THE UNIVERSITY OF BRITISH COLUMBIA

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Evolution of volumetric response in cyclic shearing using a memory-enhanced SANISAND model

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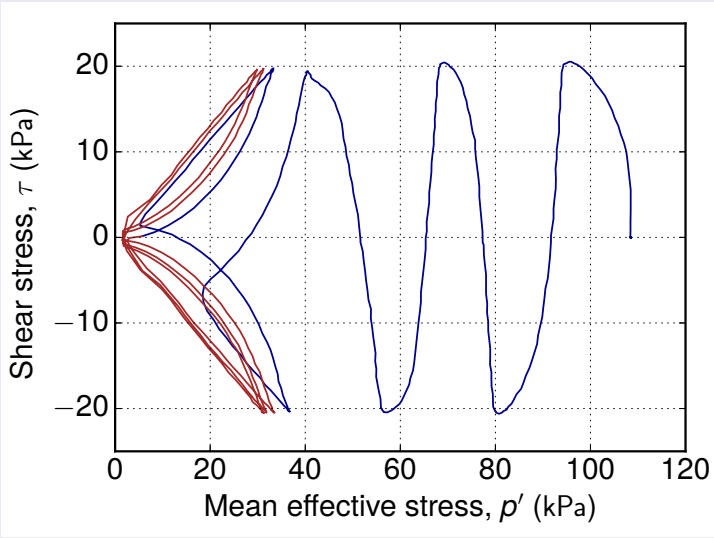
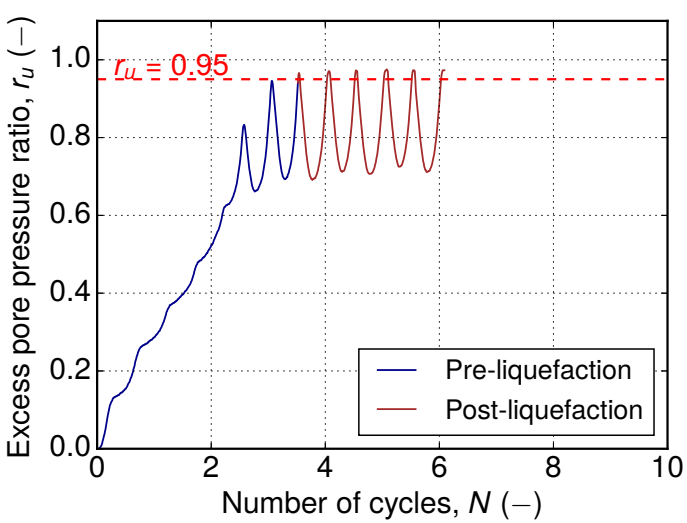
Impact of CSR on rate of pore pressure generation

- Undrained cyclic torsional tests on Ottawa-F65 sand with $D_r = 50\%$ (Ueda 2018)

