9th International Conference on MANAGING PAVEMENT ASSETS (ICMPA9)

MAY 18-21, 2015 ICMPA9 • Washington D.C.

International Conference on Managing Pavement Assets

Effect of Traffic and Environmental Factors on Roughness Progression Rate of Sealed Low Volume Arterials

- ***Nahla Alaswadko*** *(PhD Student)*
- ***Rayya Hassan***
- ***Robert Evans***

Swinburne University of Technology

AASHTO THE VOICE OF TRANSPORTATION

VirginiaTech Transportation Institute

TRB

U.S. Department of Transportation Federal Highway Administration

WORLD ROAD ASSOCIATION MONDIALE DE LA ROUTE 1909-2009

VDOT

Outline

- Introduction
- Study Aim
- Network Selection Criteria
- Study Approach
- Models Development
- Models Validation
- Study Outcomes

Introduction

- Pavement management at network or project level is impossible without reliable accurate performance prediction models

- Requirements for more powerful models:
  - A representative network
  - An acceptable database
  - A wide range of factors
  - An appropriate preparation of data
  - A suitable functional form of the model
  - An assessment of the accuracy of predicted model

Study Aim

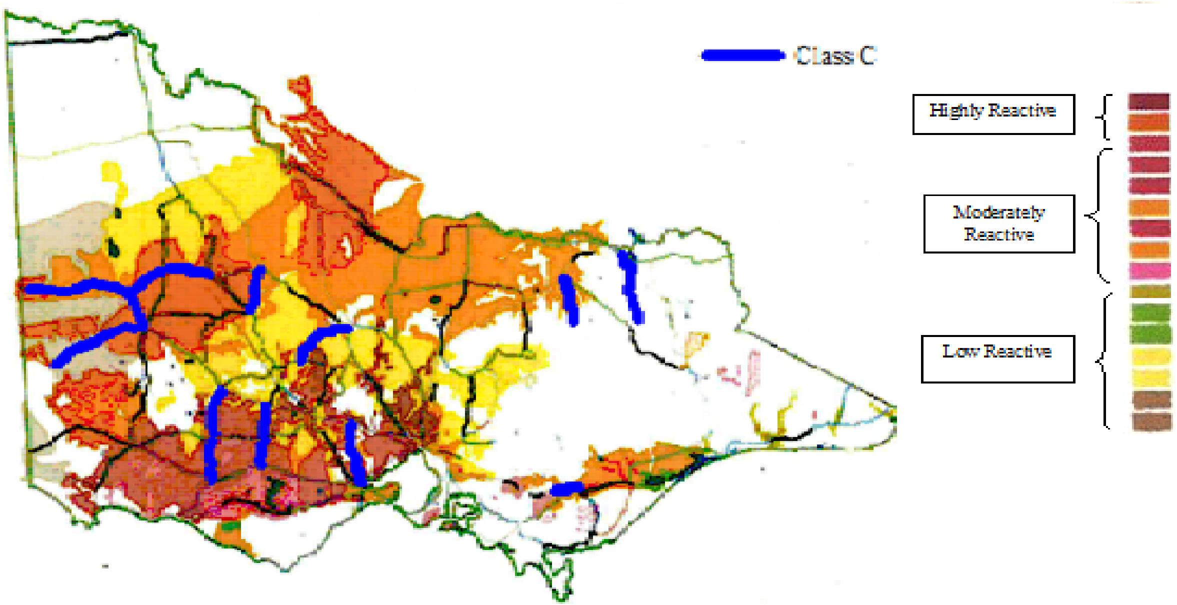
- The main purpose is to develop an empirical absolute deterministic roughness prediction models for managing low volume rural roads (class C) of Victoria's arterial network.

- Study the contribution and significance of relevant influencing factors in predicting roughness.

