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3-D Characterization of Asphalt Pavement Macrotexture for Skid Resistance Evaluation

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OUTLINE

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- Relationship between DFT60 and the 3-D indicators
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INTRODUCTION

- Surface texture of pavement is an important factor impacting skid resistance.
  - Macrotexture
  - Microtexture
- MTD and MPD are usually used to charaterize macrotexture, but it is hard to link MTD or MPD with skid resistance directly.
- Some new indicators derived from profile data have also been constructed, but the improvement is limited.

INTRODUCTION

- The macrotexture of pavement is an irregular 3-D curved surface. Indicators from profile is not enough to characterize the pavement macrotexture.
- This work adopted a 3-D laser scanner for pavement digitizing.
- Then indicators and relationships to skid resistance.

FIELD TESTS

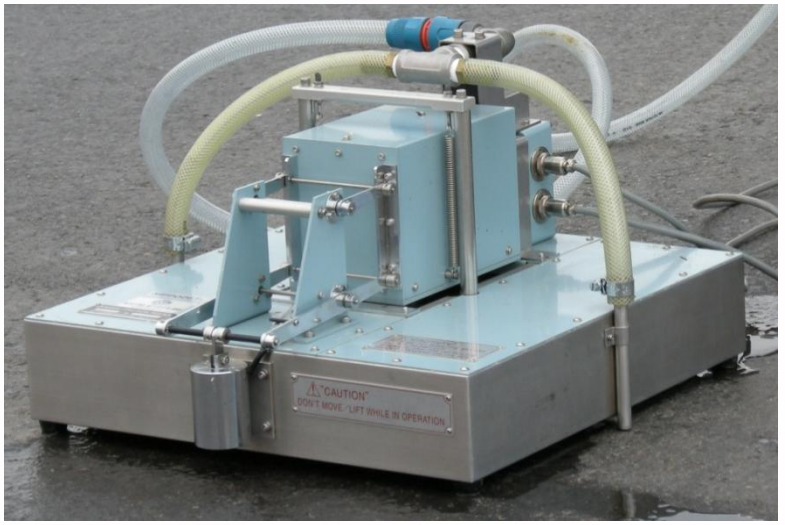
- **Asphalt pavement surfaces tested**
  - **Asphalt Concrete (AC)**
  - **Stone Matrix Asphalt (SMA)**
  - **Rubber Asphalt Concrete (RAC)**
  - **Ultra Thin Wearing Course (UTWC)**
  - **Mirco Surfacing (MS)**

FIELD TESTS

Highway coding	Grade	Surface type	Number of test sites	Opening date
G101	1	SMA	5	Aug. 2010
G101	1	UTWC	4/4	Sep. 2010/Sep. 2009
G101	1	MS	4	Sep. 2009
G111	2	AC	7	Jul. 2009
G111	2	RAC	6	Sep. 2010
X020	3	AC	3	Sep. 2009

FIELD TESTS

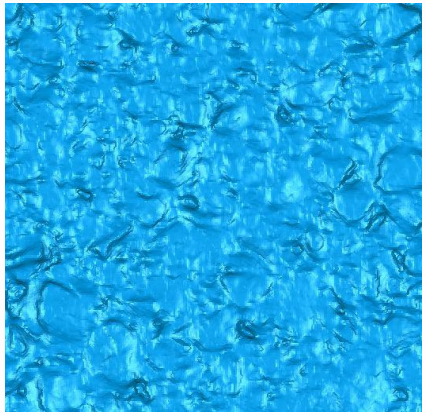
3-D laser scanner



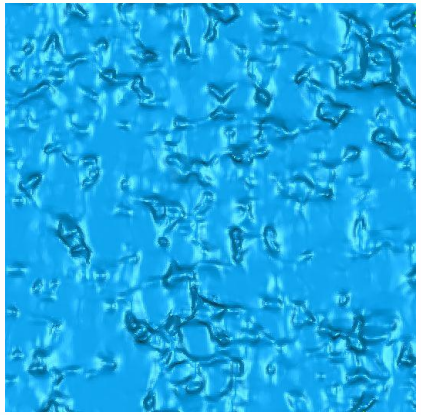
Dynamic Friction Tester (DFT)

