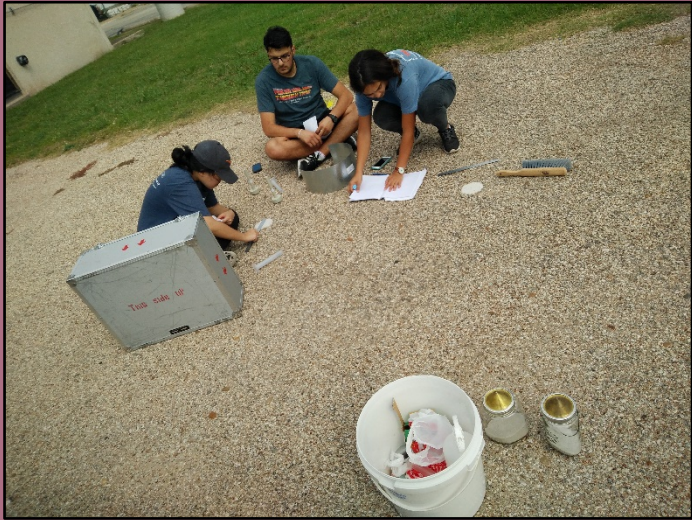# CHARACTERIZATION OF PAVEMENT TEXTURE BASED ON MACROTEXTURE ANALYSIS

Faculty Advisor: Dr. Jorge A. Prozzi

Graduate Student: Natalia Zuniga-Garcia

Undergraduate Student: Tiffany Tang

Significance

- About 70,000 crashes in 2016 were caused by wet roads in the state of Texas (TxDOT).

- Goal: Improve techniques for characterizing pavement based on surface macrotexture analysis
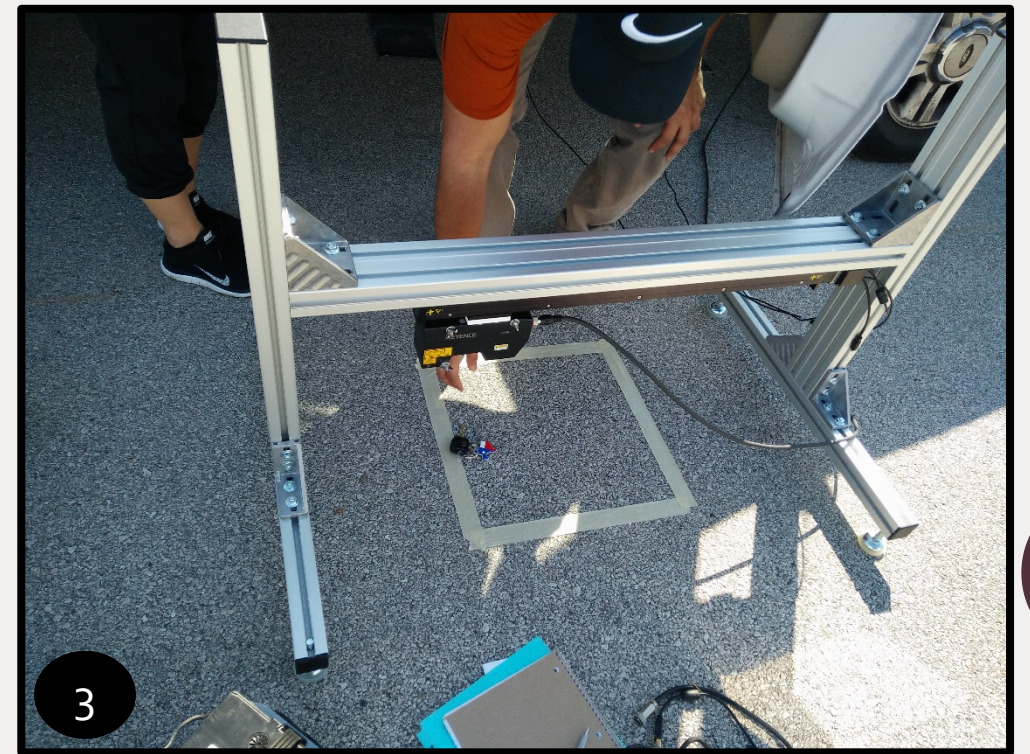
Why is Surface Texture important?

- – Controls road friction

- – Affects tire traction

- – Low-friction sections are dangerous

- – Estimate Friction Conditions of roads

Surface Texture Tests

1. Sand Patch Test

2. Circular Track Meter (CTM)

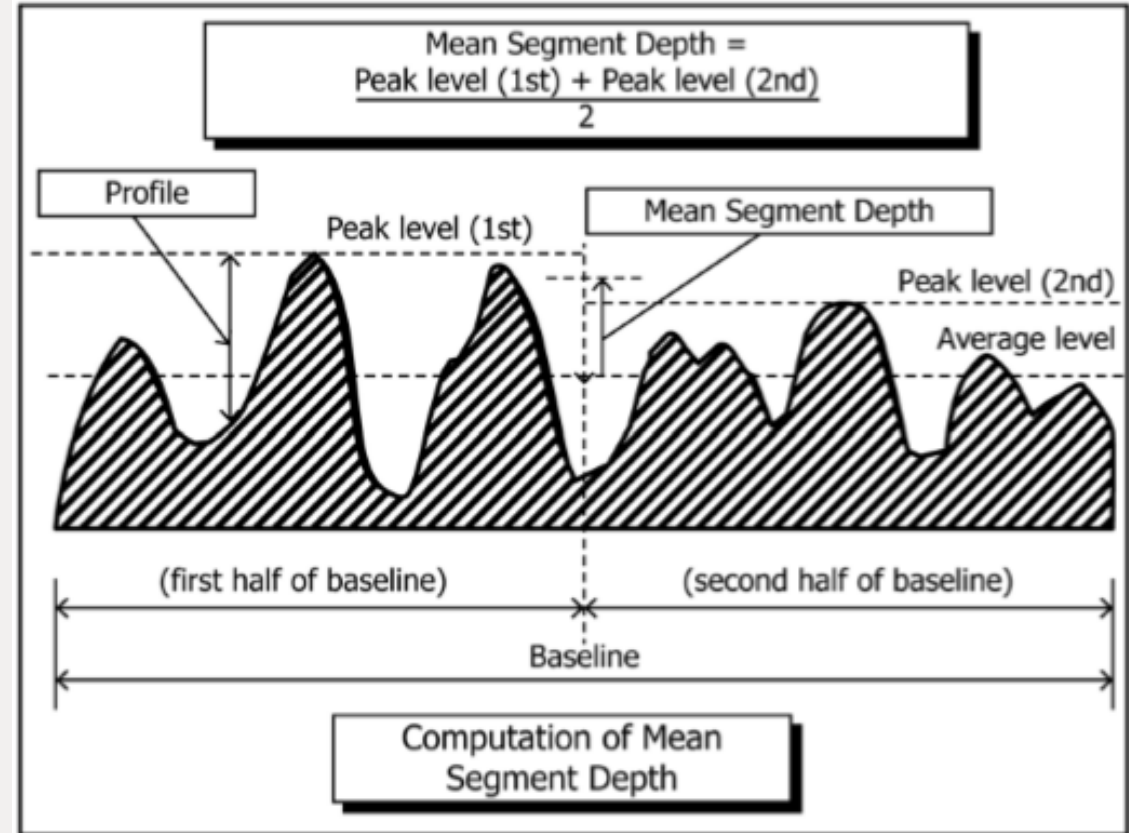3. Line Laser Scanner (LLS)