Network Selection Criteria

- (13) highway sections with a total length of 653 km (6,536 100m-segments) were selected. Covering different types of:

Subgrade soils | Climate zones | Drainage | Terrain

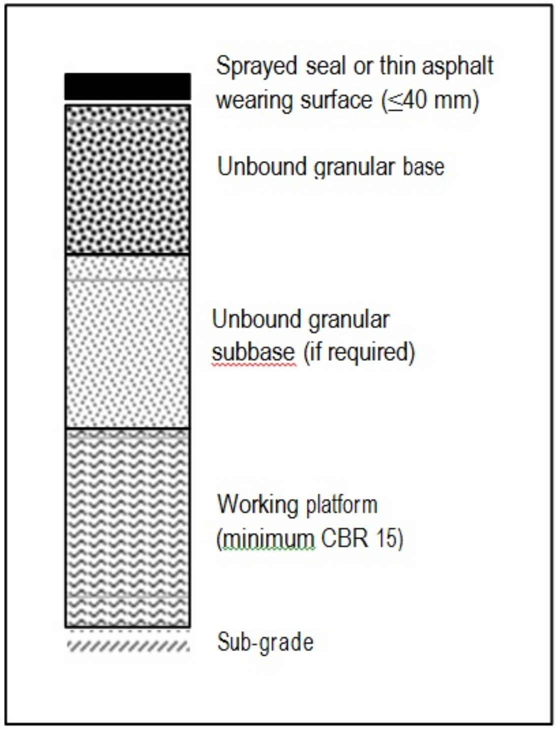


Victoria's map and locations of selected road sections

NETWORK SELECTION CRITERIA

Pavement type for class C roads

- Two lane sealed type roads with shoulders.
- Provide important links between population centers, and between these centers and the primary transport network.



Cross section of unbound granular pavement with spray/chip seal

Study Approach

Data collection process
- Condition data
- Factors affecting pavement performance

Data preparation process
- Alignment
- Filtering
- Screening
- Matching
- Arranging

Data splitting
- Model development
- Model validation

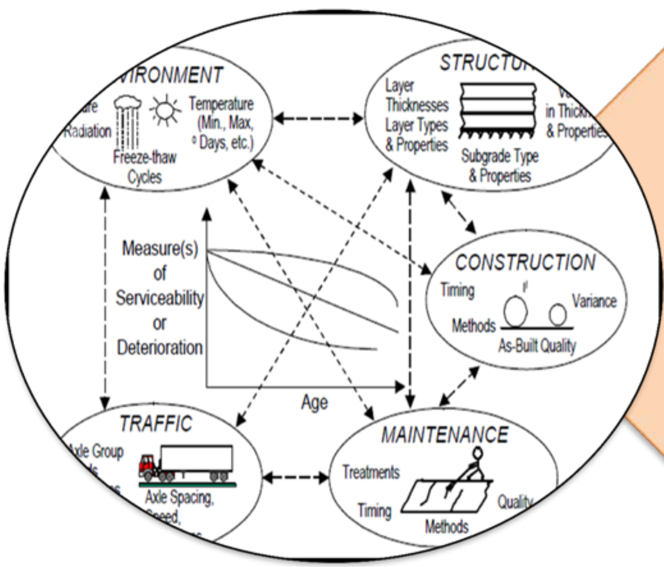
Analysis approach
- Absolute /aggregate deterministic approach
- Family group data fitting approach

STUDY APPROACH

Data Collection Process

Condition data (DV)

- Roughness (IRI, m/km)



Factors affecting pavement roughness progression (IVs)

- Traffic loading
- Pavement strength
- Pavement age
- Subgrade soil
- Climate
- Drainage
- Terrain