Sand patch

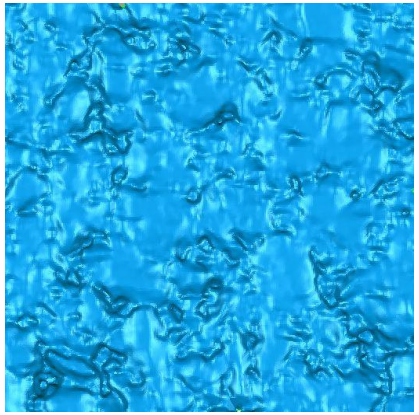
FIELD TESTS



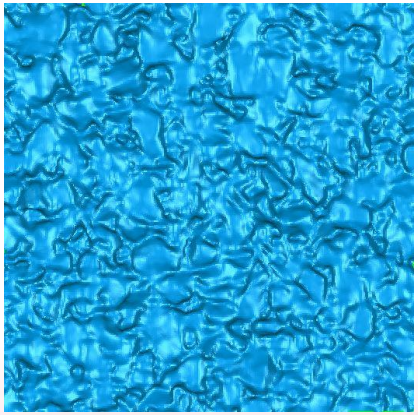
(a) AC



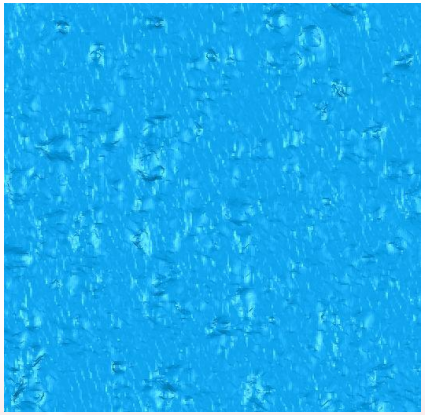
(b) SMA



(c) RAC



(d) UTWC



(e) MS

INDICATORS DERIVED FROM THE 3-D DIGITAL PAVEMENT SURFACE

$$\sigma = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(Z_i - \bar{Z})^2}$$

Z **is the value of Z coordination of each point**

Z axis directs to the normal direction of the fitting plane of the macrotexture.

INDICATORS DERIVED FROM THE 3-D DIGITAL PAVEMENT SURFACE

$$N_a = \frac{1}{n}\sum_{i=1}^{n} \arccos N_Z^i$$

N_Z is the Z component of the unit normal vector of the point

N_Z is also the cosine value of the angle between the point normal vector and Z axis

INDICATORS DERIVED FROM THE 3-D DIGITAL PAVEMENT SURFACE

$$N_{ca} = \frac{1}{n}\sum_{i=1}^{n} N_z^i$$

N_z is the Z component of the unit normal vector of the point

N_z is also the cosine value of the angle between the point normal vector and Z axis

RELATIONSHIP BETWEEN DFT60 AND THE 3-D INDICATORS

Pearson correlation coefficient matrix

Indicators	DFT60	MTD	σ	N_a	N_{ca}
DFT60	1	0.44832	0.30915	0.60327	-0.60924
MTD	0.44832	1	0.92487	0.91175	-0.88646
σ	0.30915	0.92487	1	0.89565	-0.89362
N_a	0.60327	0.91175	0.89565	1	-0.98434
N_{ca}	-0.60924	-0.88646	-0.89362	-0.98434	1

