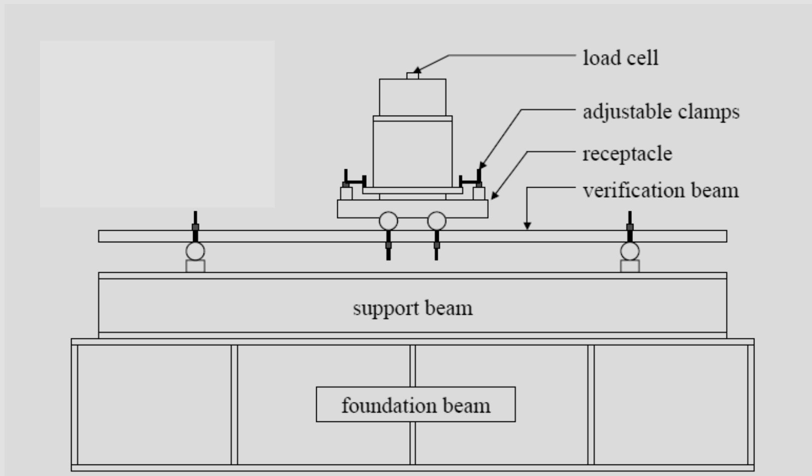
Appendix E
On-Site TAC Meeting Presentation

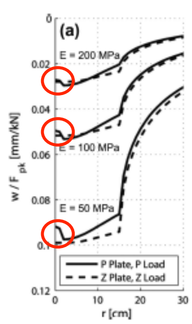
"Beam Verification Testing" (Khosravifar)

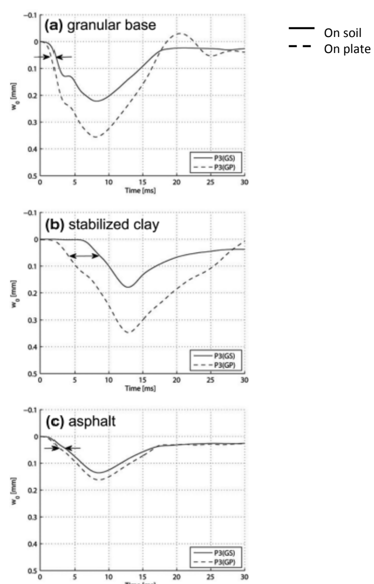
Beam Verification Tester



June 2nd and 3rd, 2015
University of Maryland College Park

Recap on One of the Key Issues in LWD study





Stamp and Mooney (2013)

- Individual LWD device details
  - Plate diameter
  - Plate rigidity
  - Contact area stress distribution
  - Loading rate
  - Deflection measurement type and location(s)

2

Study Overview

BVT: Beam Verification Tester

To assess the reliability of the test equipment using the linear elastic material
To assess whether full spectral analysis is required for field data

- A simply supported beam assembly with known and adjustable static stiffness.
- The known static stiffness of the linear elastic beam ($k_{s\text{-}beam}$) was compared to LWD measured stiffness (k_{peak}).
- Hoffman (2004) found that k_{peak} produces significant systematic error in BVT static stiffness Estimation.
- Hoffman proposed spectral analysis of data to calculate k_s.
- Our studies showed a very good agreement between k_{peak} and k_s for all the three devices in contrary to Hoffman (2004) study.

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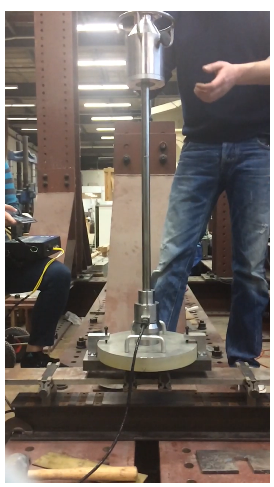
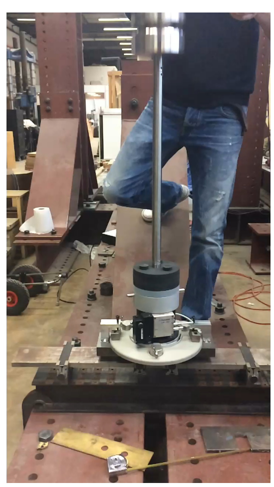
Study Overview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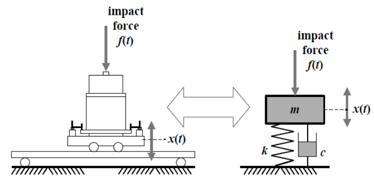
Methodology

$k(t)=f(t)/x(t) \rightarrow K(f)=F(f)/X(f)$

$m\ddot{x}(t)+c\dot{x}(t)+kx(t)=f(t)$

$\downarrow$

$K(f)=k\left[\left(1-\beta^2\right)+2i\zeta\beta\right]$



$\beta=f/f_n$ $\zeta=c/4\pi m f_n$ $f_n=1/2\pi\sqrt{k/m}$

- To reduce the effects of experimental noise and variability, a spectral average technique was used.