Calculations
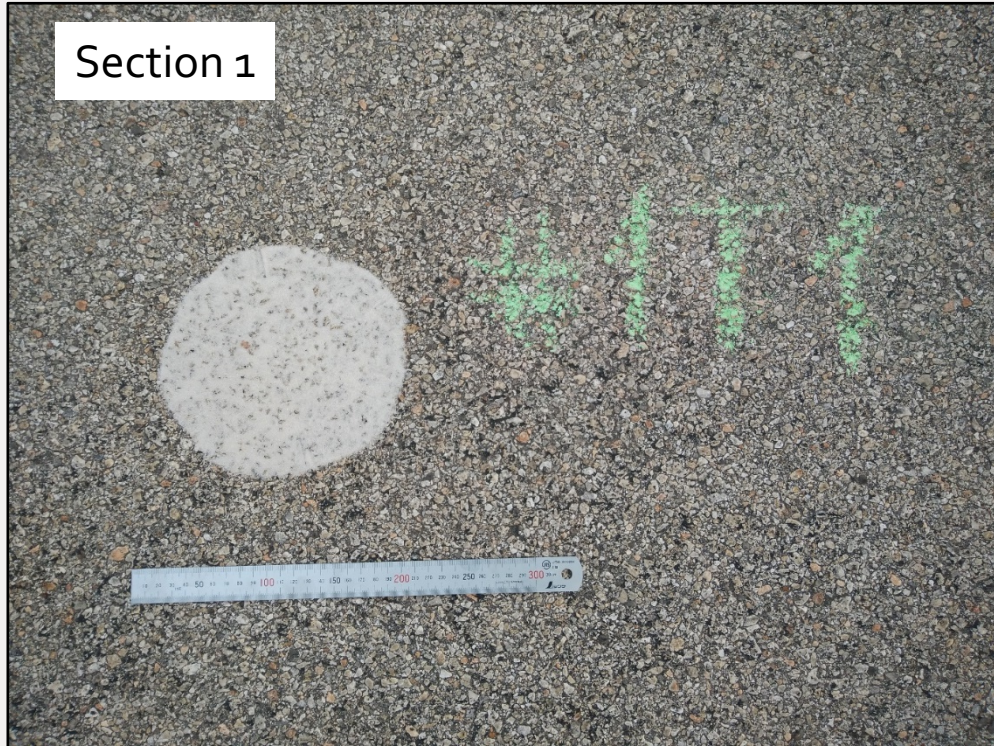
$$MTD = \frac{4V}{\pi D^2} \qquad (2)$$

where:

MTD = mean texture depth of pavement macrotexture, in. (mm),

V = sample volume, in.^{3} (mm^3), and

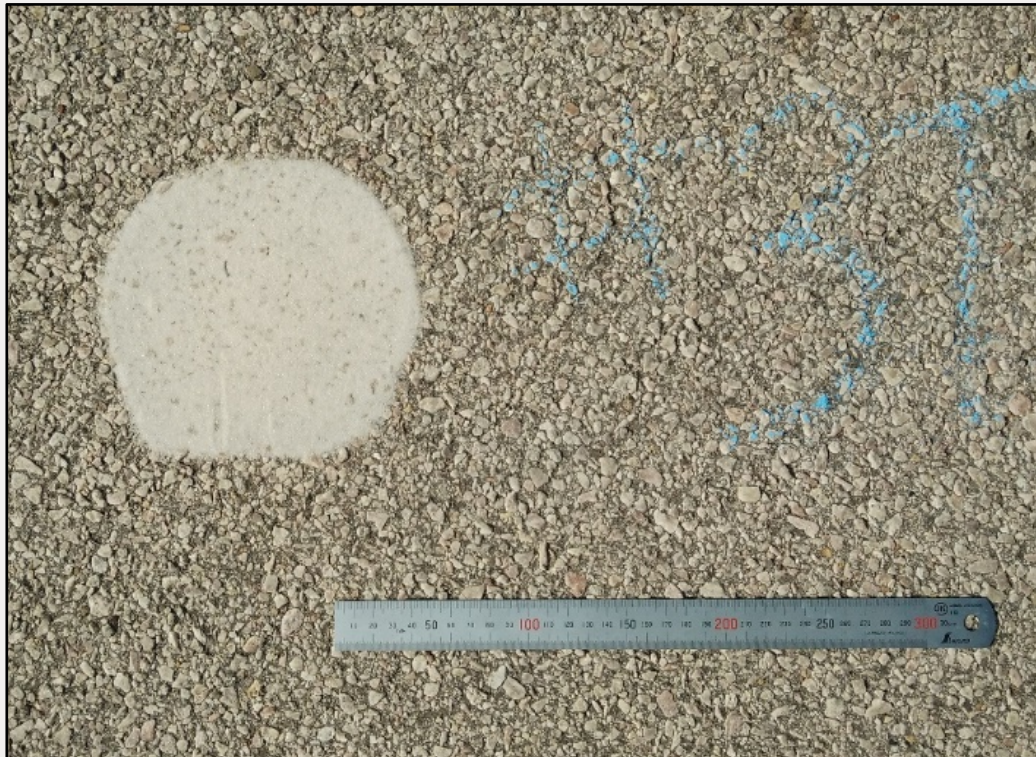D = average diameter of the area covered by the material, in. (mm).

Mean Segment Depth = $\dfrac{\text{Peak level (1st)} + \text{Peak level (2nd)}}{2}$