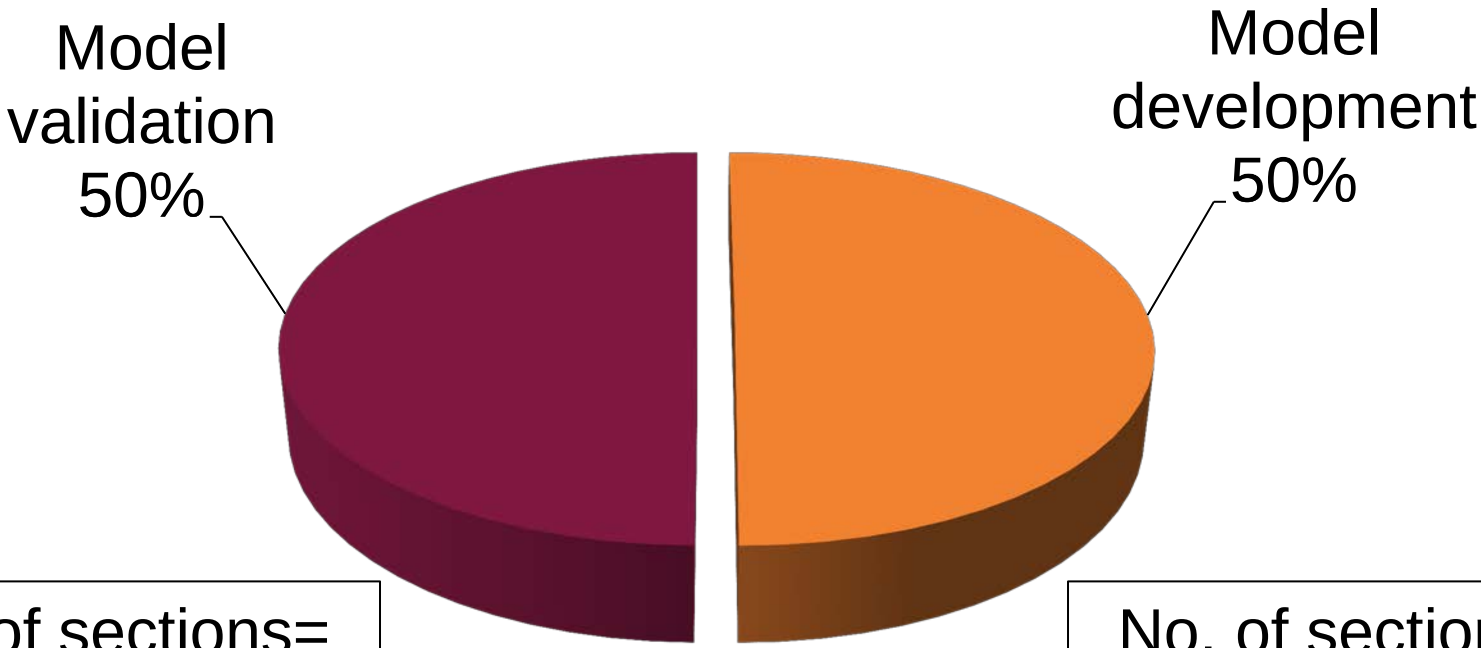
STUDY APPROACH

Data Preparation Process

Alignment	• Using profile viewing and analysis (ProVal)software • Using In-house Excel-based tool
Screening	• Using profile viewing and analysis (ProVal) software • Using statistical package for social sciences (SPSS)
Filtering	• Using linear rate of progression (LRP) tool
Matching	• Using Excel software for matching chainage of all variables.
Arranging	• Using Excel software for developing time series datasets

STUDY APPROACH

Data Splitting



No. of sections= 2,755

No. of sections= 2,767

STUDY APPROACH

Analysis Approach

- Multiple regression analysis was used to develop roughness models for the whole data set and relevant families/groups:

