Project Update:

Impact of Fines Content on Resilient Modulus Reduction of Base Courses during Thawing

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Outline

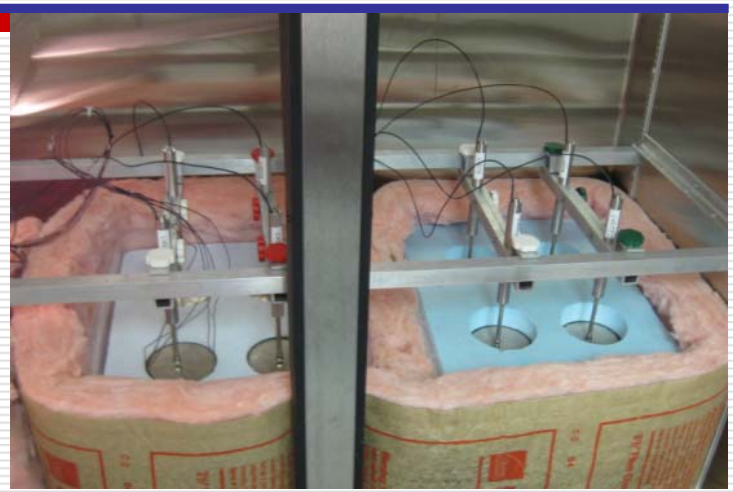
- Work Completed
- Work in Progress

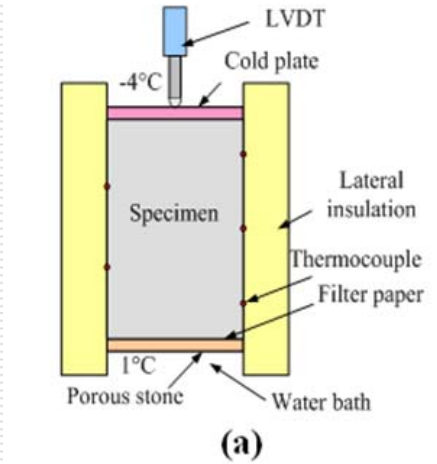
Work Completed

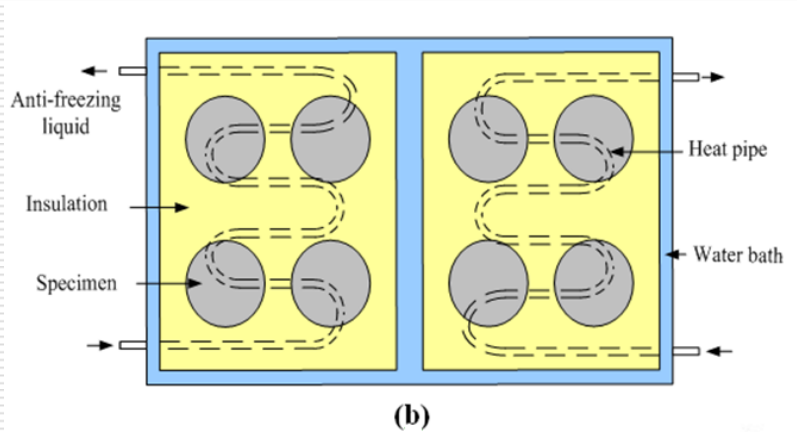
- Frost heave setup and tests
- M_R testing for D1 material from 3 regions (OMC-2%, OMC, OMC+0.7%) at various subfreezing temperatures and 20℃ after a freeze-thaw cycle
- Data analysis for D1 material from Juneau

Frost Heave Test

- D-1 from 3 regions
- Temperature gradient 0.625°C/in.
- Moisture contents:
  - OMC (5.3%)
  - OMC+0.7% (6%)
  - OMC-2% (3.3%)