Computation of Mean Segment Depth

Data Collection

Section 1

Section 2

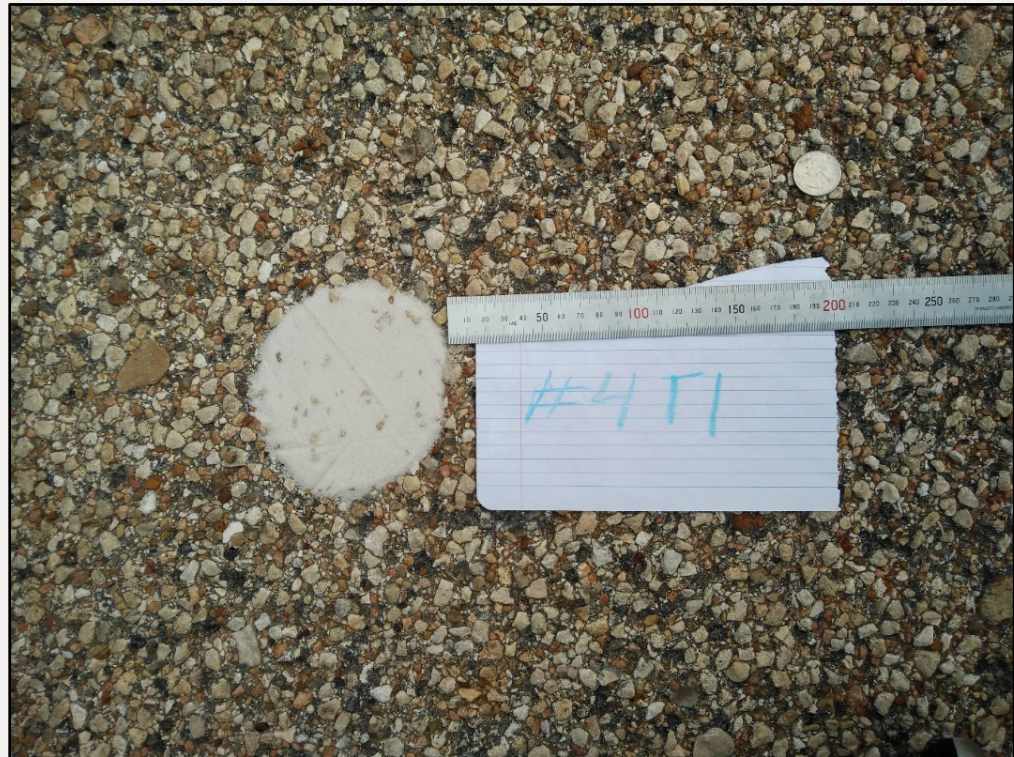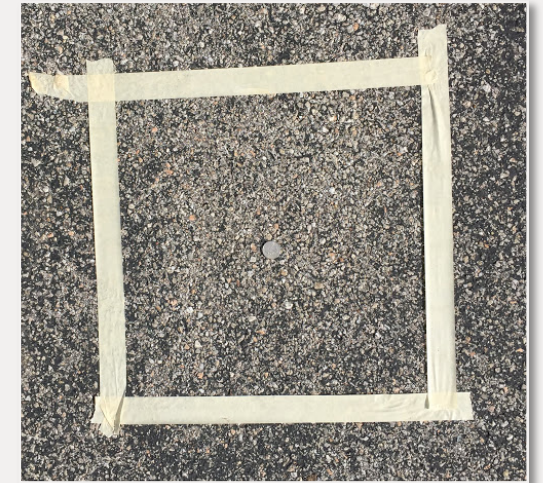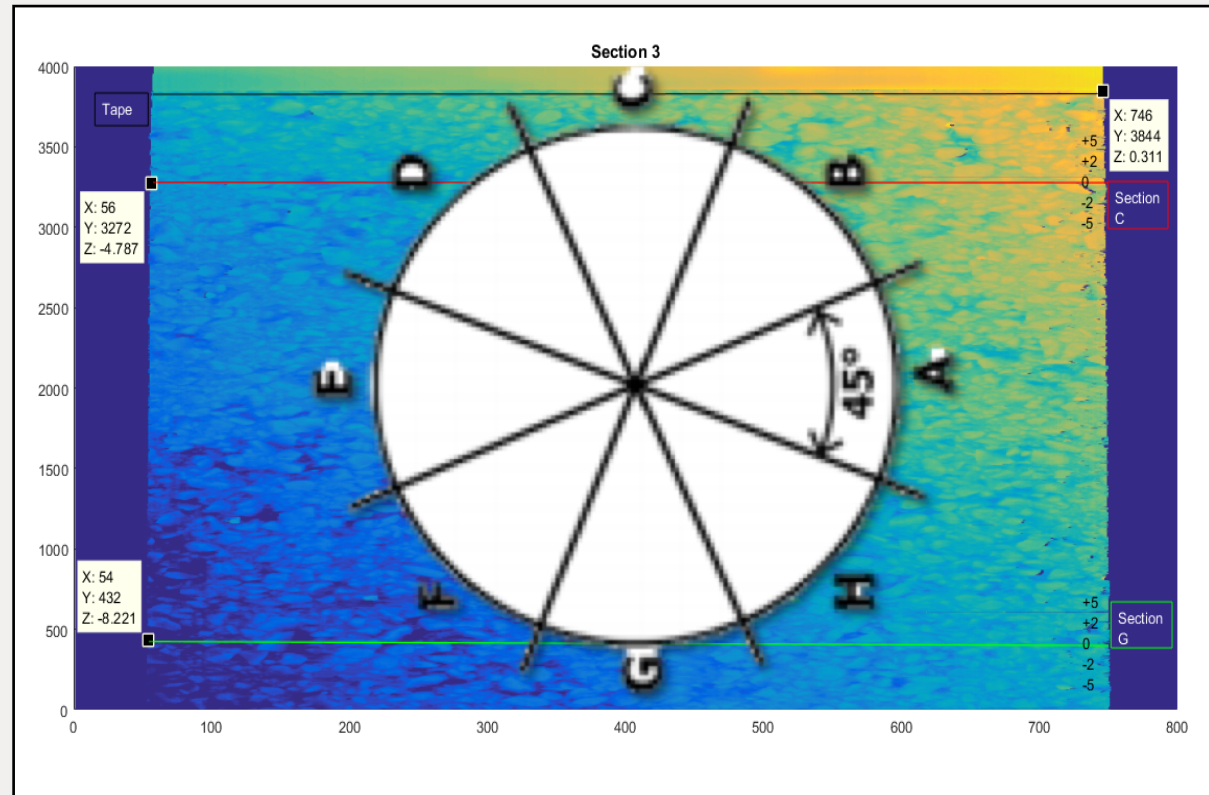# Data Collection

Section 3

Section 4

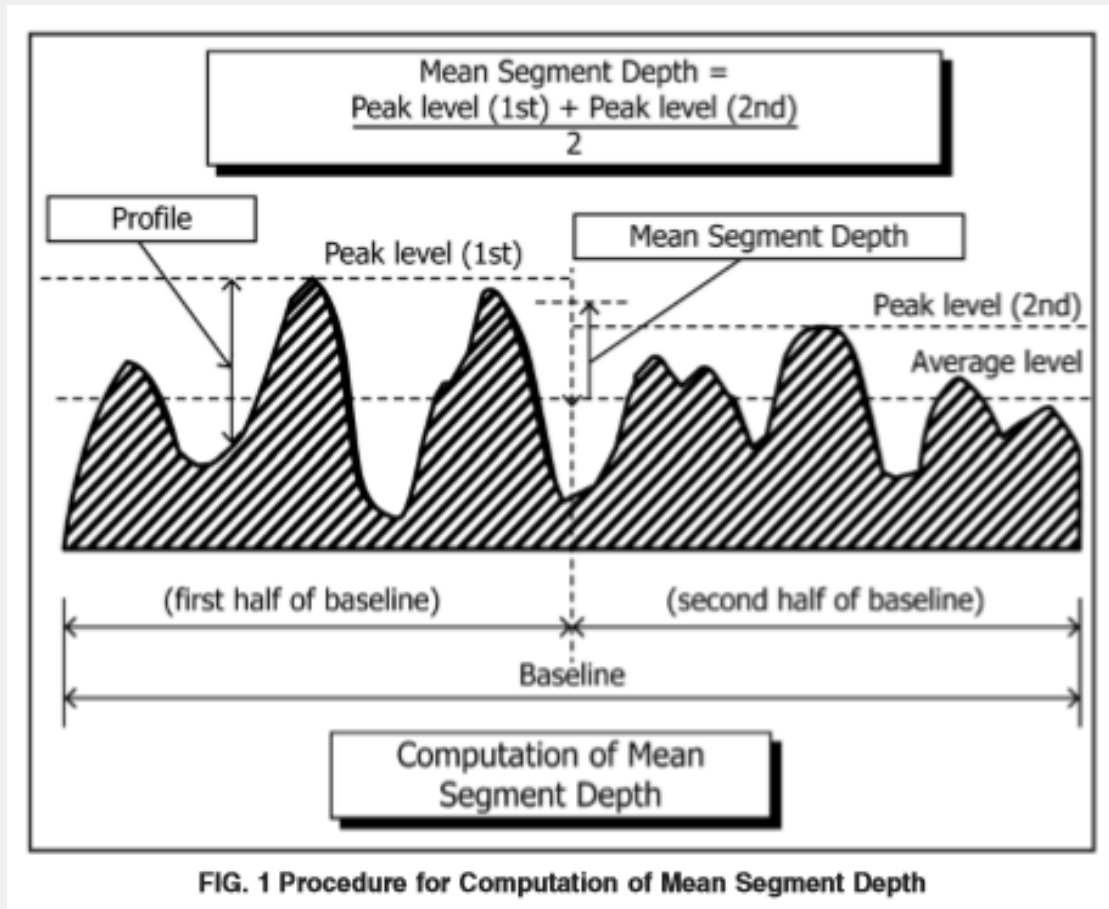# *Data Collection – Line Laser Scanner*

- Each point in the profile has a separation of 0.225 mm.
- 446 points are used to get profiles of 100 mm each.