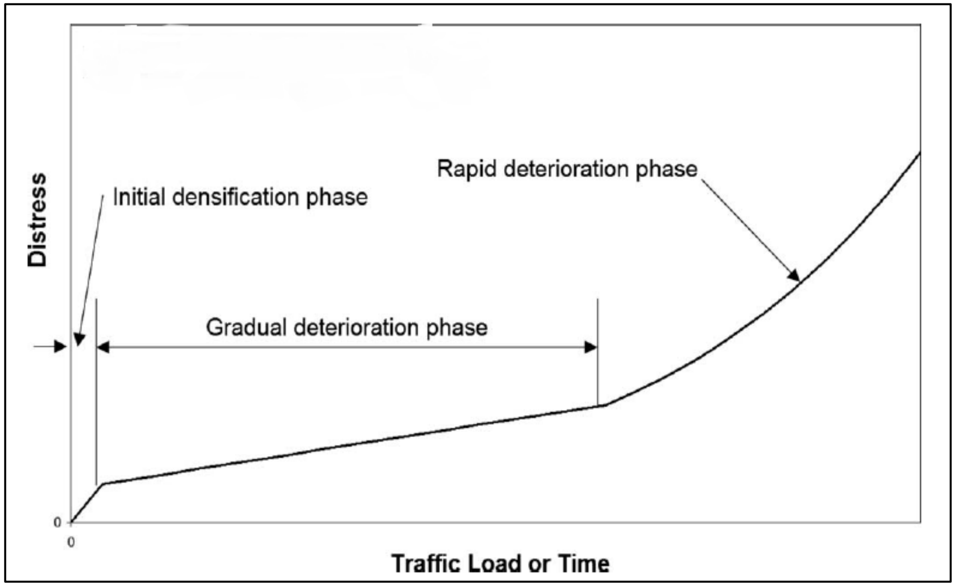
Roughness (IRI) = *f* (traffic loading, soil reactivity, climate, drainage and terrain)

  - Traffic loading in million equivalent standard axles (MESA): ranged (0.032 to 2.495)
  - Soil reactivity (SSR): coded (non- expansive=0 and expansive=1)
  - Climate in terms of Thornthwaite Moisture Index (TMI) : ranged (-24 to 54)
  - Drainage (DRA): coded (good = 0 and poor = 1)
  - Terrain (TER): coded (flat = 0 and non- flat = 1)

STUDY APPROACH

Analysis Approach

The development of roughness includes three phases; initial, gradual and rapid deterioration. Only gradual phase was considered.



Phases of pavement deterioration (Reproduced after Freeme, 1983)

Models Development

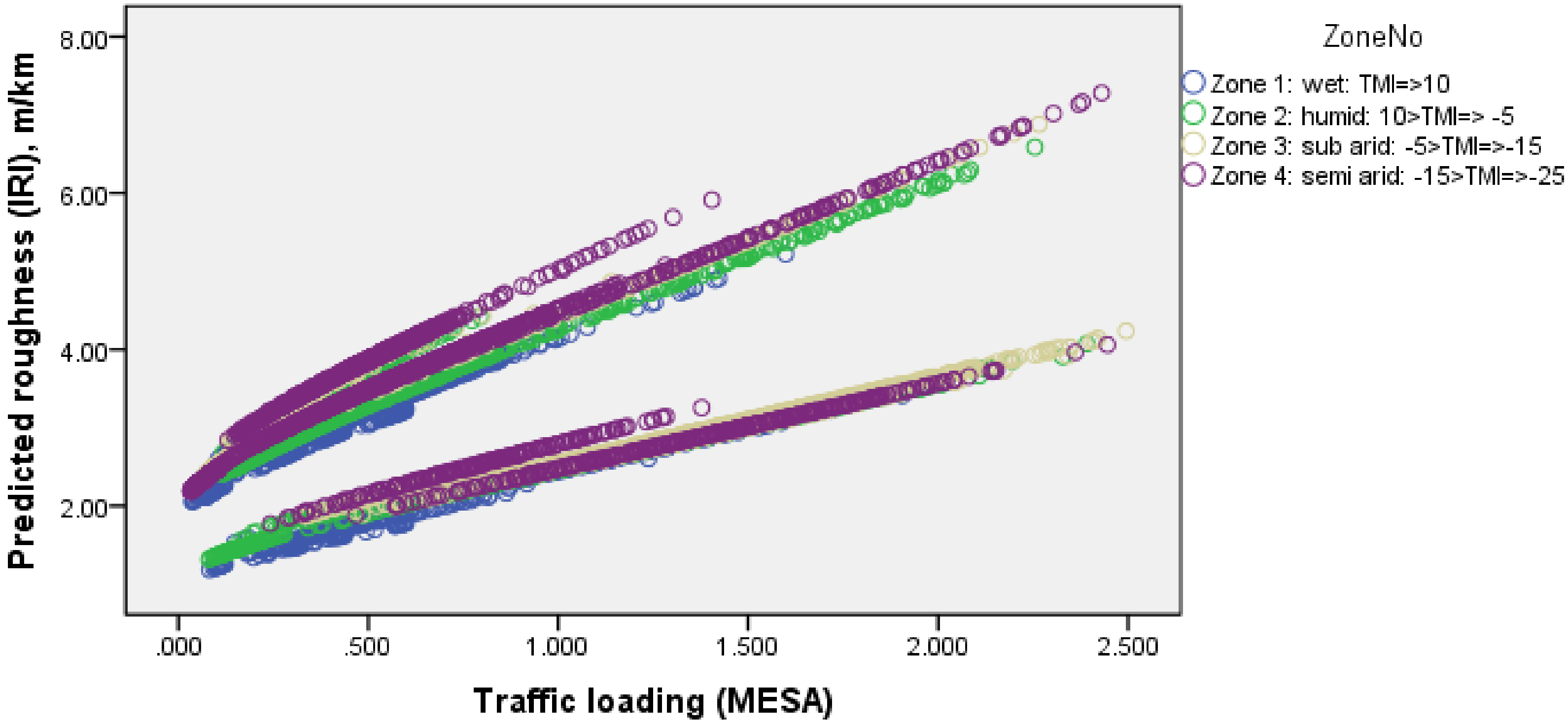
Roughness Model (IRI, m/km)