Frost Heave Test

Soil samples after frost heave test

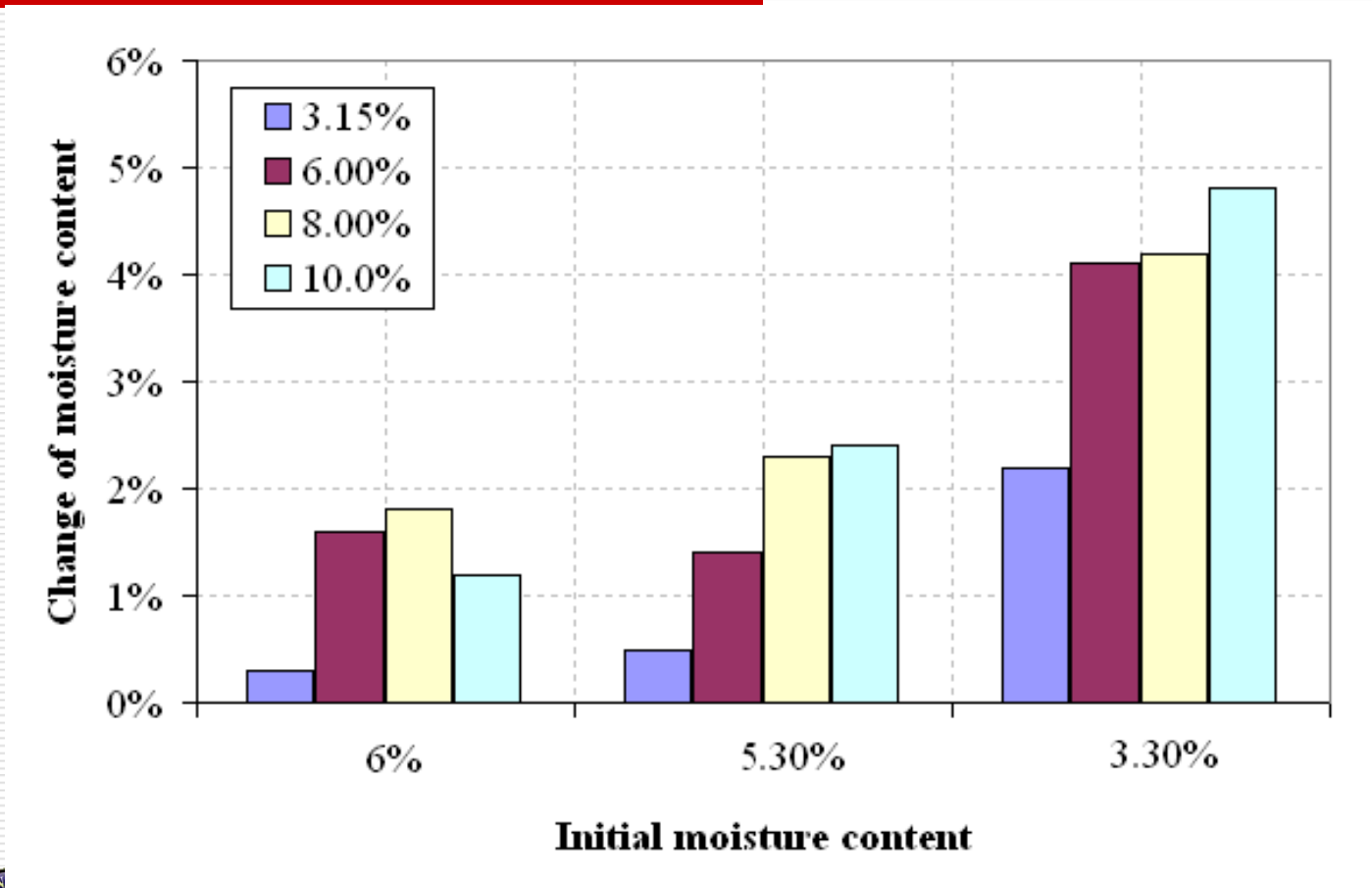
Resilient Modulus Testing

- D-1 from 3 regions
- Temperatures:
  (-10, -7, -5, -4, -3, -2, -1, 20^{o}C)
- Moisture contents:
  - OMC (5.3%)
  - OMC+0.7% (6%)
  - OMC-2% (3.3%)