Total of 10 Profile Lines

- 5 from C Region
- 5 from G Region

Data Processing - MPD (LLS) Estimation

Mean Segment Depth =
$$\frac{\text{Peak level (1st)} + \text{Peak level (2nd)}}{2}$$

FIG. 1 Procedure for Computation of Mean Segment Depth

```
In [19]: profile = signal.detrend(z[4,:]) # Assume the profile is 100 mm
    ...:
    ...: def MPD_estimate(x):
    ...:     # Input
    ...:     # x: a 100 mm texture profile in an 1D array
    ...:     # Output:
    ...:     # MPD in mm as float number
    ...:
    ...:     rows=np.shape(x)[0]
    ...:     max1 = np.max(x[0:int(rows/2)])
    ...:     max2 = np.max(x[int(rows/2+1):rows])
    ...:     MPD = np.average([max1, max2])
    ...:     return MPD
    ...:
    ...:
    ...: MPD_estimate(profile) # call the function
Out[19]: 0.90644560870525215
```

* Written in Python for MPD Estimation

Data Processing - MPD Profile Processing

```python
"""
Created on Thu Oct 26 13:43:32 2017

@author: Tiffany
"""

import numpy as np
import matplotlib.pyplot as plt
from scipy import signal

#%% import data to z
data=np.loadtxt(open("DataG1.csv","rb"),delimiter=",") # FILE CHANGE FOR EACH SAMPLE
data=np.array(data).astype('float') # Original Data to check
z=np.array(data).astype('float')

#%% Plot X

plt.figure(1);
plt.plot(z[4,:]);
plt.title('Profiles in X axis');
plt.ylabel('Height (mm)');
plt.xlabel('X (mm)');
plt.savefig('05_ProfilesG.png');

#%% Detrend

plt.plot(signal.detrend(z[4,:]))
plt.title('MPD of Profile 5');
plt.ylabel('Height (mm)');
plt.xlabel('Baselength (100mm)');
plt.savefig('05_ProfilesG.png');
```
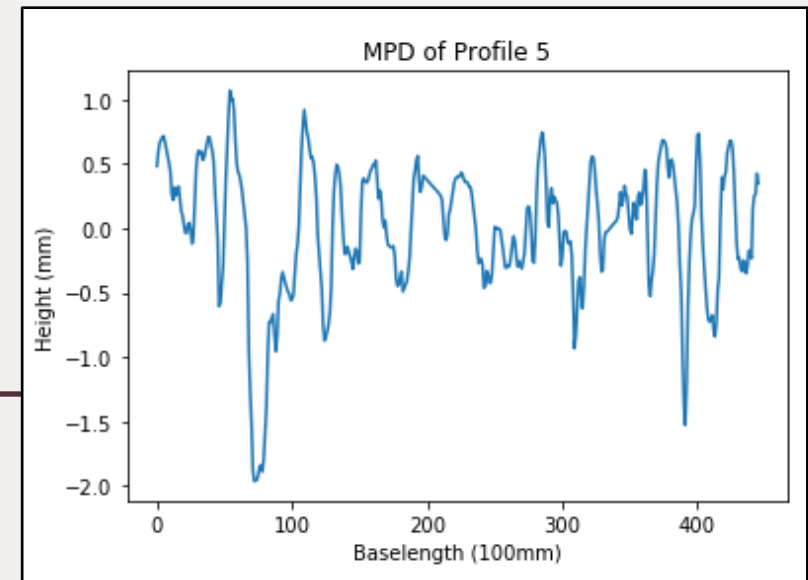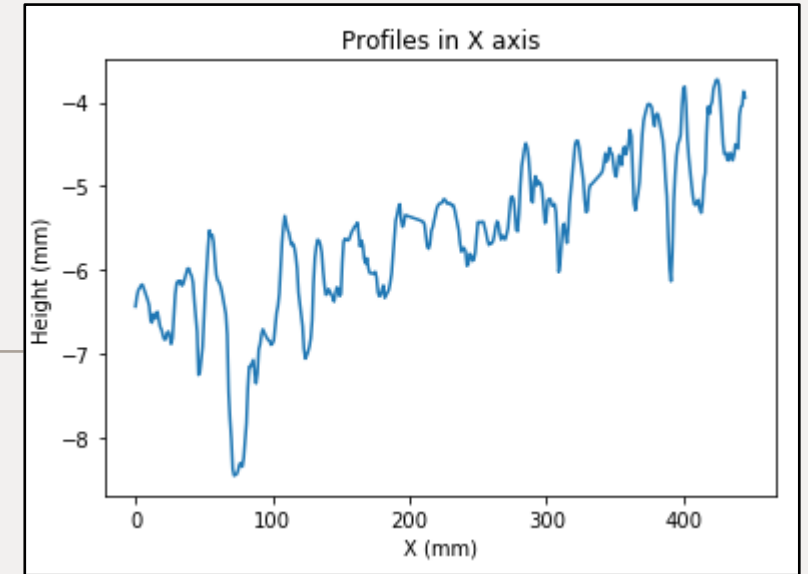