$K(f)=G_{xf}(f)/G_{xx}(f)$ $G_{xf}(f)$=one-sided cross-spectral density function
$G_{xx}(f)$= one-sided auto-spectral density function

- Quality of the measurements and validity of the linearity assumption via the coherence function

$\gamma^2(f)=|G_{xf}(f)|^2/G_{xx}(f).G_{xx}(f)$

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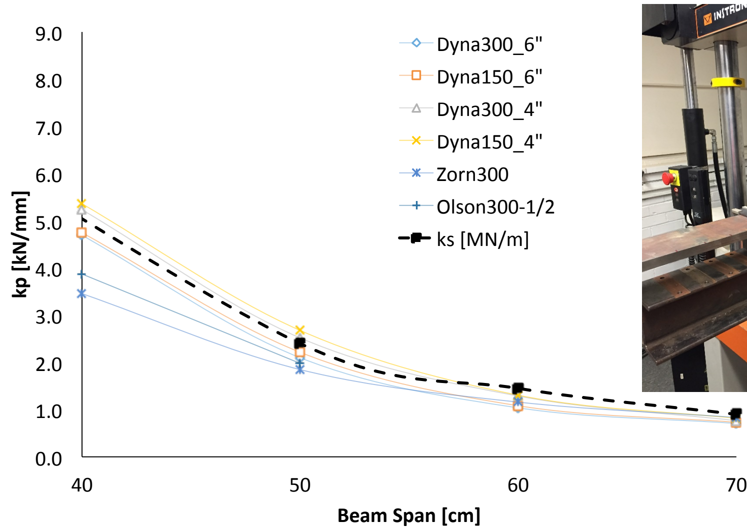
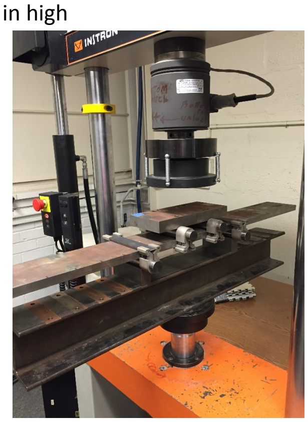
BVT Test Results

The reason for Zorn and Olson slightly underestimating in high





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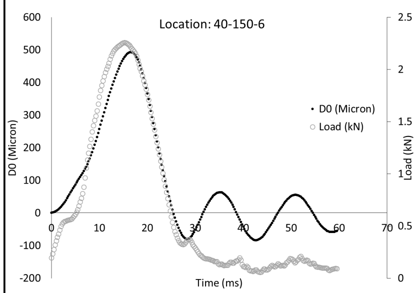
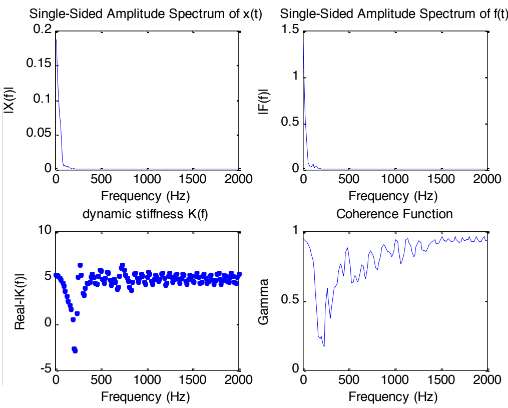
BVT Test Results

	k_p [kN/mm]	k_s [kN/mm]
40-150-6	4.7	5.2
40-150-4	5.3	5.2





Dynatest:
40-150-6"

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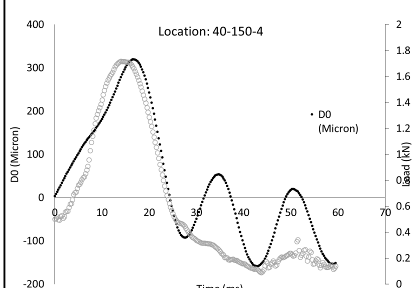
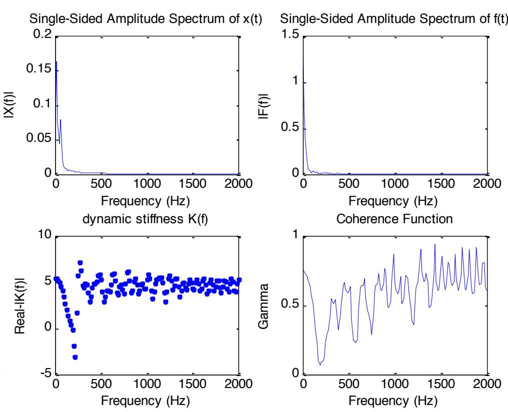
BVT Test Results

	k_p [kN/mm]	k_s [kN/mm]
40-150-6	4.7	5.2
40-150-4	5.3	5.2





Dynatest:
40-150-4"

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BVT Test Results

Span	ks	Zorn 300	Dyna 300_6"	Dyna 150_6"	Dyna 300_4"	Dyna 150_4"	Olson 300-1/2	Prima100 Hoffmann
[cm]	[kN/mm]	[kN/mm]	[kN/mm]	[kN/mm]	[kN/mm]	[kN/mm]	[kN/mm]	[kN/mm]
70	0.9	0.834	0.707	0.732	0.767	0.810		3.400
60	1.5	1.159	1.038	1.082	1.288	1.305		2.670
50	2.4	1.848	2.099	2.215	2.519	2.678	1.982	2.170
40	5.0	3.457	4.693	4.748	5.234	5.360	3.872	
30	7.9							

	Zorn 300	Dyna 300_6"	Dyna 150_6"	Dyna 300_4"	Dyna 150_4"	Olson 300-1/2	Prima100 Hoff/ hammer
Relative Error [%]	-7%	-21%	-19%	-15%	-10%		278%
	-20%	-28%	-25%	-11%	-10%		84%
	-23%	-13%	-8%	5%	12%	-17%	-10%
	-31%	-6%	-5%	5%	7%	-23%	