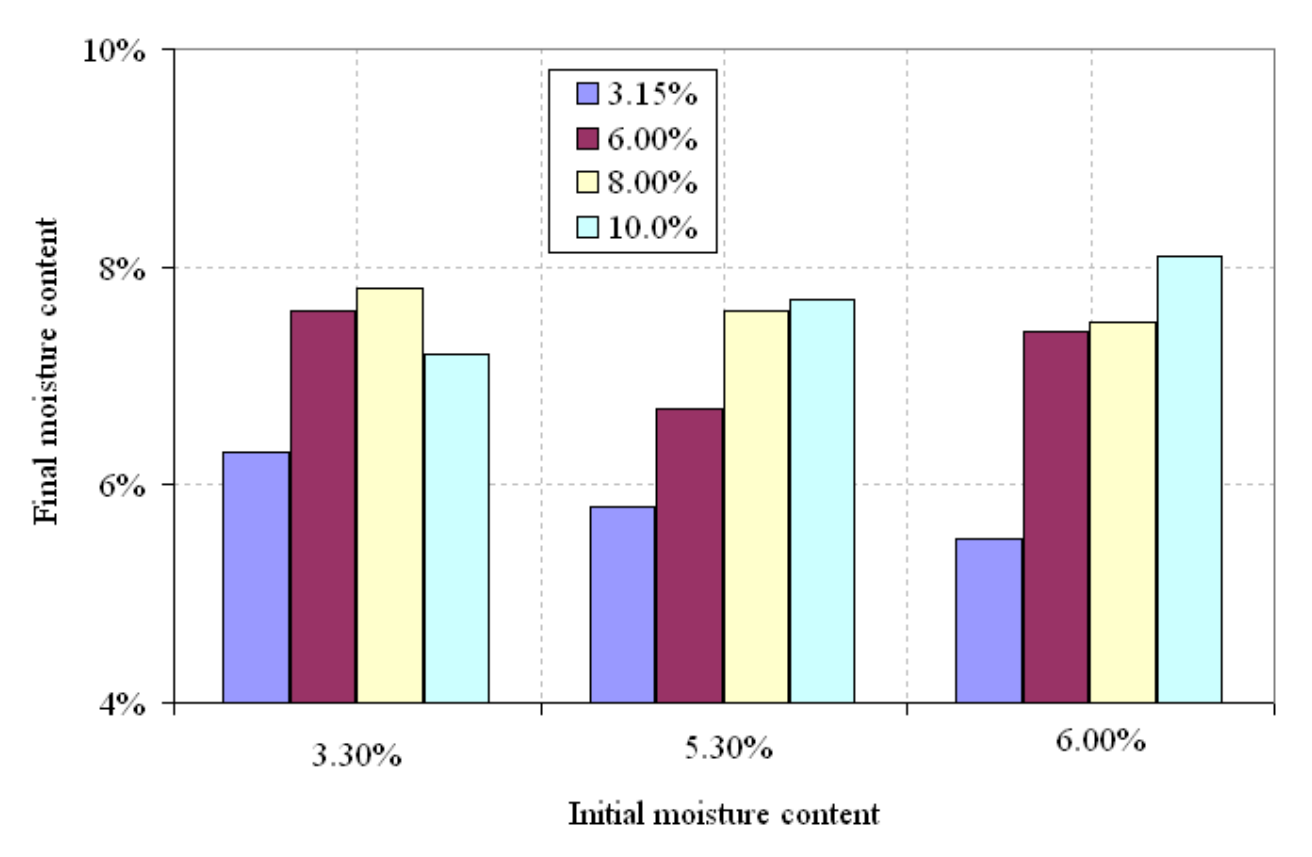
Resilient Modulus Testing

Confining pressure (psi)	Deviator stress (psi)	Bulk stress (psi)
3	2.7	11.7
	5.4	14.4
	8.1	17.1
5	4.5	19.5
	9	24
	13.5	28.5
10	9	39
	18	48
	27	57
15	9	54
	13.5	58.5
	27	72
20	13.5	73.5
	18	78
	36	96