Profiles in X axis

MPD of Profile 5

Results- Section 1

Average MPD (LLS) , mm	Average MPD (CTM) , mm	Percent Error
0.6585	0.6075	8.39 %

LLS- C Region
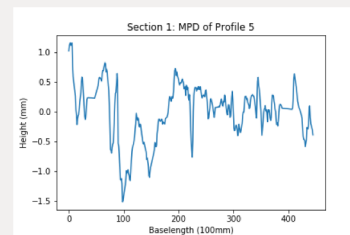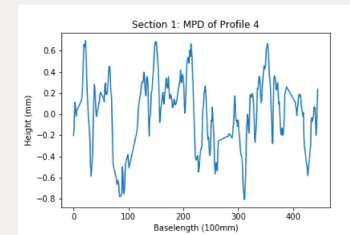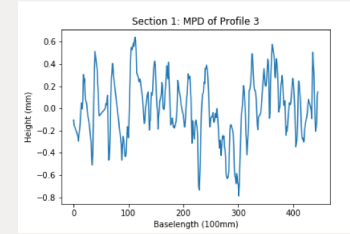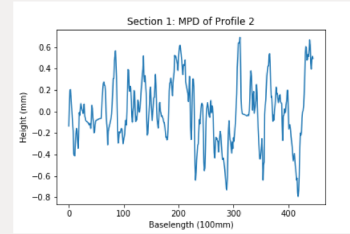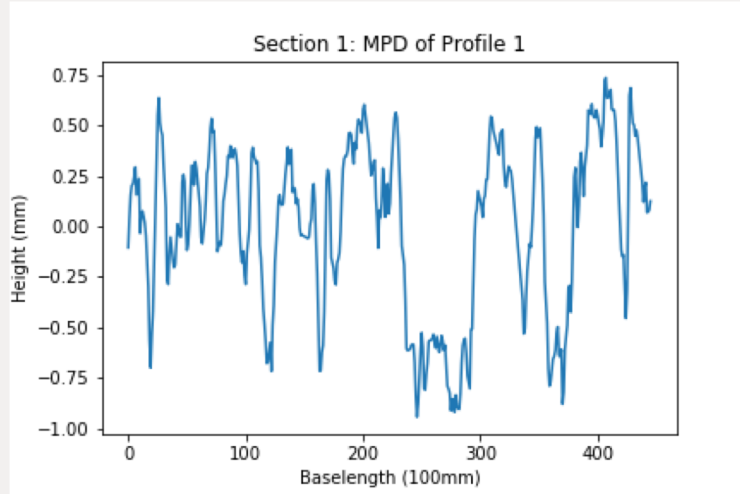
CTM Results
Section C: 0.4775 mm
Percent Error: 47.7906 %

$s = 0.1100$
$s^2 = 0.0121$

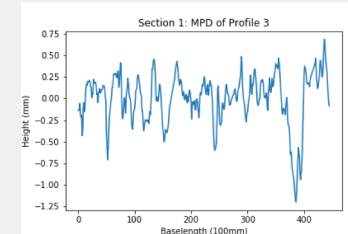| Profile Number	MPD (mm)
1	0.6866
2	0.6532
3	0.6104
4	0.6838
5	0.8946
Average	**0.7057**

LLS- G Region
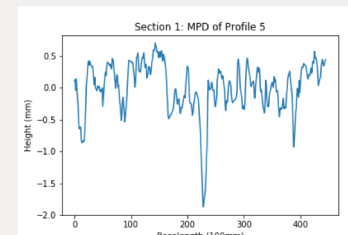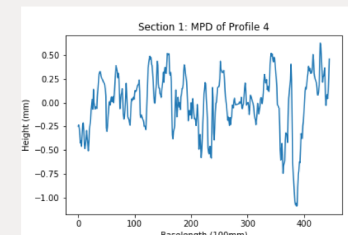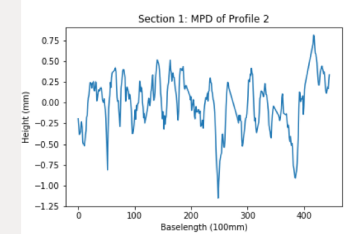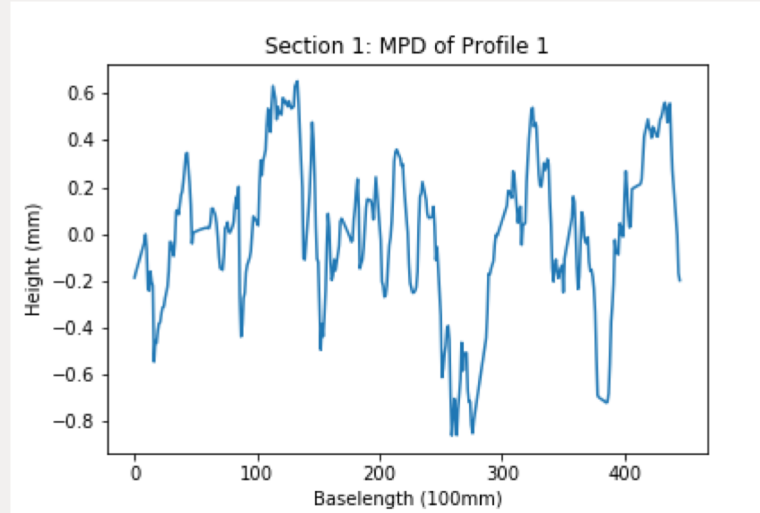
CTM Results
Section G: 0.7800 mm
Percent Error: 21.6282 %

$s = 0.0415$
$s^2 = 0.0017$

Profile Number	MPD (mm)
1	0.6070
2	0.6682
3	0.5697
4	0.5755
5	0.6360
Average	**0.6113**

Results- Section 2

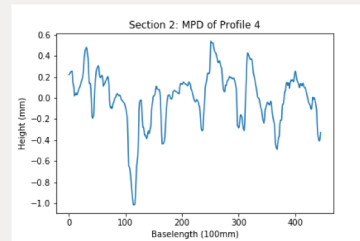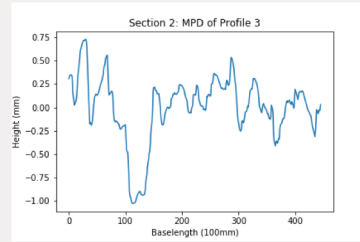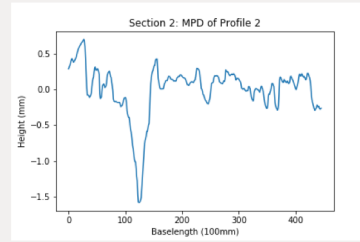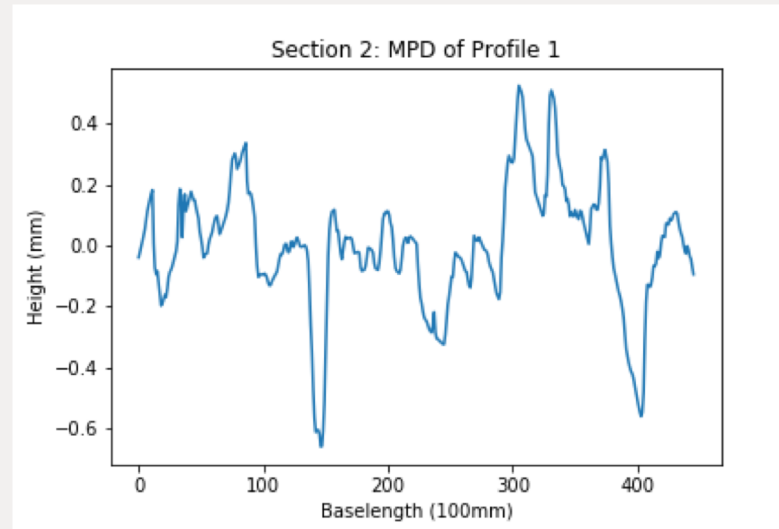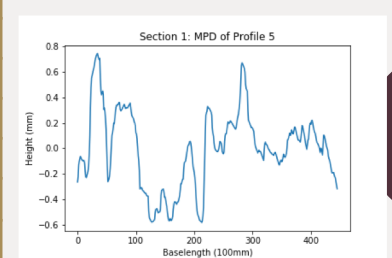| Average MPD (LLS) , mm	Average MPD (CTM) , mm	Percent Error
0.5299	0.4875	8.69 %