CSR=0.19





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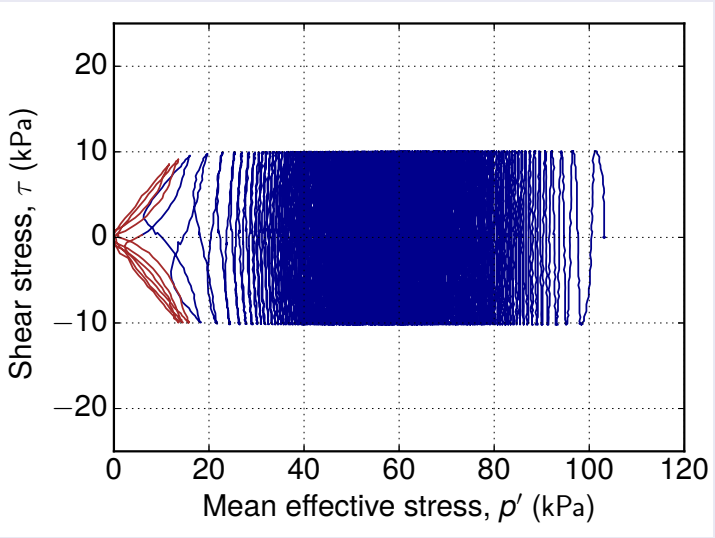
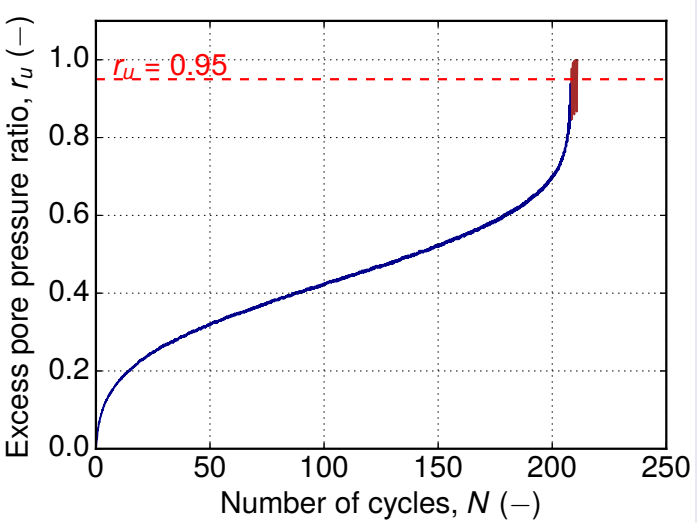
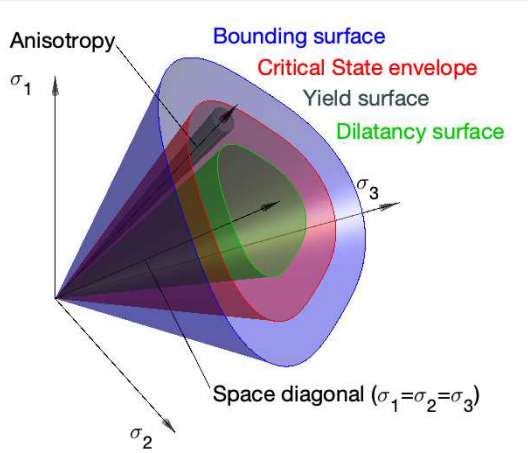


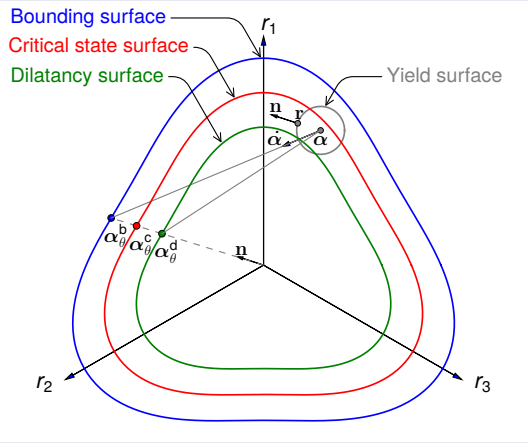


Reference model: SANISAND04

- SANISAND: Simple ANIsotropic SAND plasticity model
  - Evolving fabric anisotropy (Dafalias and Manzari 2004)

Model "surfaces"





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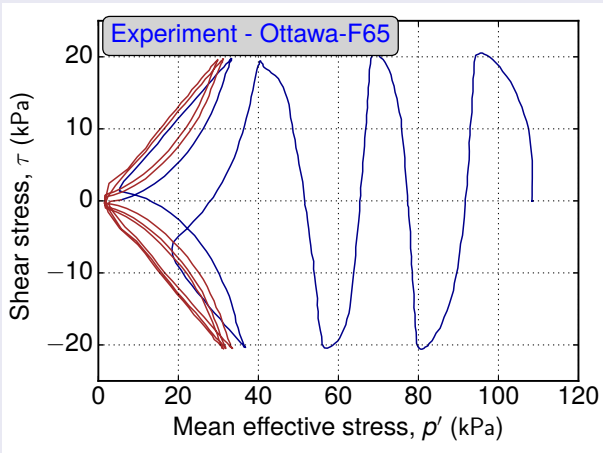