Log IRI = 0.38 √MESA – 0.001 TMI + 0.255 SSR + 0.047 DRA + 0.018 TER

- No constant
- Gradual phase (IRI = 1.8 to 6.7 m/km)
- Time series sample size (N) = 8,971
- Std. Error of Est. = 0.143 m/km IRI
- Partial R^2 for MESA = 62%, SSR = 53%, TMI=1%, DRA=1.7% & TER=0.3%
- Higher traffic loading and soil reactivity, poor drainage, non-flat terrain and dry climate increase roughness progression rate.

MODELS DEVELOPMENT

Roughness Model (IRI, m/km)



MODELS DEVELOPMENT

Roughness Model (IRI, m/km)

Roughness model for expansive soil	Roughness model for non-expansive soil
Log IRI = 0.675 √MESA – 0.002 TMI + 0.067 DRA + 0.163 TER	Log IRI = 0.42 √MESA + 0.004 TMI + 0.237 DRA

Roughness model for expansive soil:

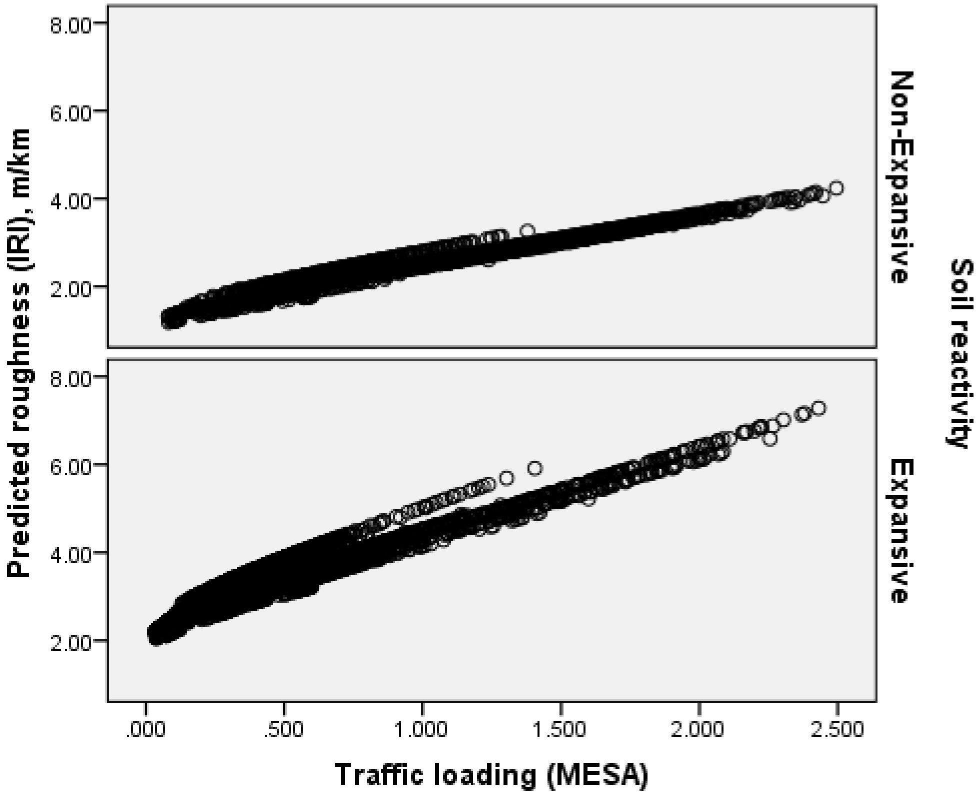
- Sample size (N) = 6,848
- Std. Error of Est. = 0.178 m/km IRI
- Partial R^2 for MESA = 81%, TMI=5%, DRA=3% & TER=10%