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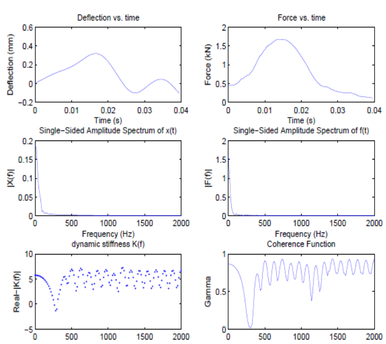
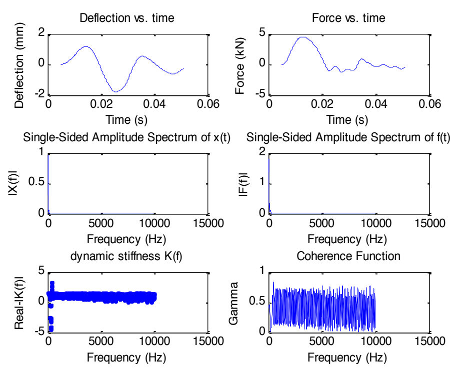
BVT Test Results

Dynatest



Olson



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Conclusion

Overall, in contrary to Hoffman (2004,) it was found that the conventional, peak-based method of backanalysis produces correct estimates of the static stiffness of the BVT.

The spectral-based data interpretation method could enhance the results marginally for Dynatest, but was deficient for Olson LWD.

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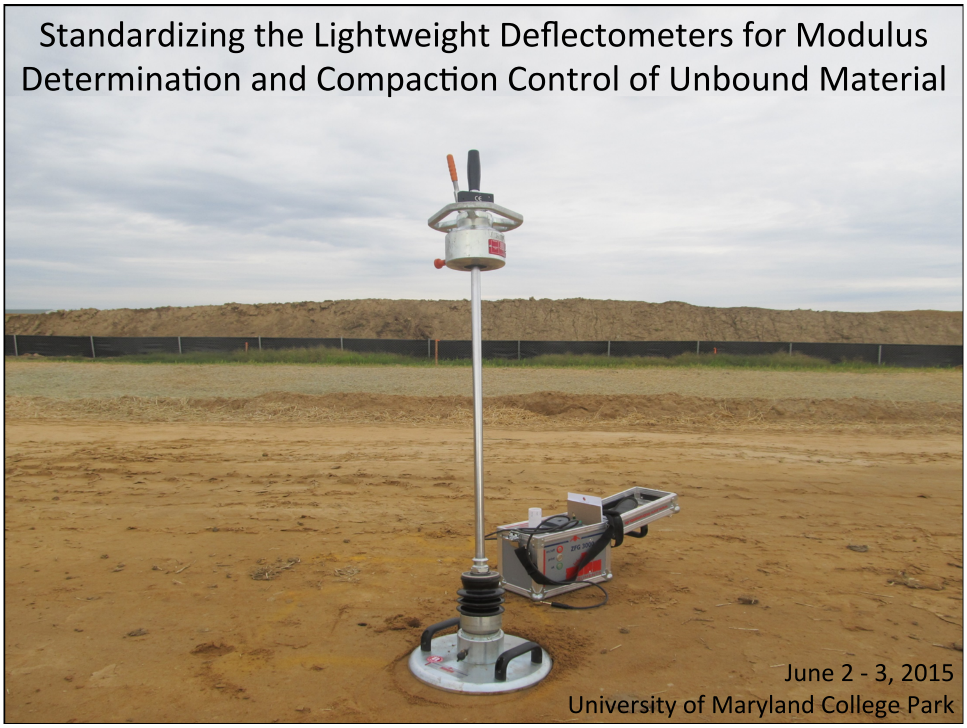
Appendix F
On-Site TAC Meeting Presentation

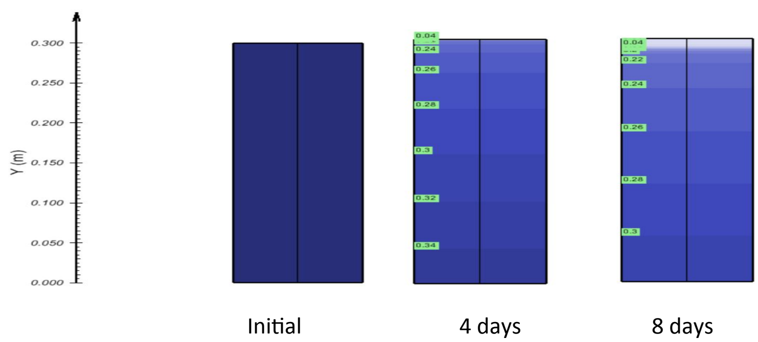
"Drying Analyses" (Afsharikia)



Parametric Study of Soil Drying in the Field

Objective

- Investigate the factors that affect moisture change in the field
- Develop a simple tool for predicting moisture changes due to drying after placement and compaction of soil
- Establish a reference to specifying the amount of drying based on field conditions
- Utilize the predicted moisture profile after drying for interpreting LWD modulus measurements