RELATIONSHIP BETWEEN DFT60 AND THE 3-D INDICATORS

The stepwise selection result of multiple linear regression

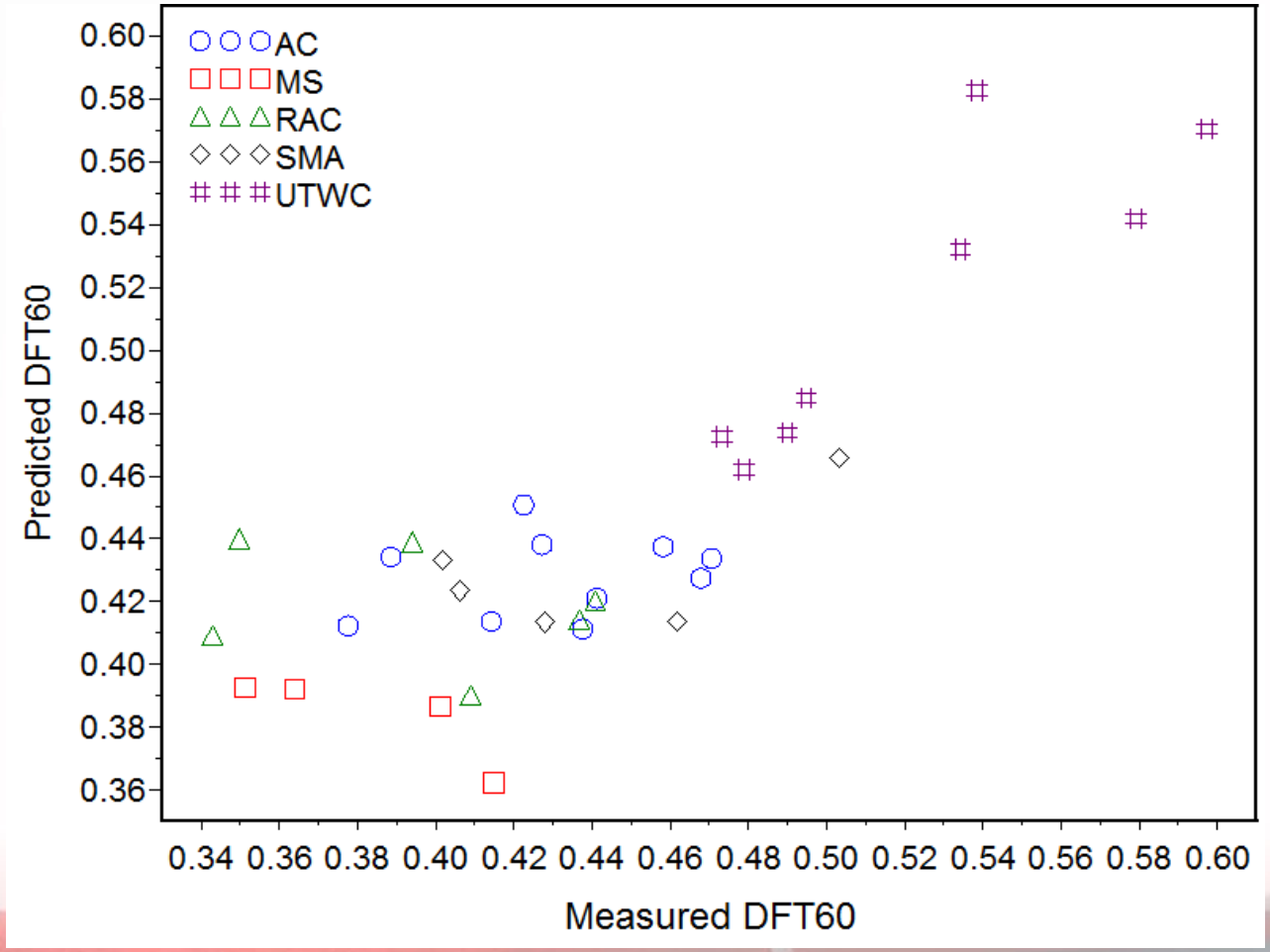
Step	Variable entered	Partial R-square	Model R-square	C(p)	F value	Pr > F
1	N_{ca}	0.3712	0.3712	26.0675	18.3	0.0002
2	σ	0.2748	0.646	4.0044	23.28	<.0001
3	MTD	0.0316	0.6775	3.2407	2.84	0.1028

RELATIONSHIP BETWEEN DFT60 AND THE 3-D INDICATORS

- **Three macrotexture indicators, including Na, σ, and MTD, entered the linear regression model with R-square of 0.6775.**