Roughness model for non-expansive soil:

- Sample size (N) = 2,123
- Std. Error of Est. = 0.133 m/km IRI
- Partial R^2 for MESA = 90%, TMI=18% & DRA=31%

MODELS DEVELOPMENT

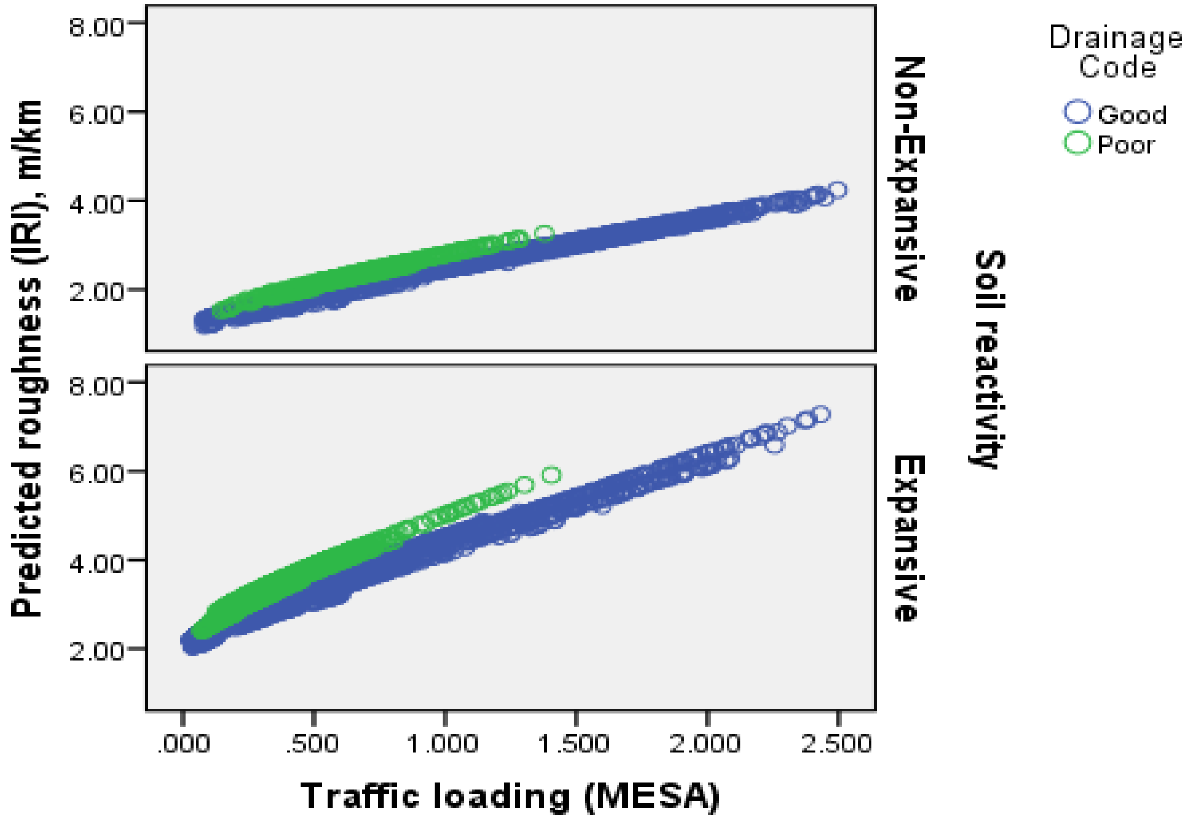
Roughness Model (IRI, m/km)