Analysis Approach

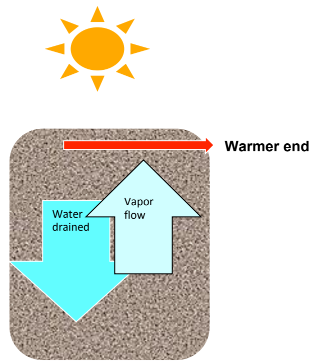
- Identify the physical process of evaporation from soil to atmosphere
- Identify the appropriate soil properties and variables which control evaporation
- Identify the theoretical framework to describe evaporation from soil
- Find the practical software/code available to model the evaporation
- Model the one layered subgrade and two layered base on subgrade systems
- Validate the results based on available laboratory measurements
- Compare predicted vs. measured moisture contents in the test pits
- Demonstrate the applicability of modeling to practical field situations

Flow Equation

- System of equations for describing soil to atmosphere evaporation (Wilson, 1990) :
  - Evaporation

$$E = f(u)(e_S - e_a)$$

E= Vertical vapor flux into the atmosphere, (mm/day)
f(u)= A function depending on wind speed, surface roughness and atmospheric stability
e_S = Vapor pressure at the soil surface, kPa
e_a = Vapor pressure in the air above the soil, kPa



Flow Equation

- System of equations for describing soil to atmosphere evaporation (Wilson, 1990) :
  - Moisture Flow

$$\frac{\partial h_w}{\partial t} = C_w^1 \frac{\partial}{\partial y}\left(k_w \frac{\partial h_w}{\partial y}\right) + C_w^2 \frac{\partial}{\partial y}\left(D_V \frac{\partial p_V}{\partial y}\right)$$

h_w = Total hydraulic head, m
C_w^1, C_w^2 = Coefficient of consolidation
k_w = Coefficient of permeability
D_V = Coefficient of vapor diffusion
p_V = Partial Vapor pressure

  - Heat Flow

$$C_V \rho_s \frac{\partial T}{\partial t} = \frac{\partial}{\partial y}\left(\lambda \frac{\partial T}{\partial t}\right) - L_V \left(\frac{p + p_V}{p}\right) \frac{\partial}{\partial y}\left(D_V \frac{\partial p_V}{\partial y}\right)$$

$C_V \rho_s$ = Volumetric specific heat
T = Temperature, C
λ = Termal conductivity
p_V = Partial Vapor pressure
L_V = Latent heat of vaporization, J/Kg.

Software Evaluated

- HYDRUS
- UNSAT-H Code
- Flux Fortran code
- ✓ SoilVision SVFlux

HYDRUS Validation

- Clay
- Top soil

Table 1. Soil geotechnical properties.

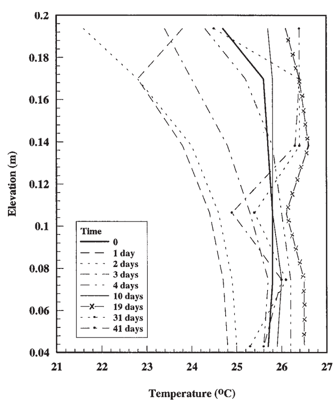
Property	Clay	Top soil
Specific gravity	2.70[a]	2.64
Grain size		
% fine sand	0[a]	7
% silt	10[a]	71
% clay	90[a]	22
Atterberg limits		
Liquid limit	63.9%[b]	32.5%
Plastic limit	30.9%[b]	21.0%
Plasticity index	33.0%[b]	11.5%
Compaction test		
Optimum water content	25%	16.2%
Maximum dry density	1.58 Mg/m^3	1.75 Mg/m^3

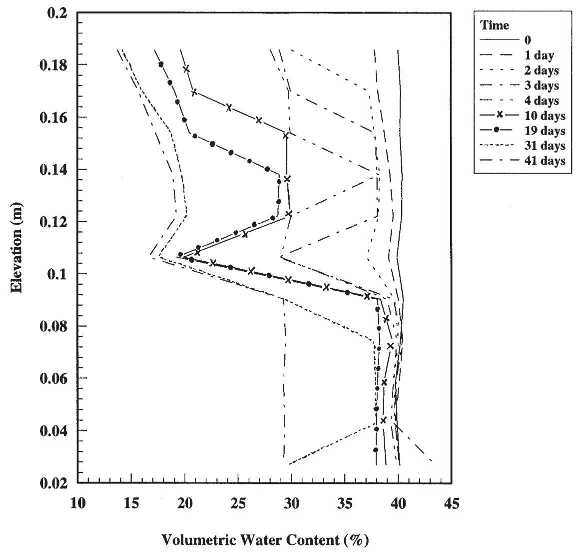
[a] From Yong et al. (1991) and Yanful and St-Arnaud (1991).
[b] From Machibroda et al. (1993).

HYDRUS Validation

- Clay

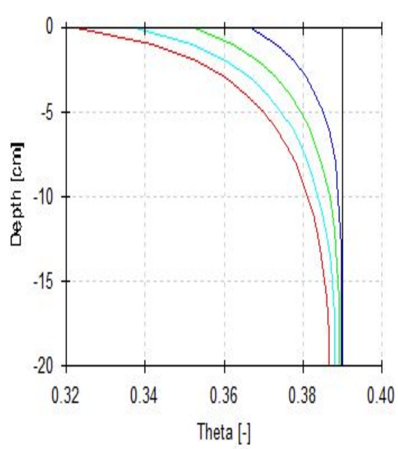
(Yanful and choo)