LLS- C Region
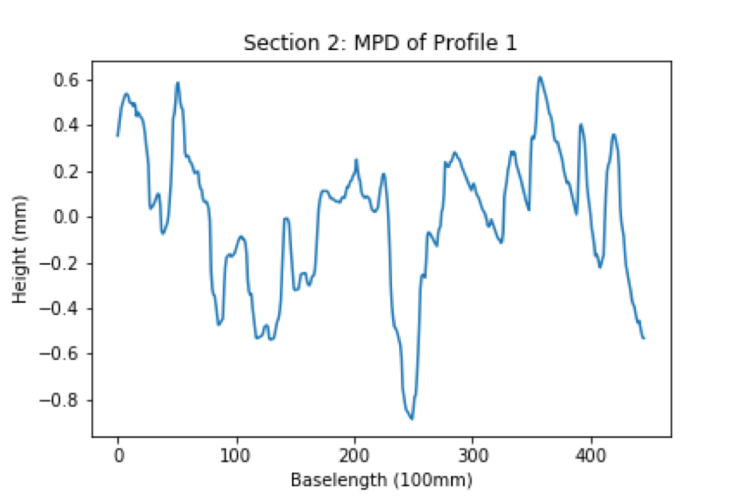
CTM Results
Section C: 0.5800 mm
Percent Error: 6.7943 %

$s = 0.0683$
$s^2 = 0.0047$

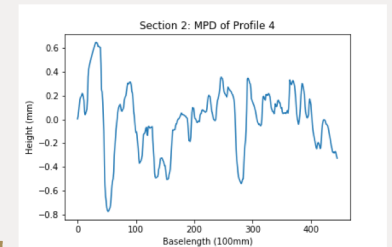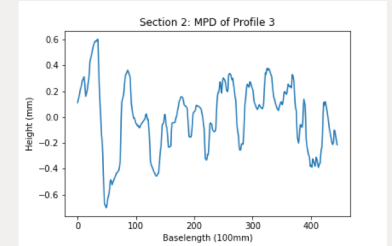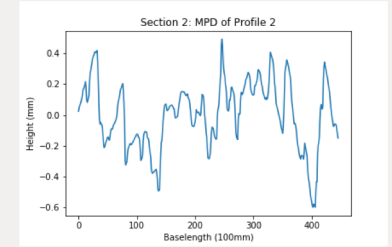| Profile Number	MPD (mm)
1	0.5984
2	0.5007
3	0.6323
4	0.5098
5	0.4742
Average	0.5431
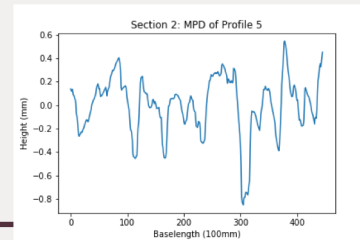
LLS- G Region

CTM Results
Section G: 0.4425 mm
Percent Error: 18.2153 %

$s = 0.1111$
$s^2 = 0.0123$
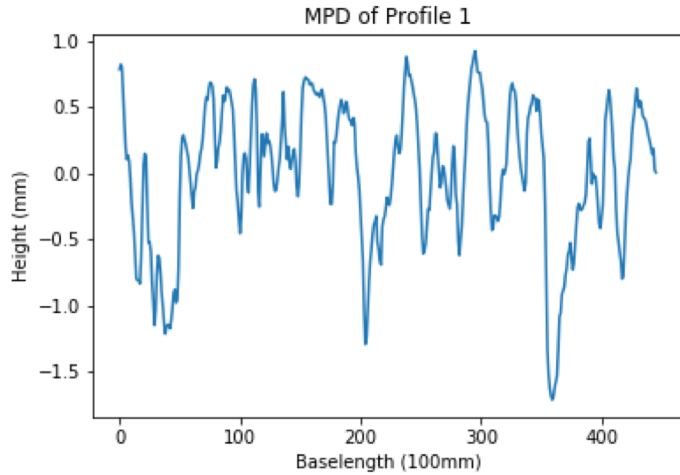
Profile Number	MPD (mm)
1	0.4296
2	0.4546
3	0.4906
4	0.4994
5	0.7089
Average	0.5166

Results- Section 3

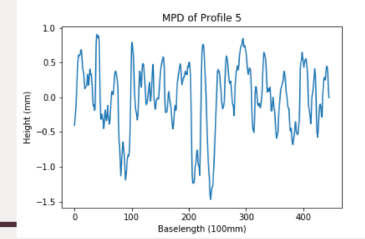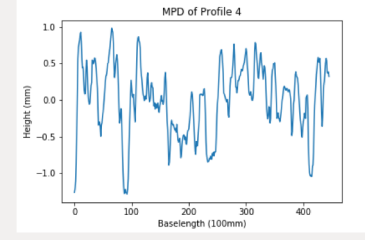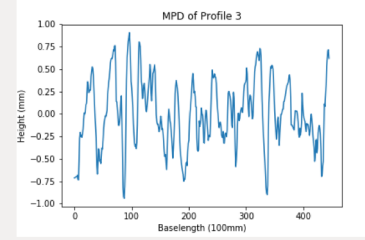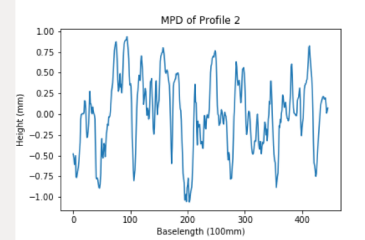| Average MPD (LLS) , mm	Average MPD (CTM) , mm	Percent Error
0.8794	0.8675	1.37 %

LLS- C Region

CTM Results
Section C: 0.8275 mm
Percent Error: 4.5921%

s = 0.0268
s^2 = 0.0007

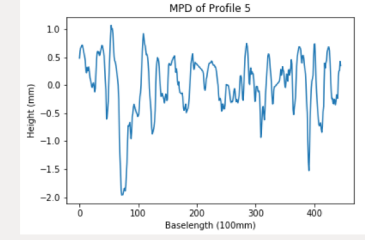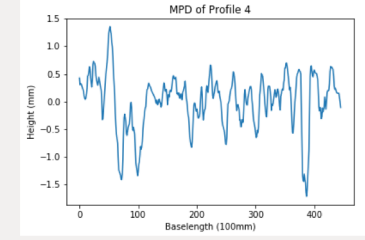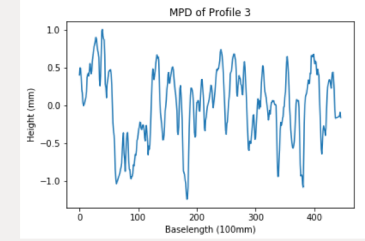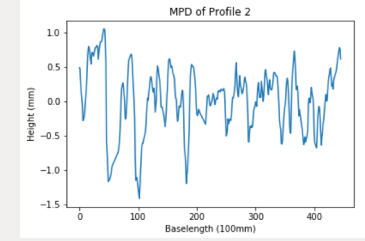| Profile Number	MPD (mm)
1	0.8711
2	0.8786
3	0.8182
4	0.8834
5	0.8761
Average	**0.8655**