- Expansive soils are associated with higher roughness rate than non-expansive

MODELS DEVELOPMENT

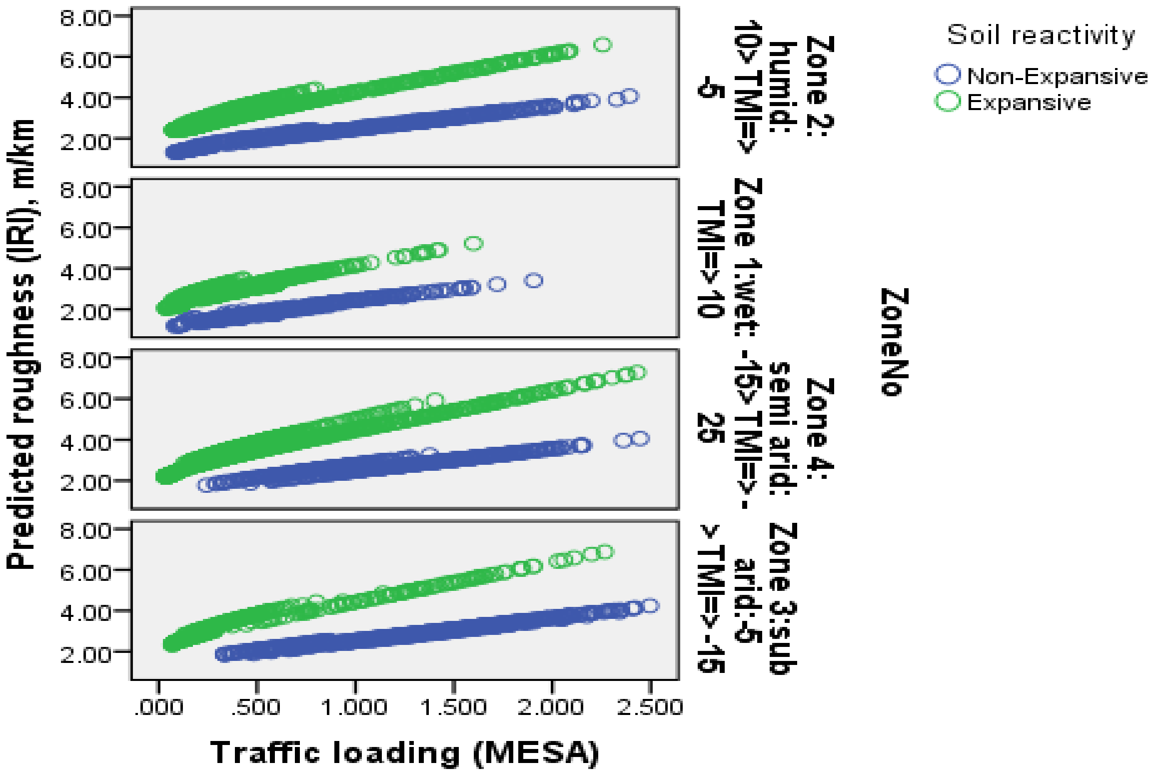
Roughness Model (IRI, m/km)



- Poor drainage produces higher roughness rate than good drainage

MODELS DEVELOPMENT

Roughness Model (IRI, m/km)