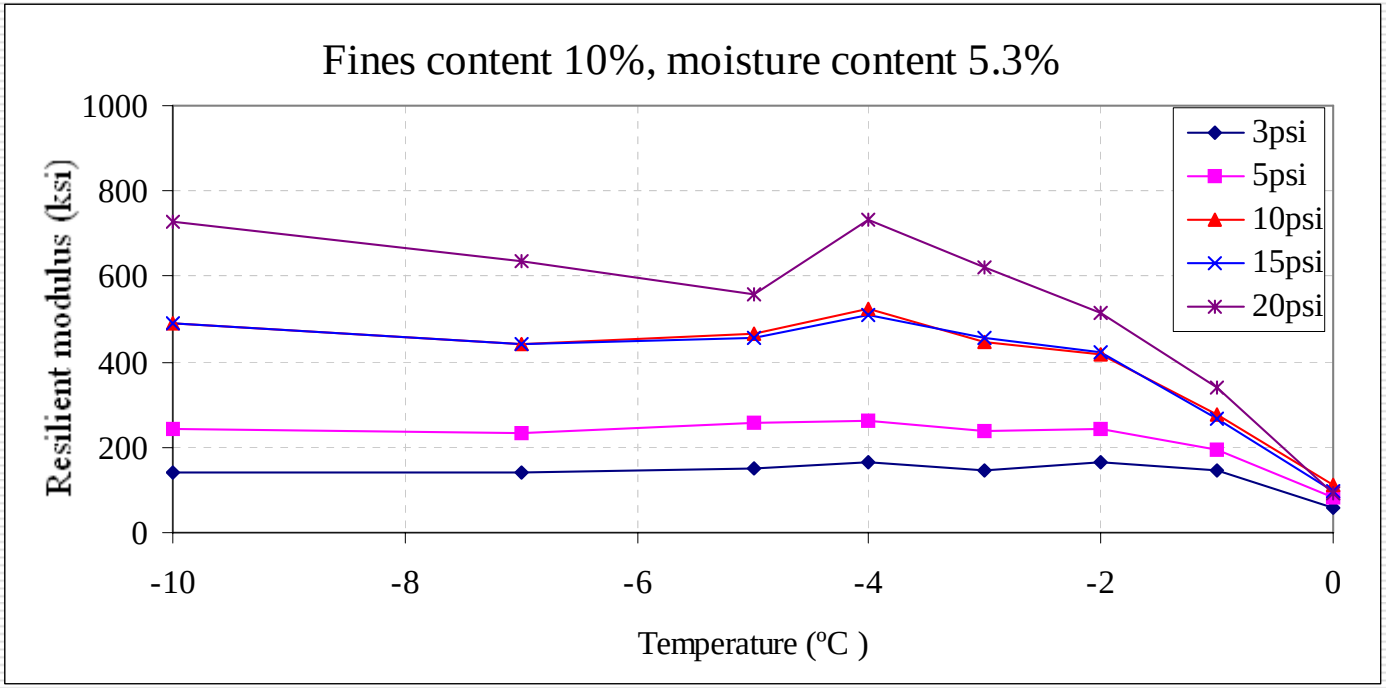
Moisture Content Changes after Frost Heave