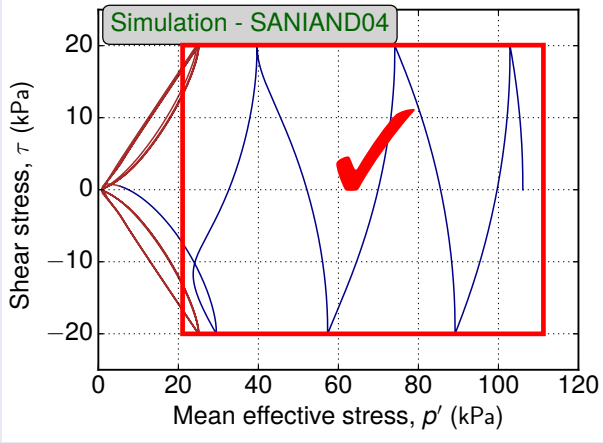

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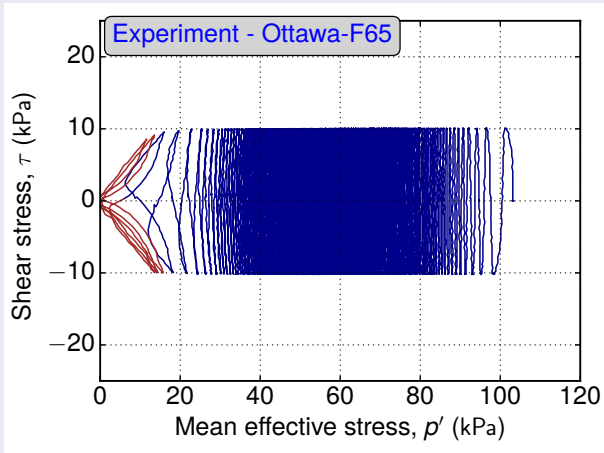
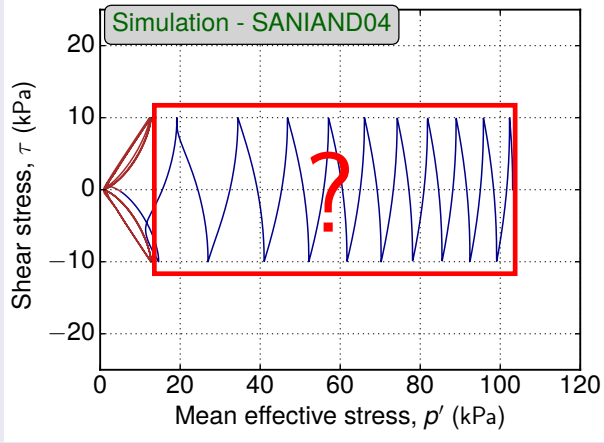
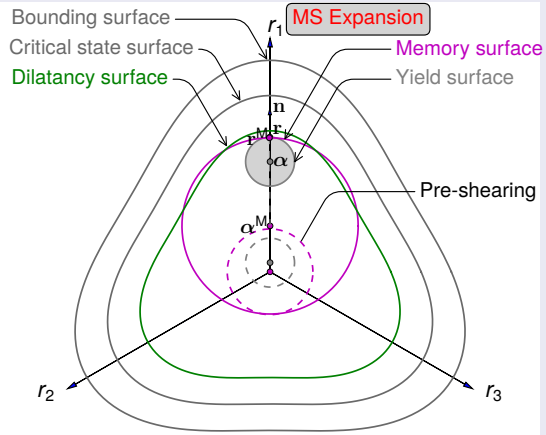


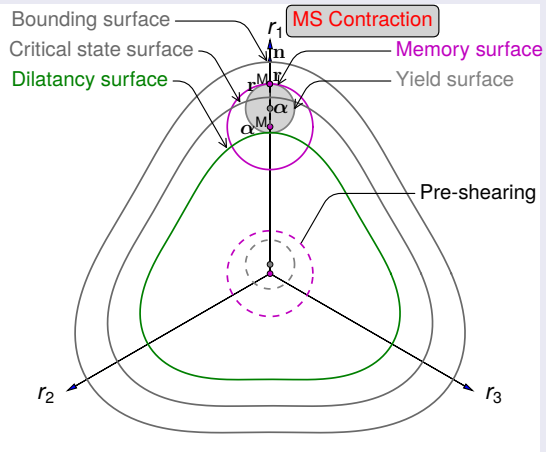


"Memory surface": memorizing recent stress history

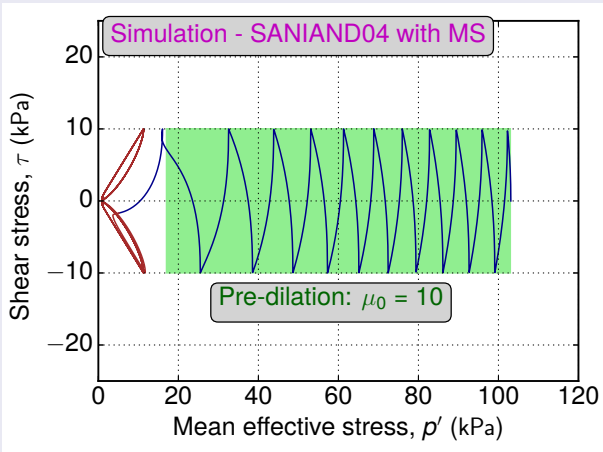
- Homologous to yield surface; isotropic and kinematic hardening; size influencing the plastic stiffness: Severn-Trent (Corti et al. 2016), SANISAND04 (Liu et al. 2018)