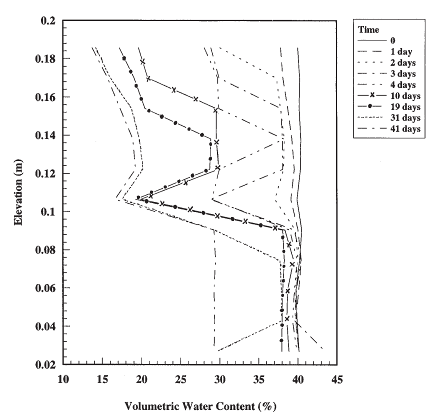




HYDRUS Validation

Clay

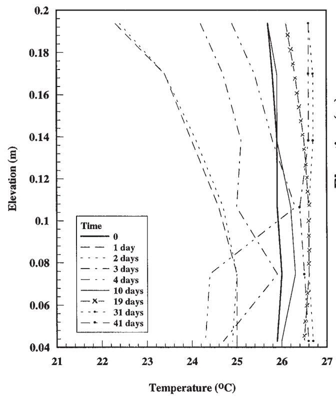


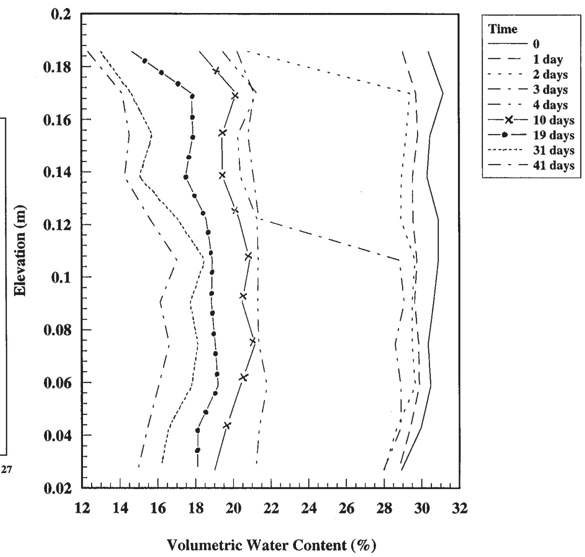


HYDRUS Validation

- Top Soil

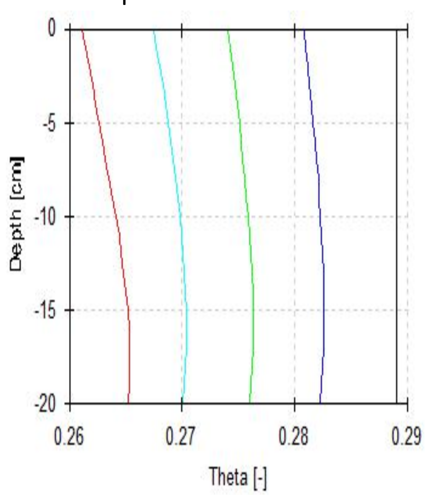
(Yanful and choo)

