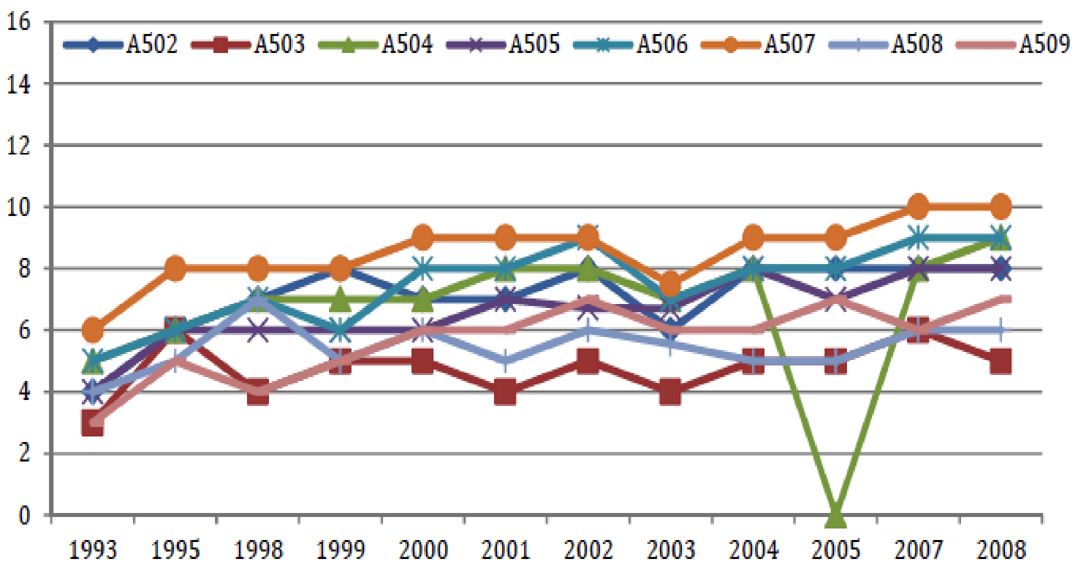
Rutting

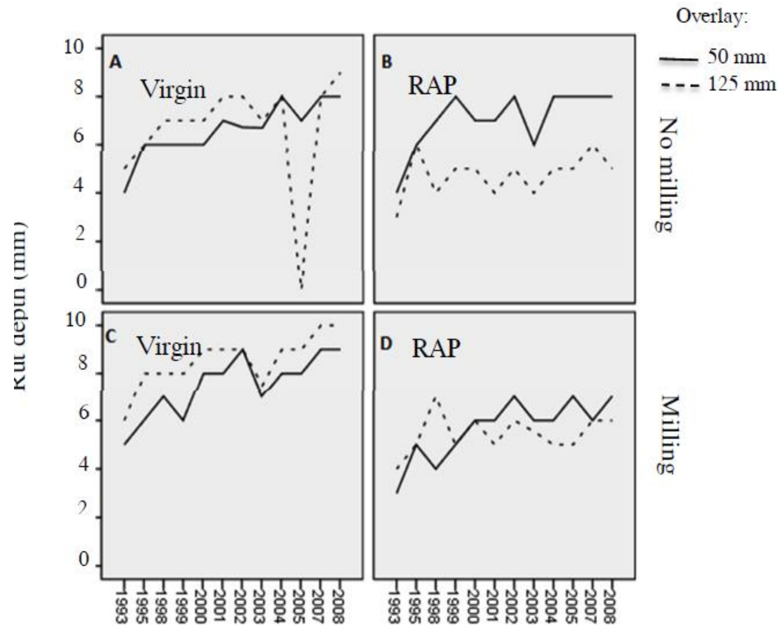
DATA ANALYSIS AND RESULTS DISCUSSION

Data Analysis and Results Discussion

Rutting

For the sections located in **Texas**, the available information from the LTPP database is presented as an example below.