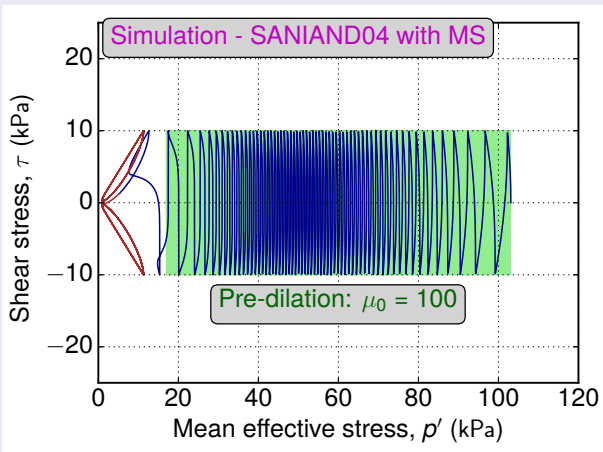
Evolution of MS



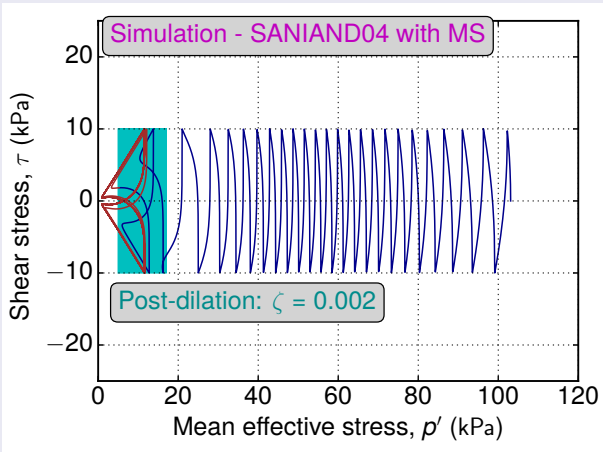


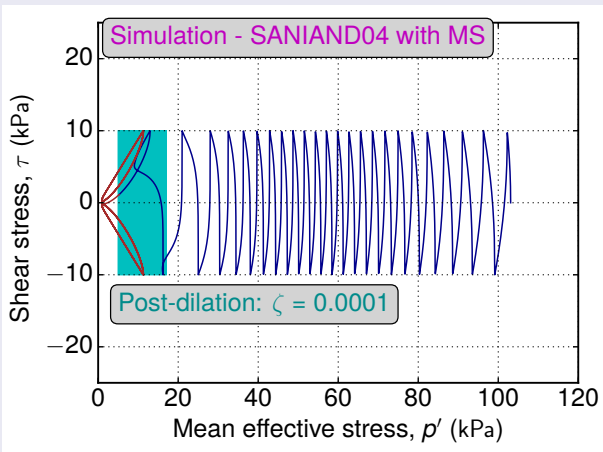
Parameter μ_0





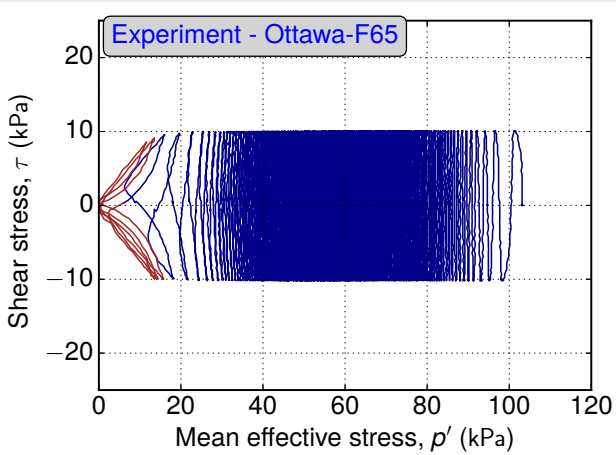
Parameter ζ

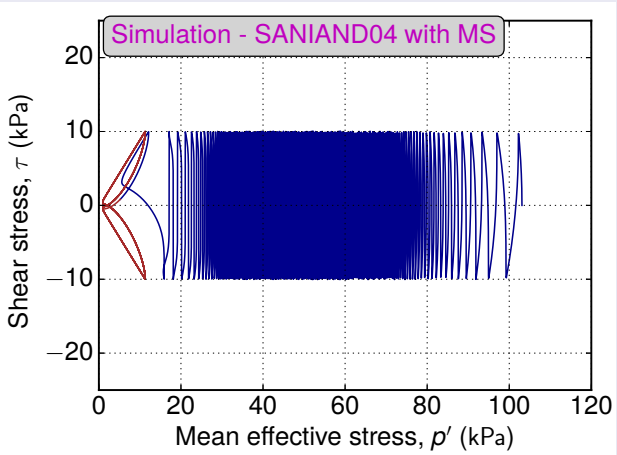