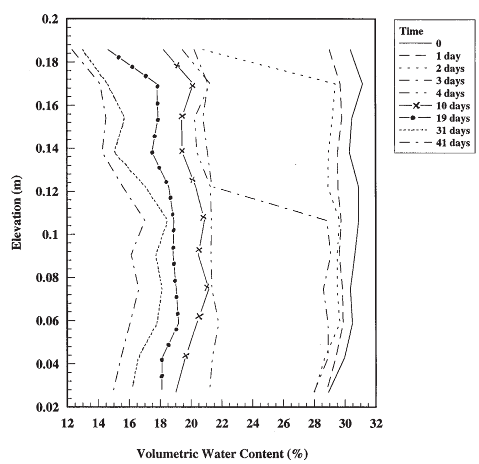




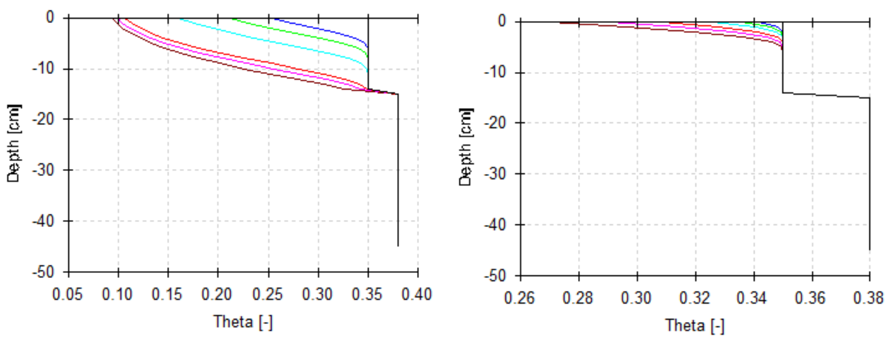
HYDRUS Validation

Top Soil

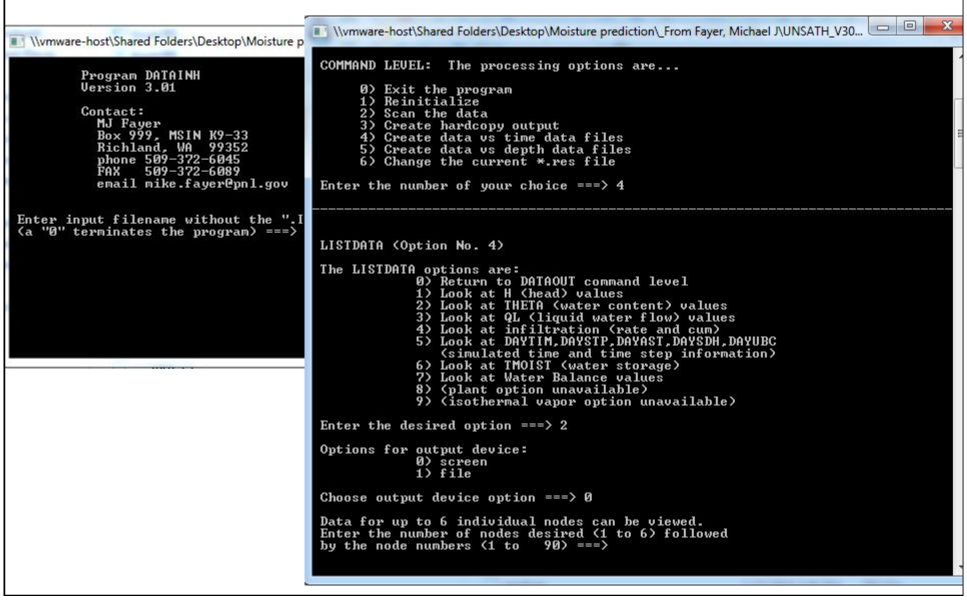




HYDRUS Two Layered Soil System

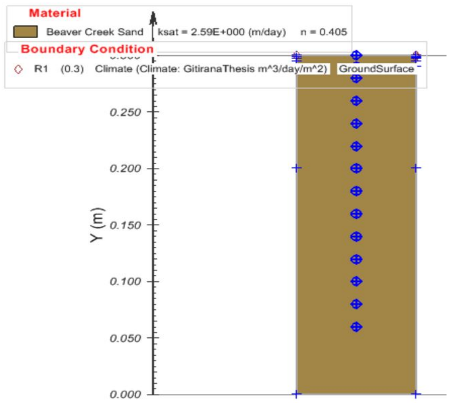


UNSAT-H



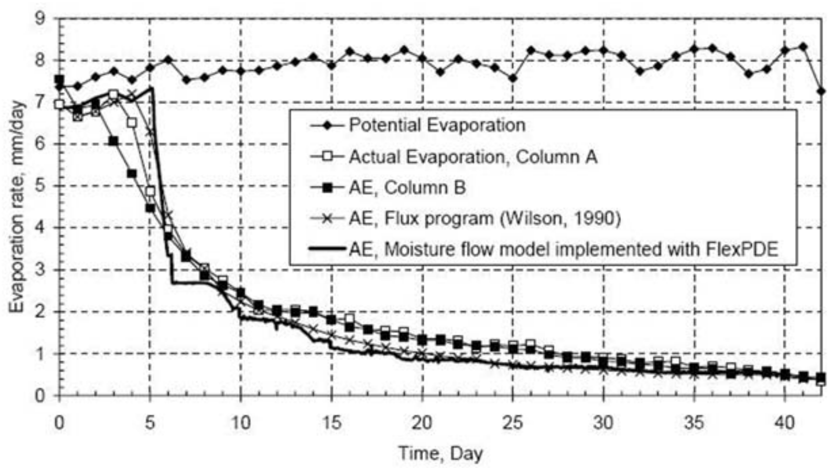
Validation

- An initial comparison to the results obtained by Wilson (1990) was performed by Gitirana (2004) using the FlexPDE solver used by SVFlux. The FlexPDE formulation presented by Gitirana included full coupling of the moisture and temperature partial differential equations.



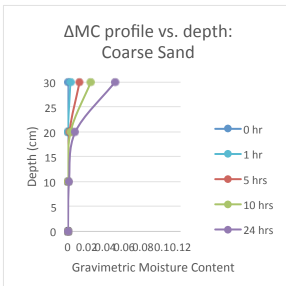
Wilson Sand Column example Model in SoilVision Software

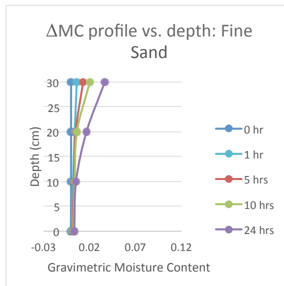
Validation

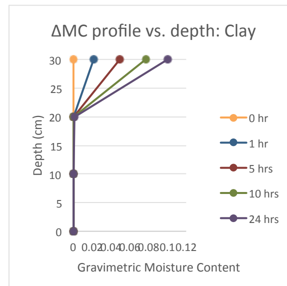


Results of Gitirana (2004) as compared to Wilson (1990)