Data Analysis and Results Discussion

Rutting

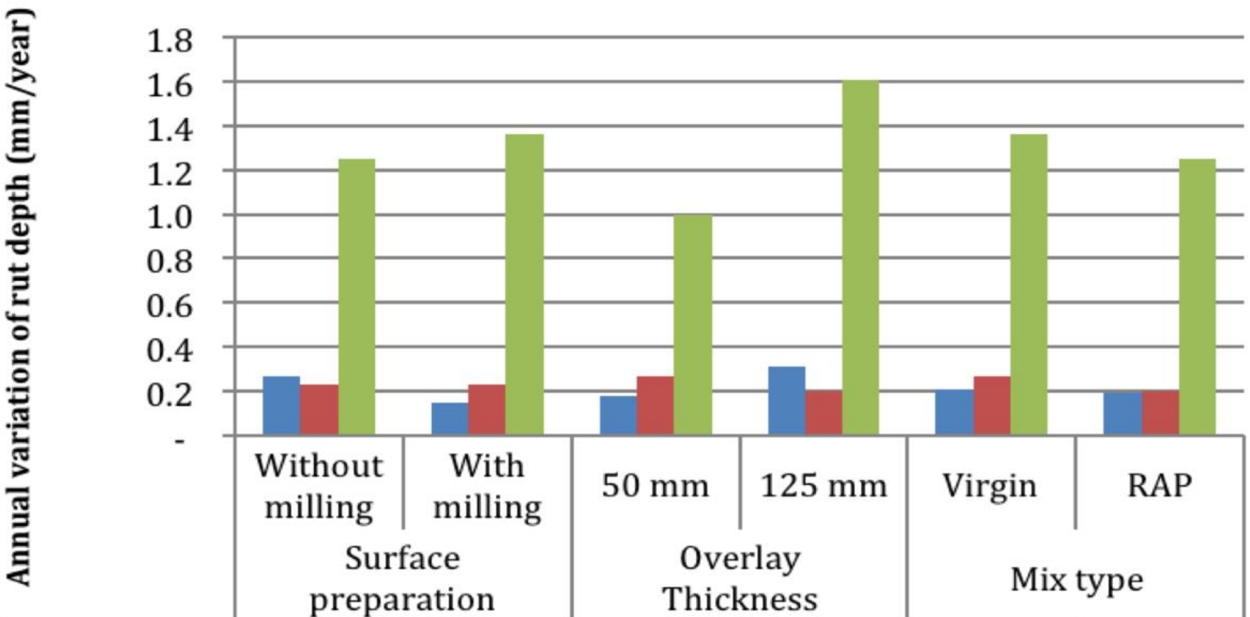
The statistical model (**regression analysis**) for rut depth variation in Texas includes *void content* and *binder content* as independent variables since they revealed strong correlation with *mix type* and *overlay thickness*, respectively.

$$y = 1.638 \times x1 + 0.001 \times x2 - 0.919 \times x3 - 1.176 \times x4 \qquad [R^2 = 98.7\%]$$

Y: estimate of rut depth, mm
X1: Surface preparation = 0 no milling / 1 milling
x2: traffic, traffic, equivalent 80 kN single axle loads, thousands (from 540 to 3029);
X3: void content (from 2.1 to 4.6 %)
X4: binder content (from 4.1 to 5.1 %)

Data Analysis and Results Discussion

Rutting



	Without milling	With milling	50 mm	125 mm	Virgin	RAP
California	0.27	0.15	0.18	0.31	0.21	0.19
Texas	0.23	0.23	0.27	0.20	0.27	0.20
Mississippi	1.25	1.36	1.00	1.61	1.36	1.25