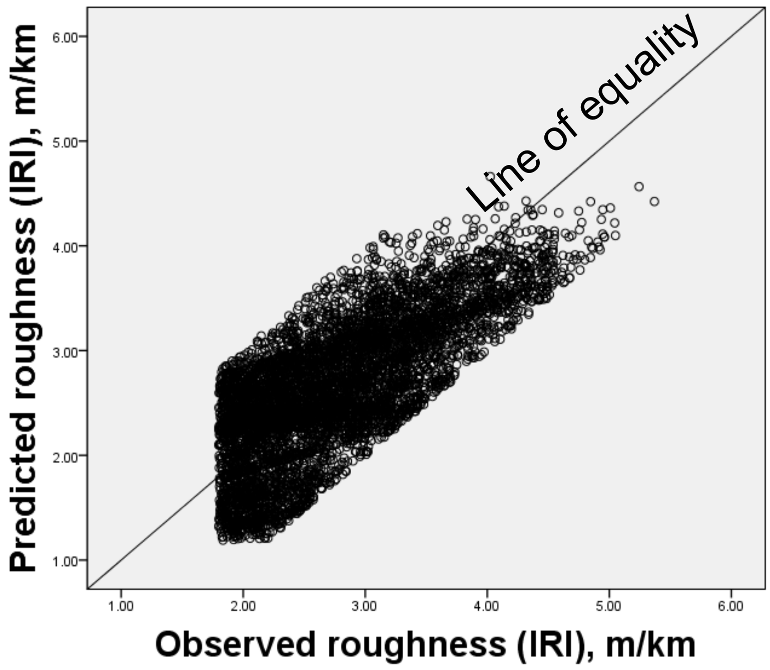


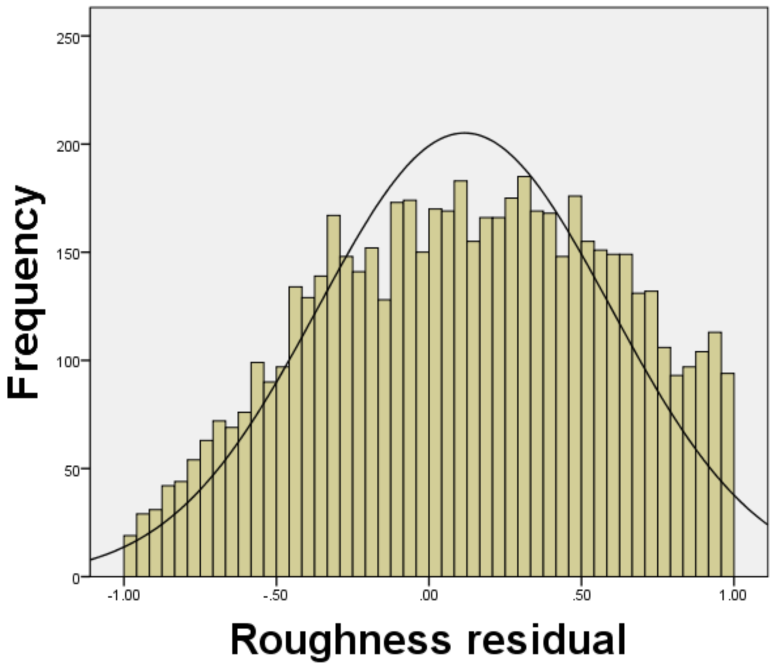
- Dry areas exhibit higher roughness rate than wet areas in expansive soil
- Wet areas exhibit higher roughness rate than dry areas in non-expansive soil

Model Validation

Validation of whole dataset model

72% of sample size (8,263) within residual value ±1 IRI with std. dev. = 0.48





Conclusions

Main points of study outcomes are:

- Traffic loading and soil reactivity are the most important predictors of pavement roughness progression.

- Sections built on expansive subgrade soils are associated with higher roughness values and progression rates than those with non-expansive soils
  - Expansive soil is sensitive to moisture changes during seasonal variation cycles which leads to swelling or shrinkage phenomena.

Conclusions

- Sections in arid climates exhibit higher roughness progression than those in wet climates, regardless of the type of subgrade soil reactivity.
  - This is mainly due to the fact that the former experience higher seasonal moisture variation than the latter.

- Sections with expansive subgrade soils in arid climates exhibit higher roughness progression than those in wet climates.

- Sections with non-expansive subgrade soils in wet climate zones exhibit higher roughness progression than those in dry climate zones.

- Any Questions