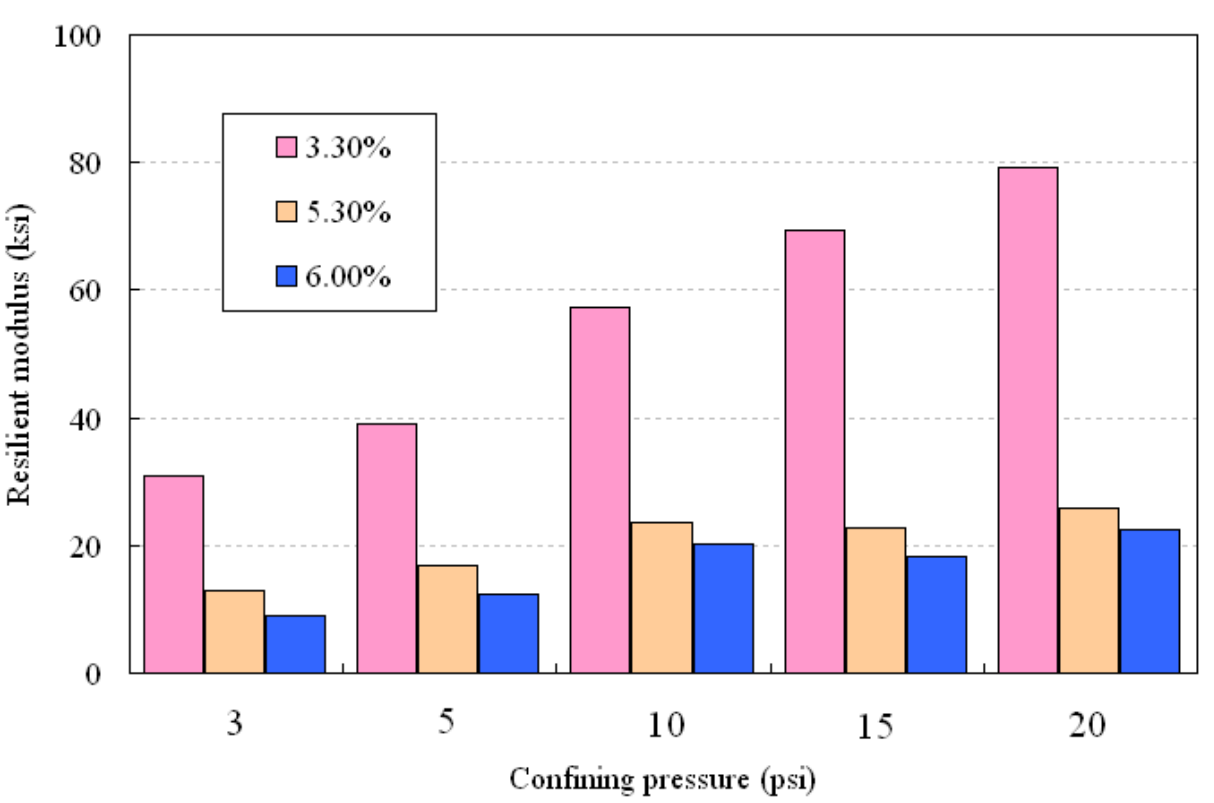
Final Moisture Content Changes after Frost Heave



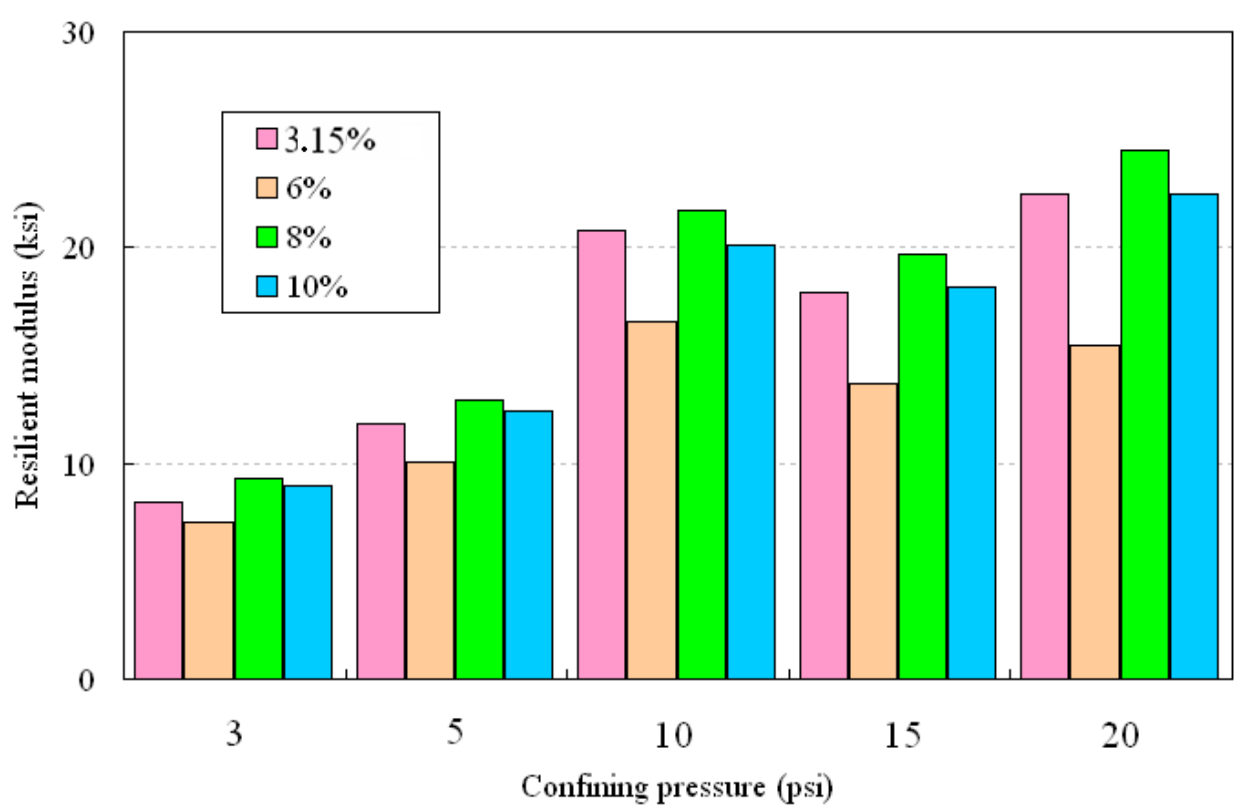
Typical results of M_R as a function of temperature (Juneau)