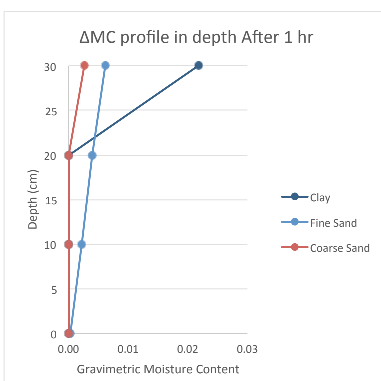
Preliminary results

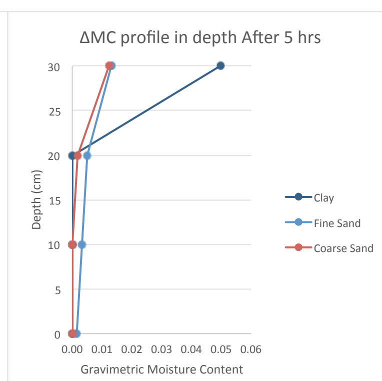




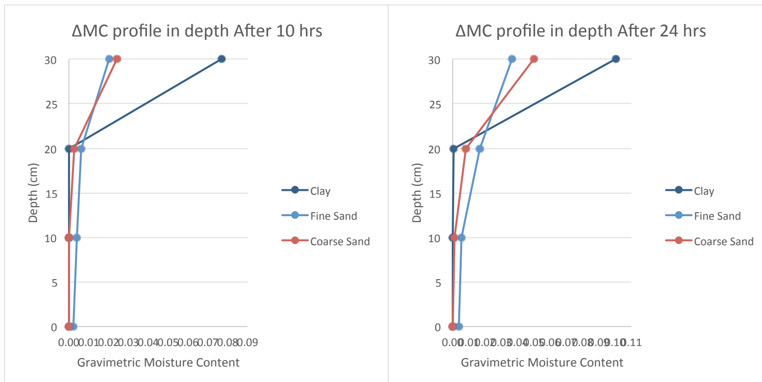


Preliminary results



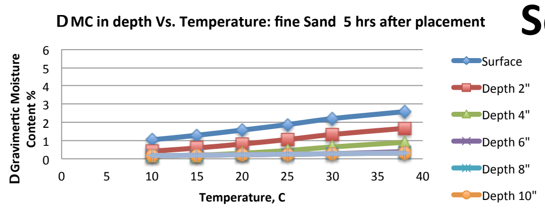


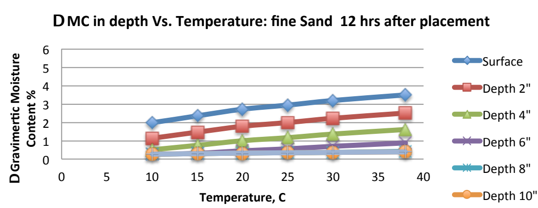
Preliminary results

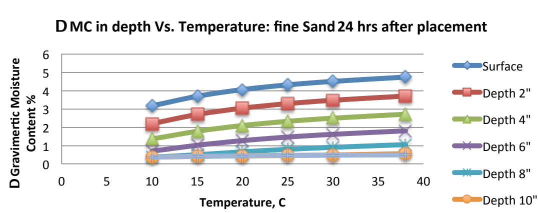


Sensitivity Analysis

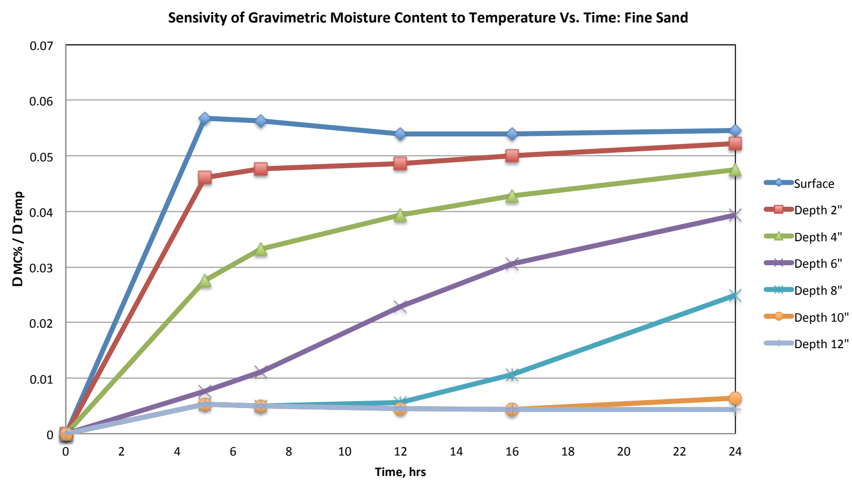
Temperature
Fine Sand



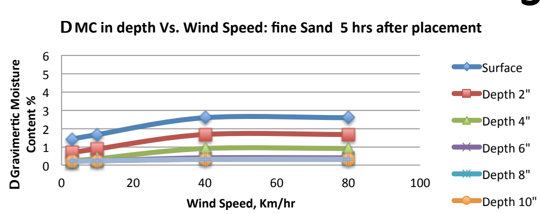


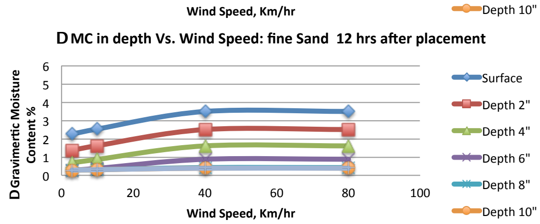


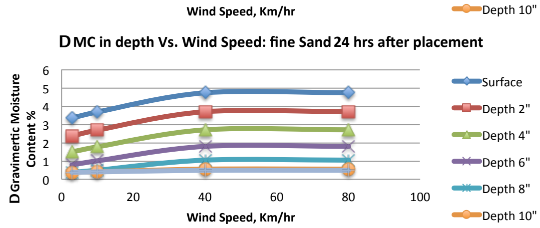
Sensitivity Analysis
Temperature
Fine Sand