Longitudinal cracking

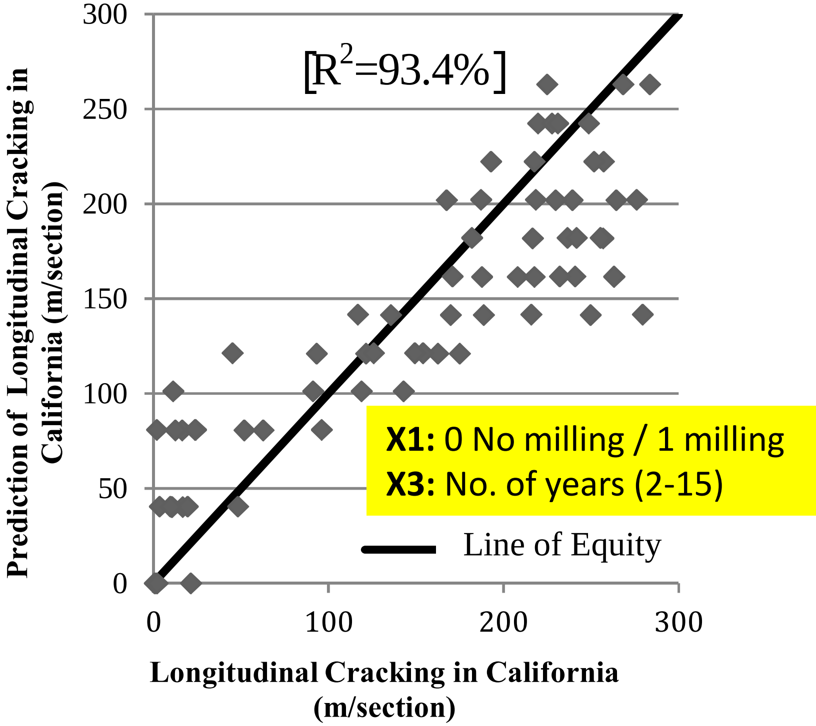
& Transverse Cracking

DATA ANALYSIS AND RESULTS DISCUSSION

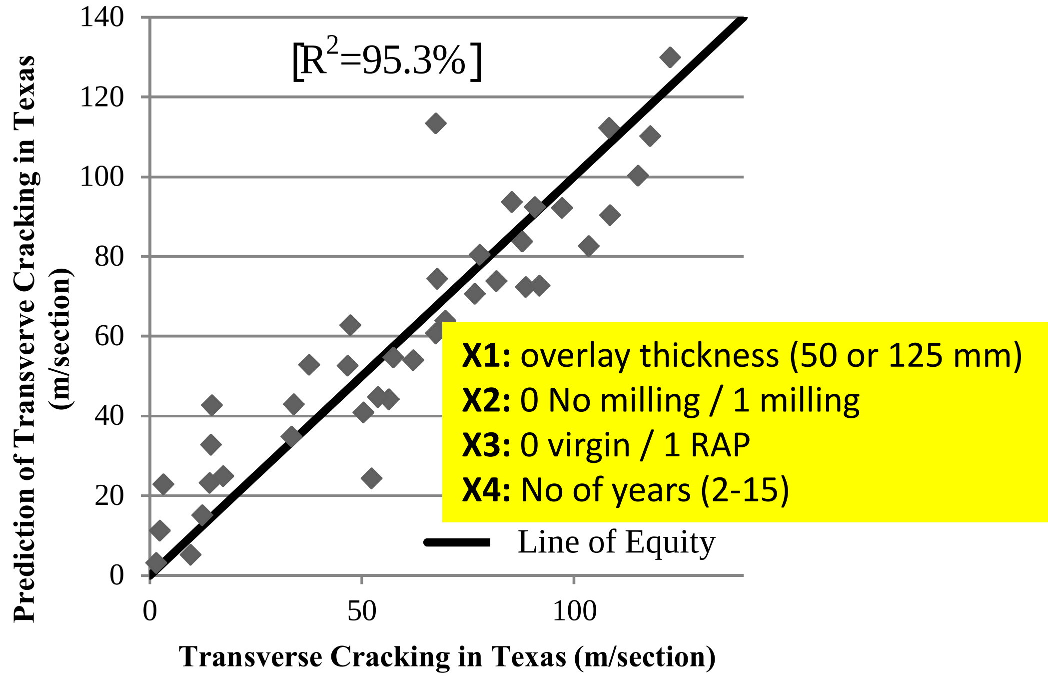
Data Analysis and Results Discussion

Longitudinal Cracking & Transverse Cracking

California: $y = -40.209 \times x_1 + 20.21 \times x_3$



Texas: $y = -0.504 \times x_1 - 17.222 \times x_2 + 16.561 \times x_3 + 9.897 \times x_4$



Summary of SPS-5 Sections Performance

DATA ANALYSIS AND RESULTS DISCUSSION

Data Analysis and Results Discussion

Summary of SPS-5 Sections Performance

Table 3 summarizes the global contribution of each variable to pavement performance for each enumerated distress type. This evaluation is based on the Annual Variation [Annual variation = (End value – Starting value)/Number of years].

TABLE 3 Summary of SPS-5 sections performance

Distress type	State	Milling prior to rehabilitation	Increase of overlay thickness	Overlay with RAP
Longitudinal cracking	California	+	-	-
	Texas	+	+	-
	Mississippi	-	-	-
Transverse cracking	California	+	-	-
	Texas	+	+	-
	Mississippi	+	+	-
Ride quality	California	-	+	-
	Texas	+	+	+
	Mississippi	-	+	+

(+) favorable contribution of the variable to pavement performance

(-) negative influence to pavement performance.

CONCLUSIONS

Conclusions

- The location of pavements and the number of ESALs are important factors that influence the observed performance.
- The scatter of data recorded in the LTPP database does not allow definitive conclusions about the recommended technologies for rehabilitation works. Nevertheless, expressions obtained by regression analysis are useful to estimate distress progress along time as a function of rehabilitation features.
- Although the climatic characteristics of American regions used in the study show some differences in comparison to the climatic regions considered for Portugal, the mix types and pavement technology are similar to the Portuguese ones. Final results allowed the inference that behavior trends are useful for the Portuguese technology.
- Next step of this project will be verification/validation of those trends with Portuguese road network available data.

Thank you