LLS- G Region
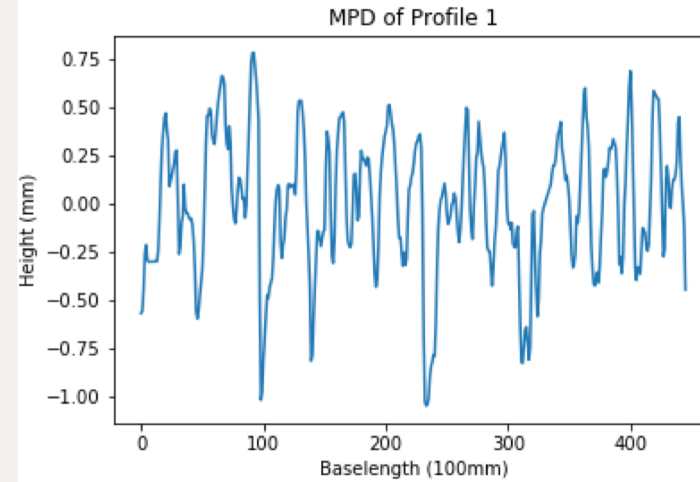
CTM Results
Section G: 0.8175 mm
Percent Error: 9.2722%
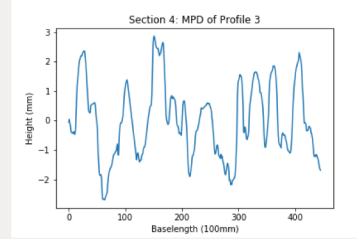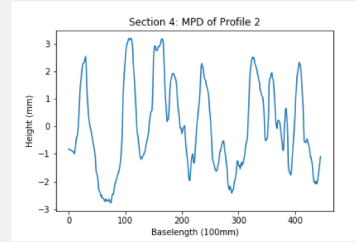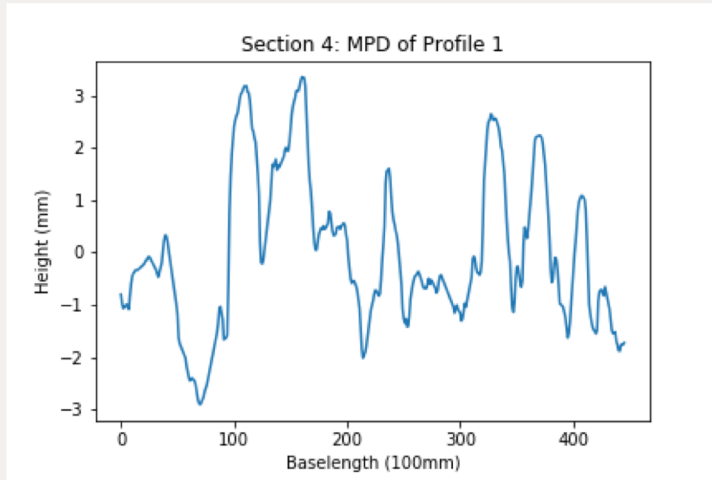
s = 0.1052
s^2 = 0.0111

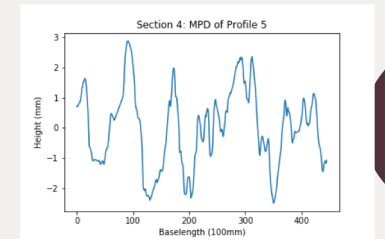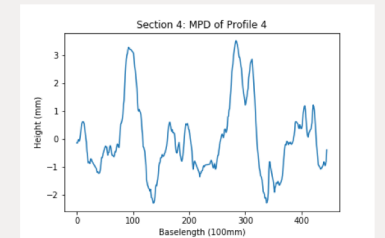| Profile Number	MPD (mm)
1	0.7350
2	0.9176
3	0.8789
4	1.0284
5	0.9064
Average	**0.8933**

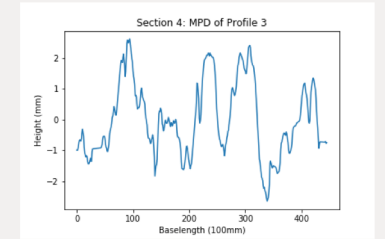# *Results- Section 4*

LLS- C Region
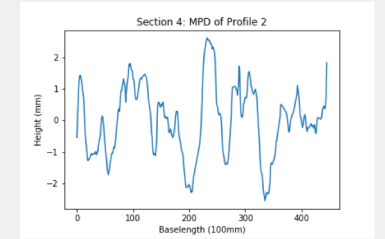

Profile Number	MPD (mm)
1	3.0019
2	2.8557
3	2.5869
4	-
5	-
Average	2.8148

CTM Results
Section C: 2.7800 mm
Percent Error: 1.2518 %

$s = 0.2105$
$s^2 = 0.0443$

LLS- G Region
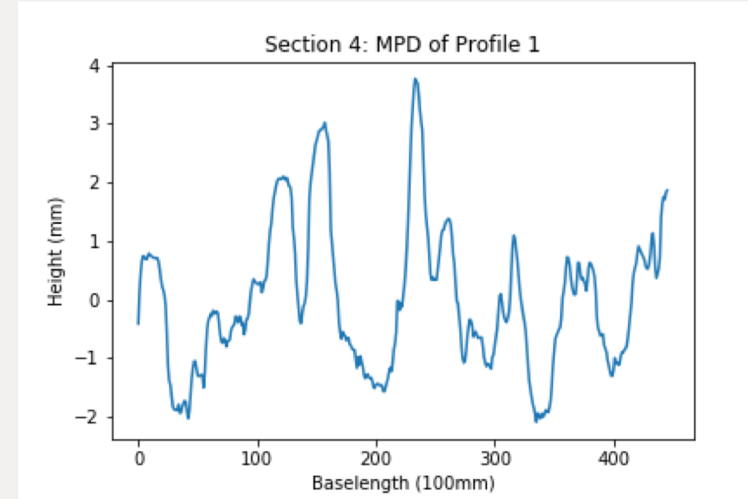
Profile Number	MPD (mm)
1	3.3930
2	2.2035
3	2.5131
4	3.4118
5	2.6272
Average	**2.8297**

CTM Results
Section G: 2.7125 mm
Percent Error: 4.3207 %

$s = 0.5453$
$s^2 = 0.2974$

Results- Summary

Section	Sand Patch, mm	MPD (CTM), mm		
	MTD	Average C & G	Region C	Region G
1	0.93	0.6075	0.4775	0.7800
2	0.51	0.4875	0.5800	0.4425
3	1.07	0.8675	0.8275	0.8175
4	2.45	2.3175	2.7800	2.7125

	Section	Average of C & G (mm)	Average C (mm)	Average G (mm)
Laser	1	0.65850	0.70574	0.61126
	2	0.52986	0.54309	0.51662
	3	0.87937	0.86548	0.89326
	4	2.82228	2.81484	2.82972

Conclusion

Average MPD of C & G — $R^2 = 0.99701$
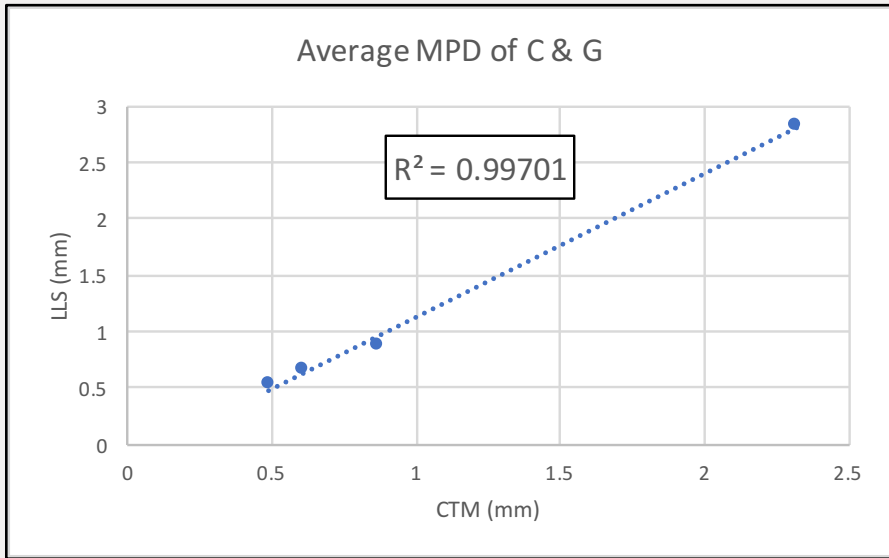
- CTM and the LLS Scanner were able to get relatively the same results

- Small Differences in pavement surface have major impact on overall MPD.