M_R at varying moisture contents (fines content 10%, 20°C, Juneau)

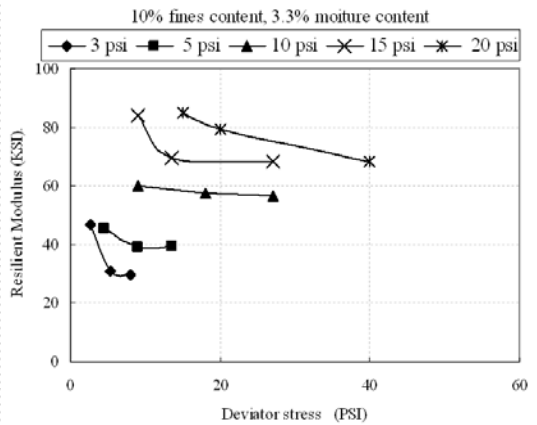


M_R at varying fines contents (moisture content 6%, 20°C, Juneau)

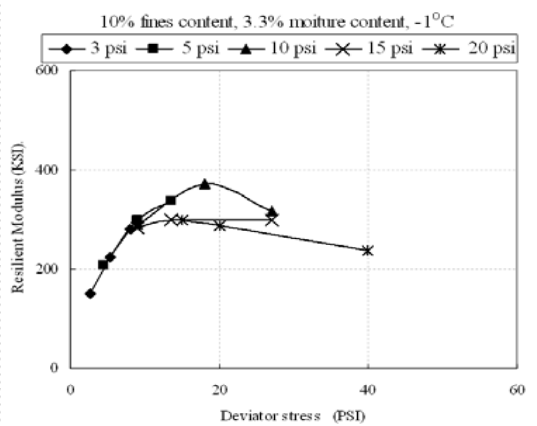


Variation of M_R at different stress statuses (Juneau)