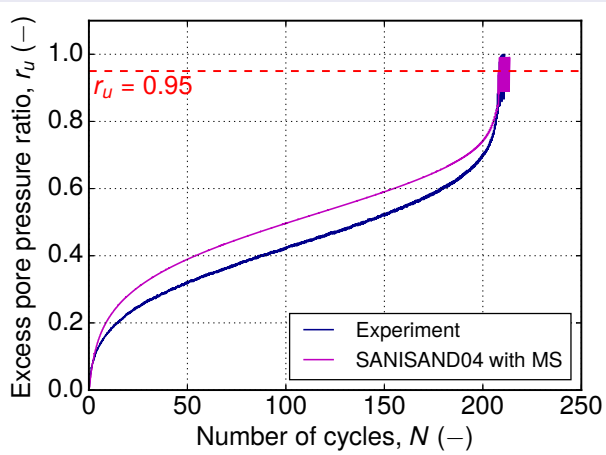


SANISAND04 with MS

CSR=0.10







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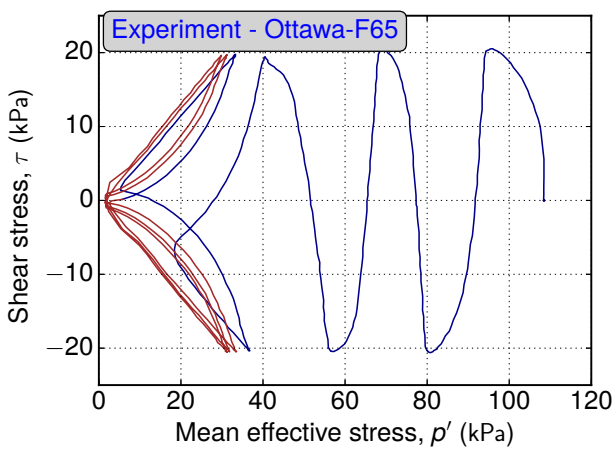
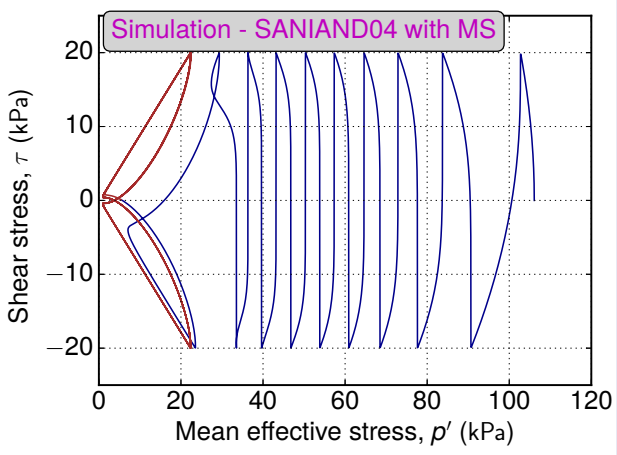
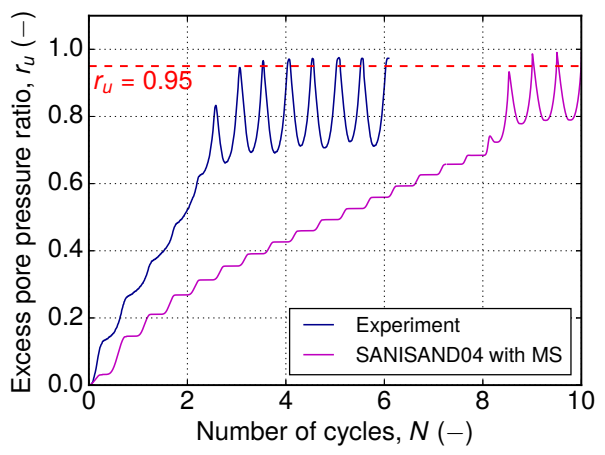