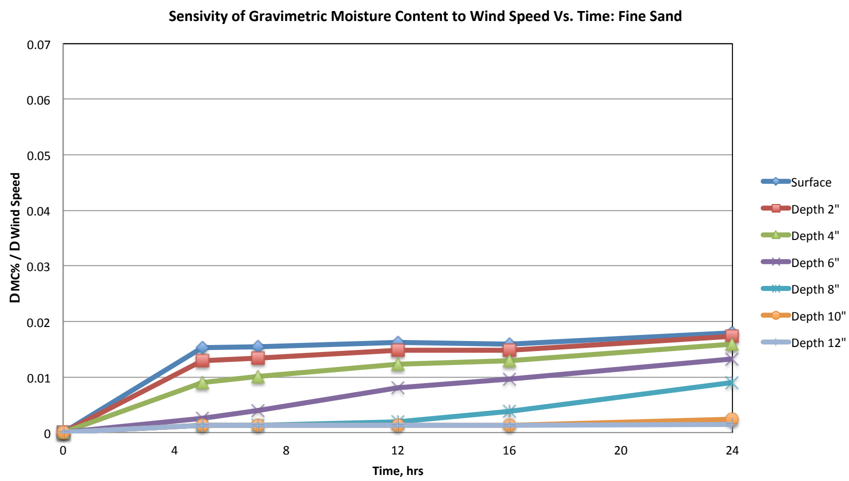
Sensitivity Analysis
Wind Speed
Fine Sand



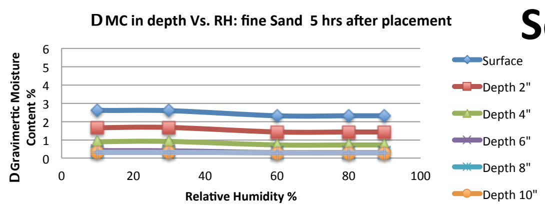


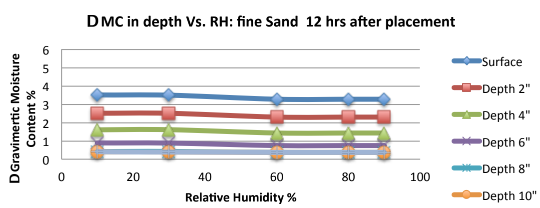


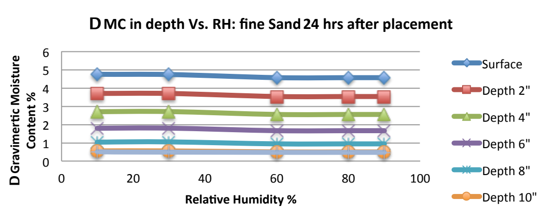
Sensitivity Analysis
Wind Speed
Fine Sand



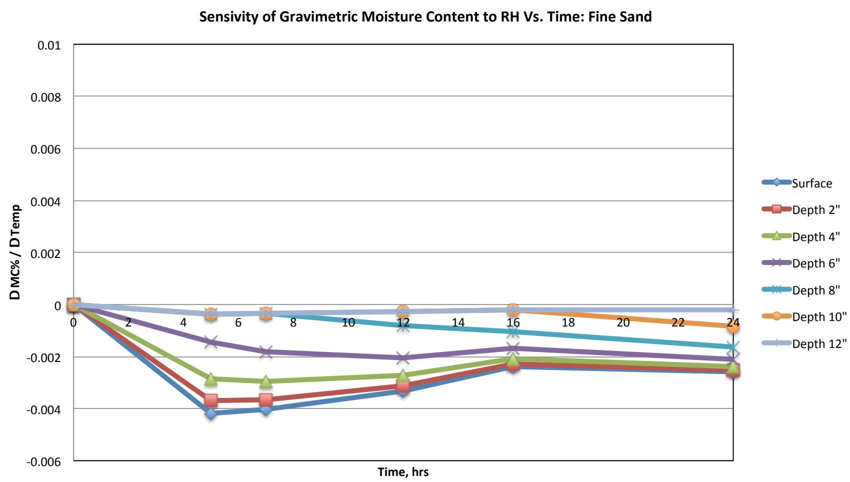
Sensitivity Analysis
Relative Humidity
Fine Sand



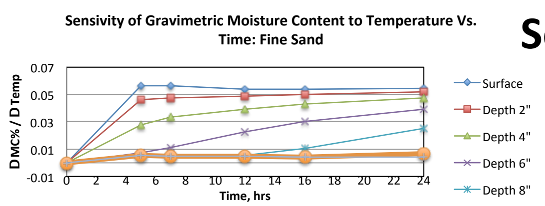


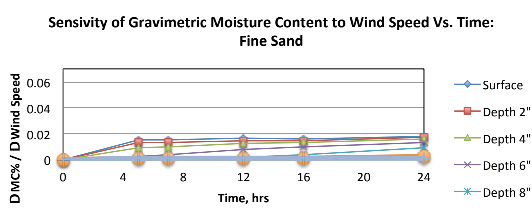


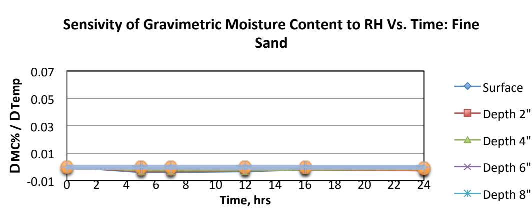
Sensitivity Analysis
Relative Humidity
Fine Sand



Sensitivity Analysis
Summary







Next Steps

- Parametric Analysis
  - Soil Type
  - Air Temperature
  - Wind Speed
  - Relative Humidity
  - Solar Radiation
  - Placement time
- Parametric analyses synthesized into an artificial neural network tool for field usage

Modeling tool

Artificial Neural Networks