- Several tests of the same area is needed for accuracy

Average MPD Region C — $R^2 = 0.9893$

Average MPD Region G — $R^2 = 0.9881$
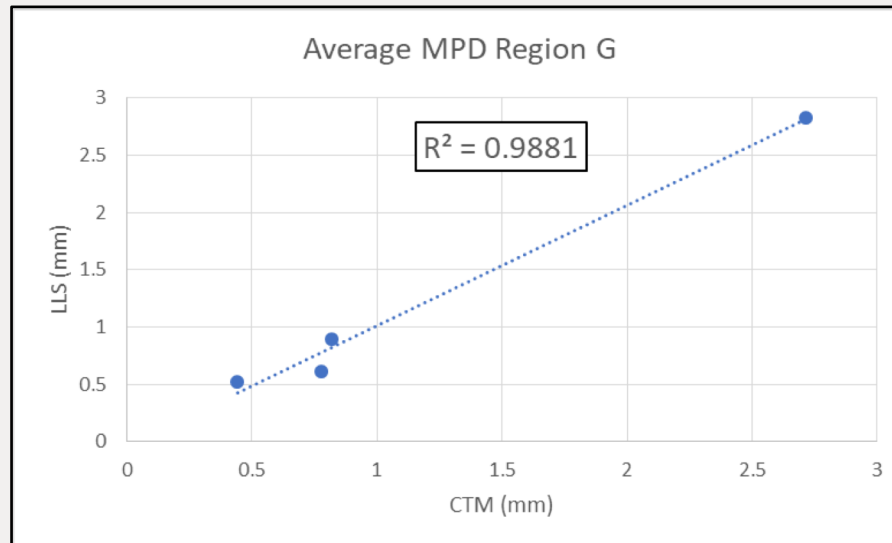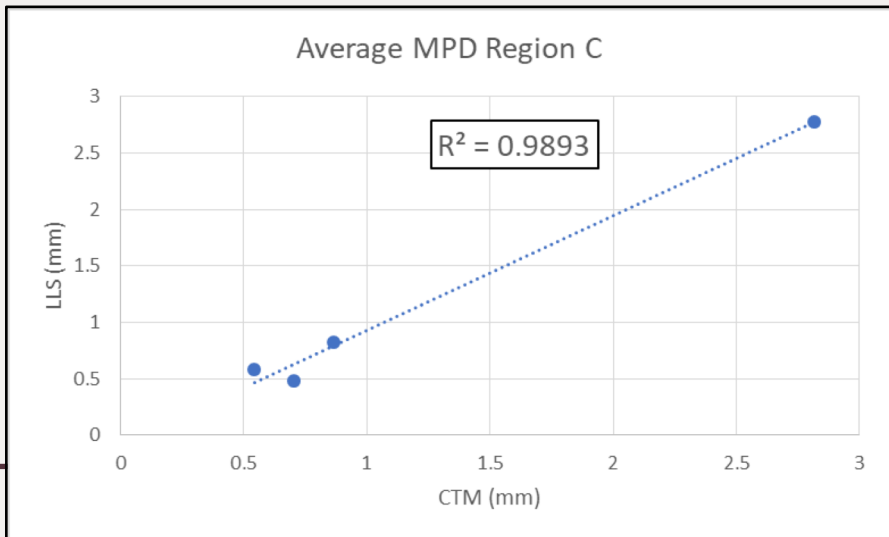
Future Work

- Conduct more field tests to determine accuracy and eliminate issues with the tests

 - Model Friction and skid resistance

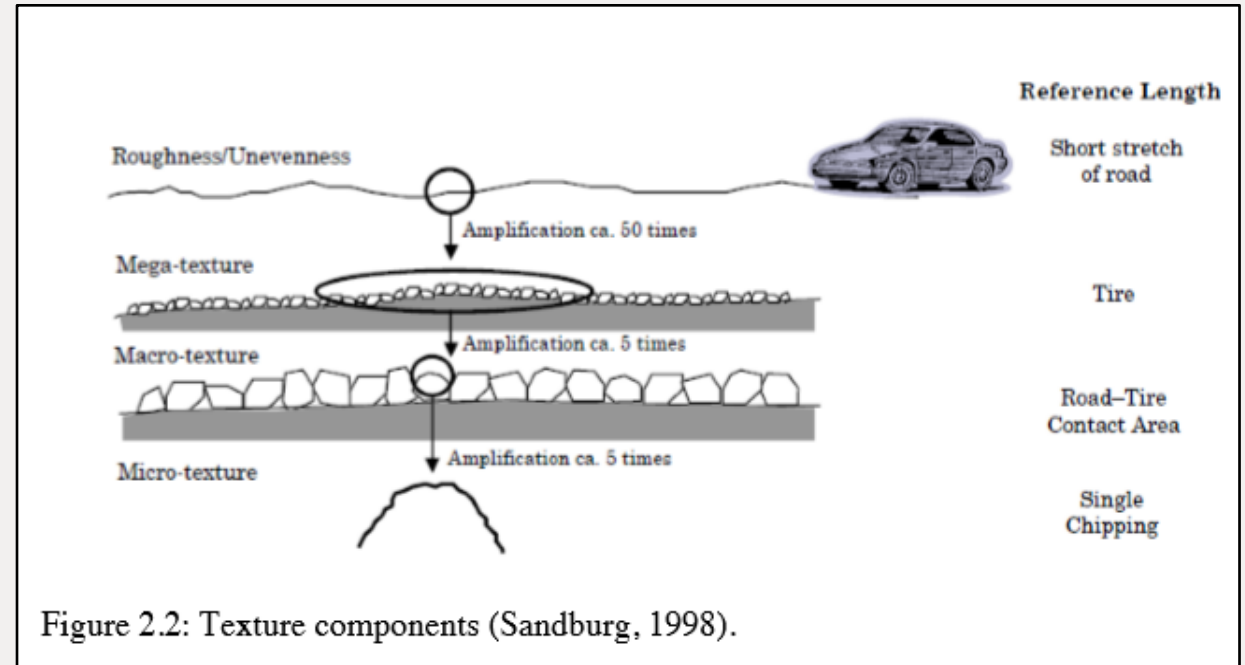- Use CTM and LLS to scan same surface and analyze for similarities in MPD

Figure 2.2: Texture components (Sandburg, 1998).

Acknowledgements

Research Team: Natalia Zuniga-Garcia, Joaquin Hernandez, Christina C. and Yorguo Elhachem

Faculty Advisors: Dr. Machemehl and Dr. Prozzi,

THANK YOU!

Questions or Comments?