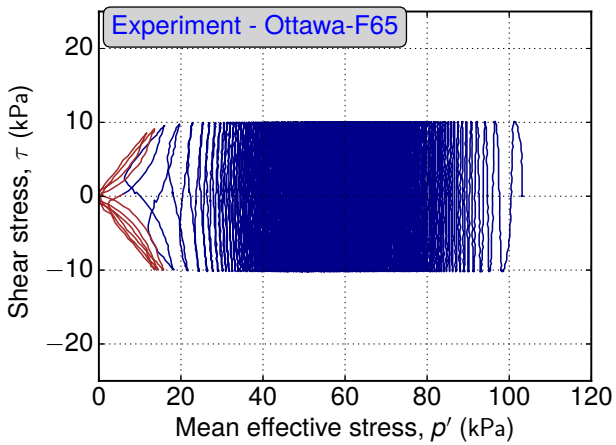


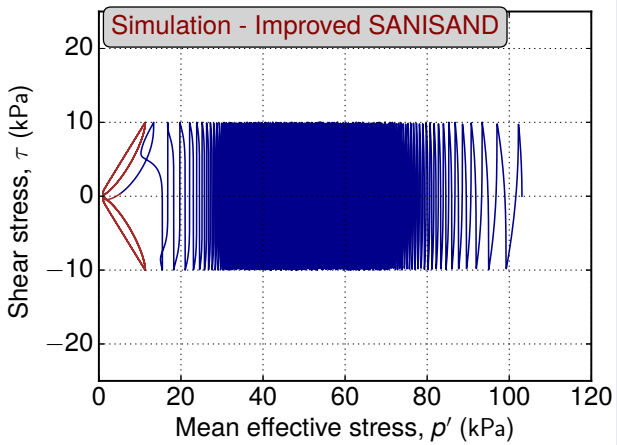
- Improved response at low CSR, but ruined performance at high CSR. Solution?

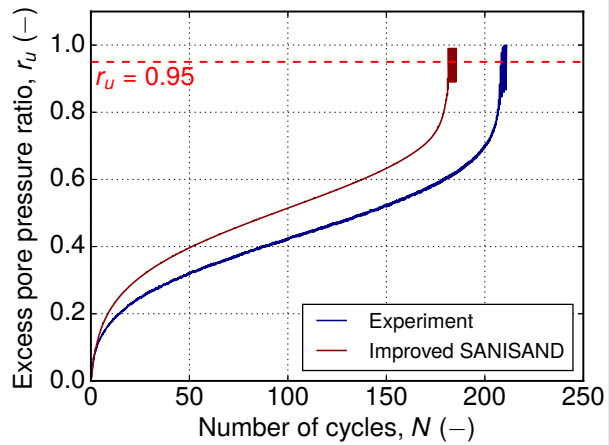
Improved memory-enhanced SANISAND

- Balance between high CSR and low CSR: making μ_0 a linear function of the stress ratio at loading reversal (α_{in}): μ_{ref}, μ_k

CSR=0.10







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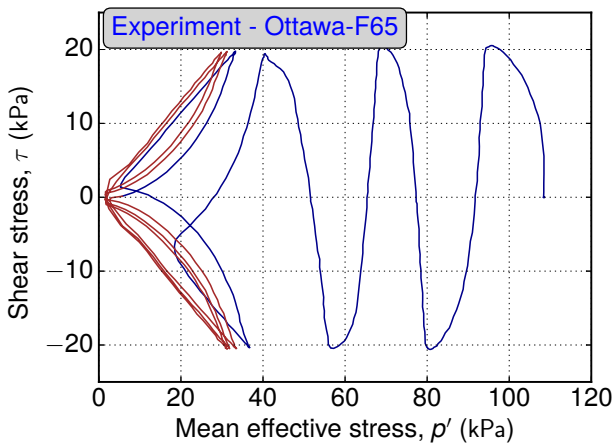
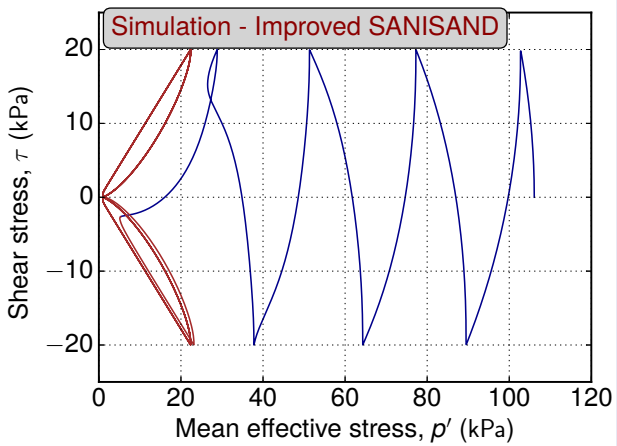
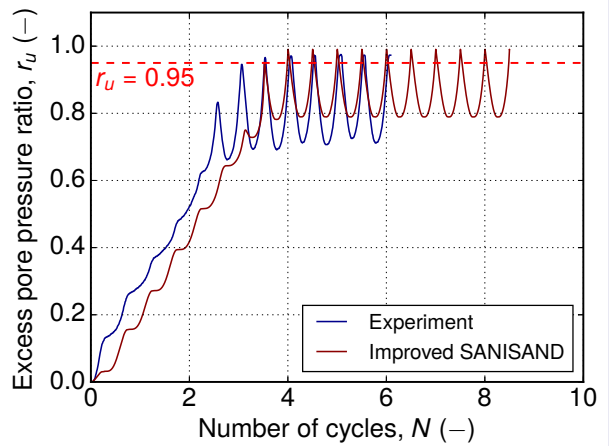