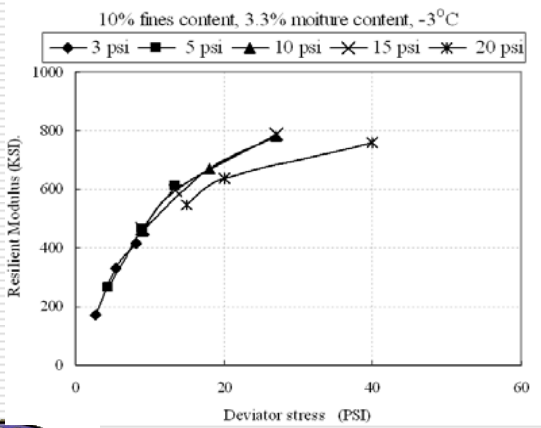
20°C



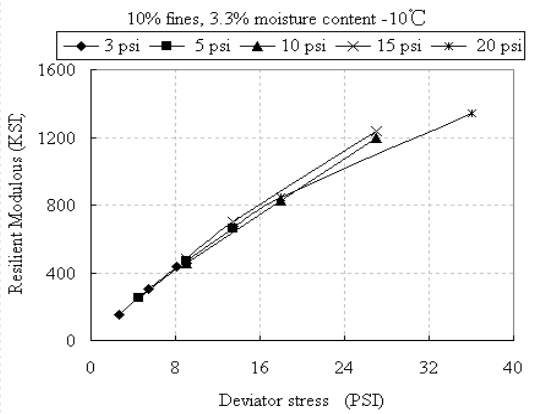
-1°C



-3°C



-10°C



Regression Model for M_R at 20°C

(Uzan 1985):

$$M_R = k_1 p_a \left(\frac{\theta}{p_a} \right)^{k_2} \left(\frac{\tau_{oct}}{p_a} + 1 \right)^{k_3}$$

where:

M_R	=	resilient modulus
θ	=	bulk stress
τ_{oct}	=	octahedral shear stress $= \frac{1}{3}\sqrt{(\sigma_1 - \sigma_2)^2 + (\sigma_1 - \sigma_3)^2 + (\sigma_2 - \sigma_3)^2}$
Pa	=	reference pressure
k_1, k_2, k_3	=	regression constants

Regression Results at 20°C (Juneau)

Moisture content	Fines content	k1	k2	k3	R^2
6%	10%	1.1937	0.252	0.342	96.3%
	8%	1.252	0.27	0.347	95.8%
	6%	1.191	0.516	0.442	93.3%
	3.15%	1.025	0.337	0.276	94.8%
5.30%	10%	1.195	0.288	0.152	95.1%
	8%	1.023	0.386	-0.011	85.7%
	6%	1.231	0.231	0.335	86.2%
	3.15%	0.923	0.595	-0.04	95.0%
3.30%	10%	1.138	0.806	-0.427	96.2%
	8%	1.095	0.78	-0.382	97.8%
	6%	1.032	0.516	-0.183	99.6%
	3.15%	1.118	0.731	-0.232	97.2%

Regression results for M_R test at nonfreezing temperature

Regression Results at 20°C

$$\log k_1 = -0.04262 + 0.8113 f_c + 0.706 m_c;\ R^2 = 33\%,\ P-value\,(f_c) = 0.082$$

$$k_2 = 1.4759 - 1.0889 f_c - 19.34 m_c;\ R^2 = 85.9\%,\ P-value\,(f_c) = 0.384$$

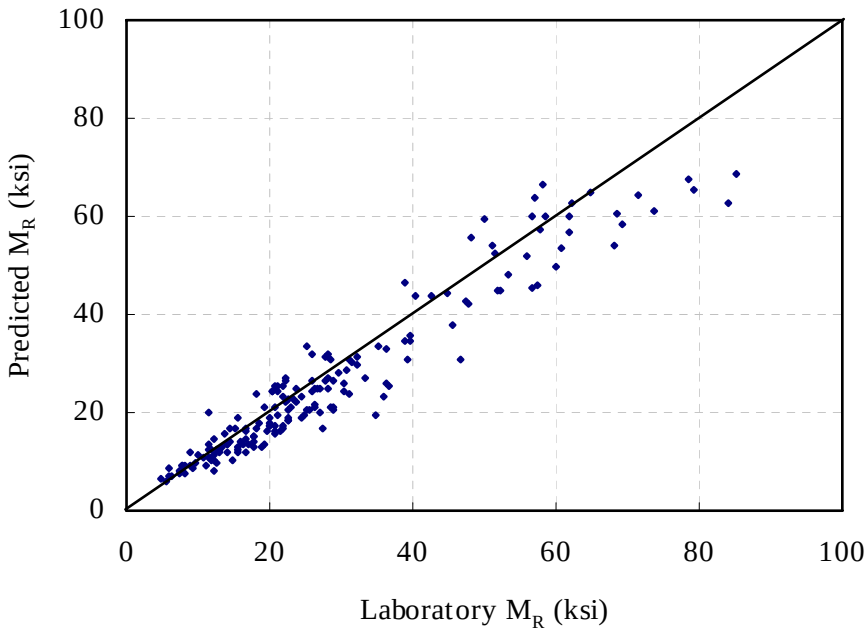
$$k_3 = -1.0664 - 0.4211 f_c + 23.56 m_c;\ R^2 = 84.8\%,\ P-value\,(f_c) = 0.786$$