$$DFT60 = -4.33086N_{ca} - 0.44673\sigma + 0.14878MTD + 4.72378$$

RELATIONSHIP BETWEEN DFT60 AND THE 3-D INDICATORS



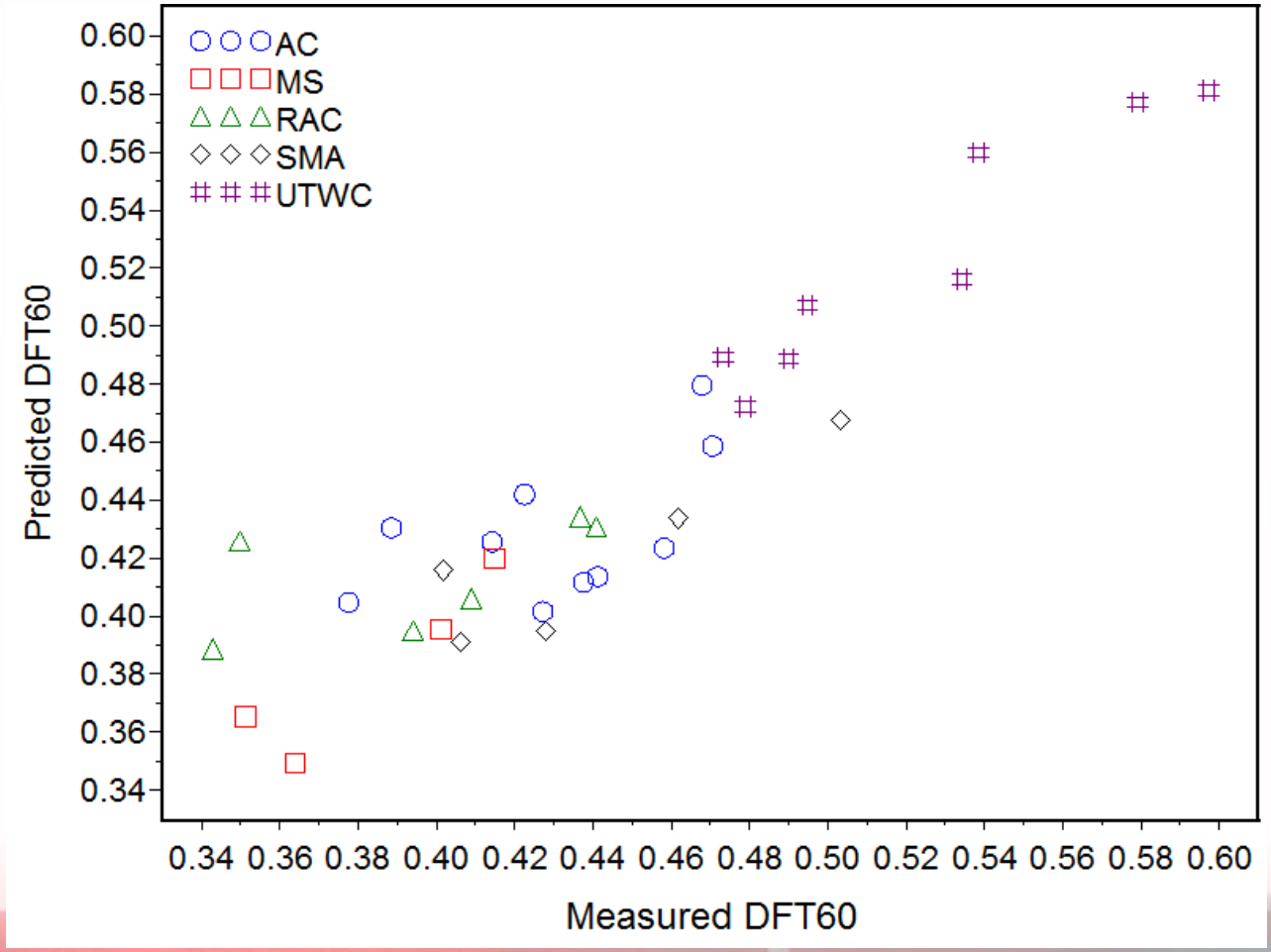
RELATIONSHIP BETWEEN DFT60 AND THE 3-D INDICATORS

- **This work tries the quadratic polynomial regression.**

$$DFT60 = MAM^T + BM^T + c$$

- **When *MTD*, σ, N_a, and N_{ca} entered the model, R-square is up to 0.8375.**

RELATIONSHIP BETWEEN DFT60 AND THE 3-D INDICATORS



RELATIONSHIP BETWEEN DFT60 AND THE 3-D INDICATORS

- The regression analyses show obvious improvement derived from 3-D macrotexture indicators in pavement skid resistance evaluation, though the 3-D macrotexture indicators constructed in this work are not very detailed.

SUMMARY

- **The conclusion can be summarized as follows:**
  - **The method using the 3-D laser scanner adopted in this work can fulfil the requirements of in situ collection of 3-D digital macrotexture.**
  - **Indicators derived from 3-D digital macrotexture have obvious advantage than TMD for pavement skid resistance evaluation.**

SUMMARY

- **This work is just a preliminary evaluation.**
  - **More detailed indicators should be constructed based on the 3-D digital macrotexture with consideration of the mechanism of tire-pavement friction.**
  - **Simpler model describing the relationship between macrotexture and skid resistance should be studied for practice application.**

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