Model parameters

Improved SANISAND

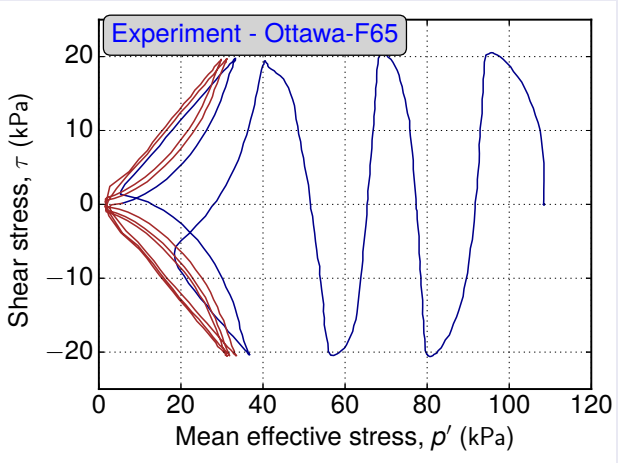
Parameters	Symbol	Ottawa-F65[1]	Karlsruhe[2]
Elasticity	G_0	125	95
	ν	0.05	0.05
CSL	M	1.26	1.35
	c	1.0	1.0
	e_c^{ref}	0.78	1.038
	λ_c	0.0287	0.056
	ξ	0.7	0.28
Yield surface	m	0.01	0.01
Dilatancy	n^d	2.50	2.15
	A_0	0.626	0.56
Kinematic	n^b	2.30	1.20
Hardening	h_0	5.00	7.60
	c_h	0.968	1.015
Fabric dilatancy	z_{max}	11.0	6.5
	c_z	500	800
Memory surface	μ_{ref}	304	324
	μ_k	1148	865
	ζ	0.0001	0.0001

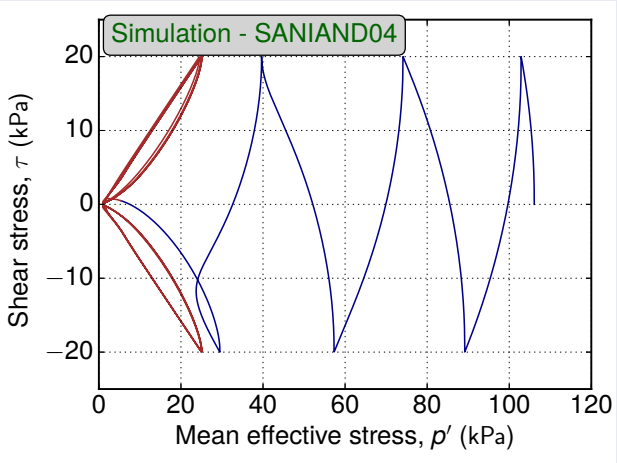
[1] Cyclic torsional tests from Ueda (2018)

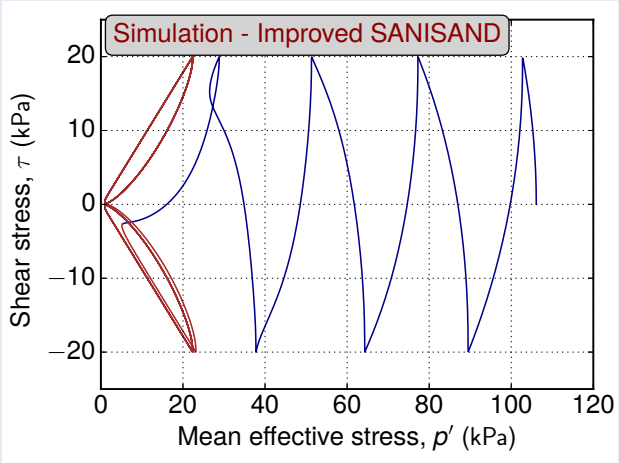
[2] Cyclic triaxial tests from Wichtmann and Triantafyllidis (2016)