Where:

f_c = fines content，and

m_c = moisture content

Regression Effect at 20°C



Predicted M_R vs. Laboratory M_R for D-1 material at nonfreezing temperature

Regression Model for M_R at Subfreezing Temperature

Simonsen et al. (2002):

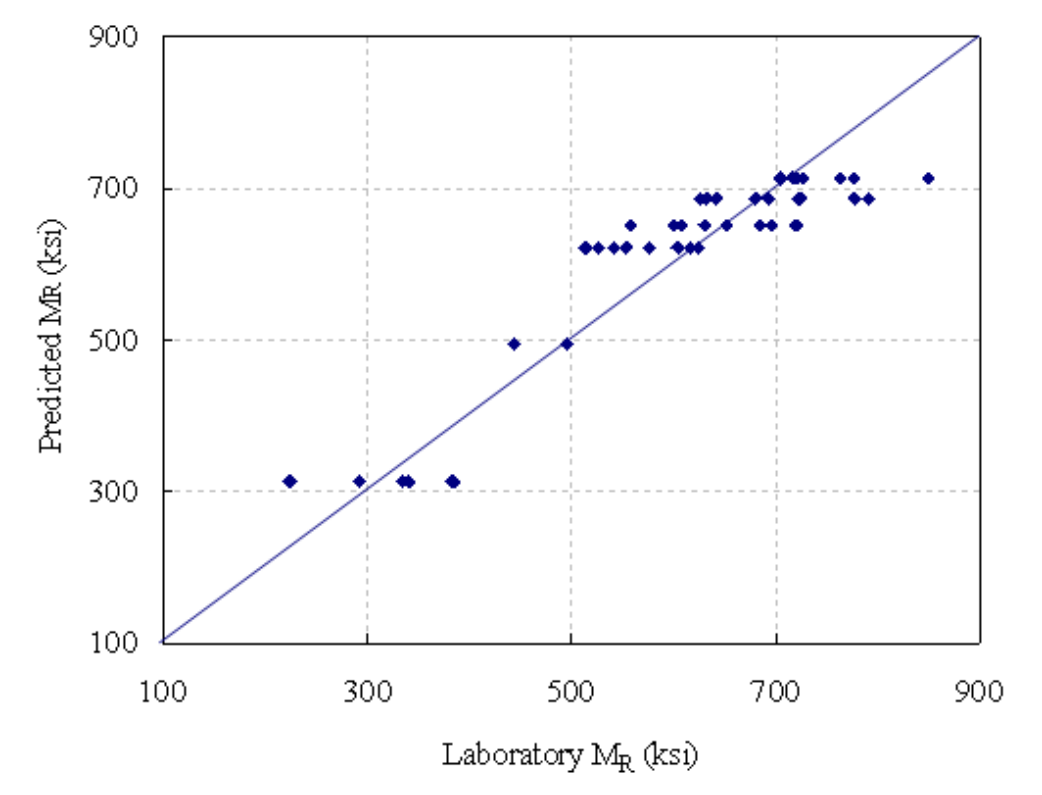
$$M_R = e^{k_1 + k_2/T}$$

Where:

k_1, k_2 = regression constants, and

T = temperature in degree Celsius

Regression Effect (Juneau)



$$M_R = e^{k_1 + k_2 / T}$$

K_1 = 6.6644
K_2 = 0.9193 , and
R^2 = 84.9%.

Work in Progress

- Frost heave test for soil specimens preparation
- M_R test for the rest D1 material at subfreezing temperatures
- Data analysis for M_R
  - Regression of M_R data from Anchorage and Fairbanks
  - ki vs. materials factors

The end

Thank you!