Undrained cyclic torsional on Ottawa-F65 sand

CSR=0.19







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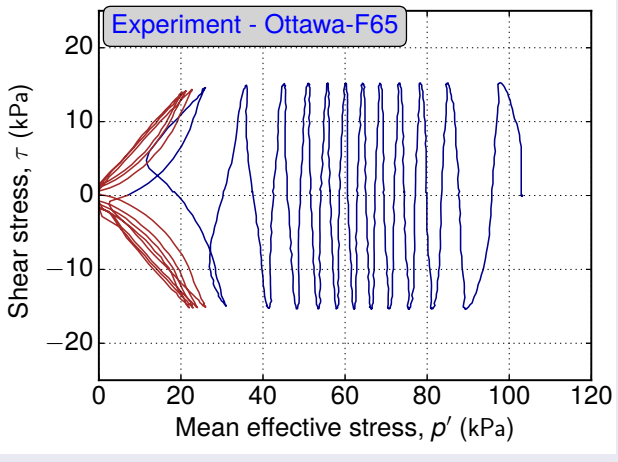
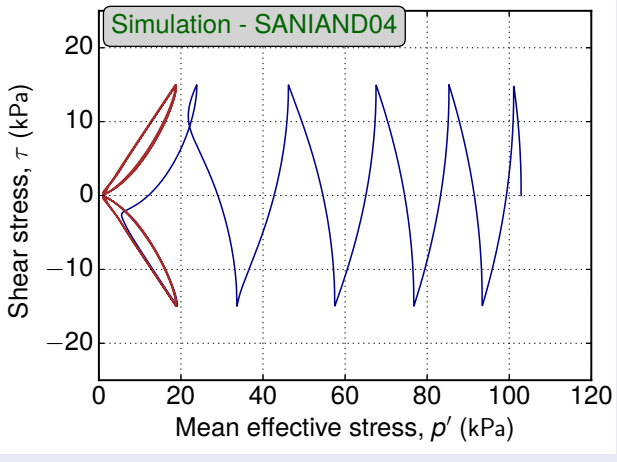
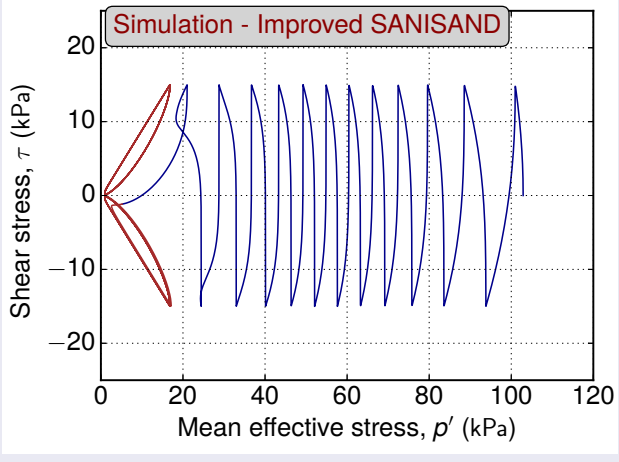
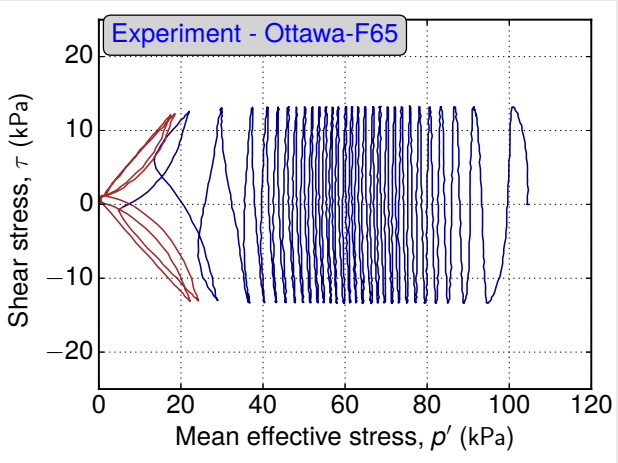


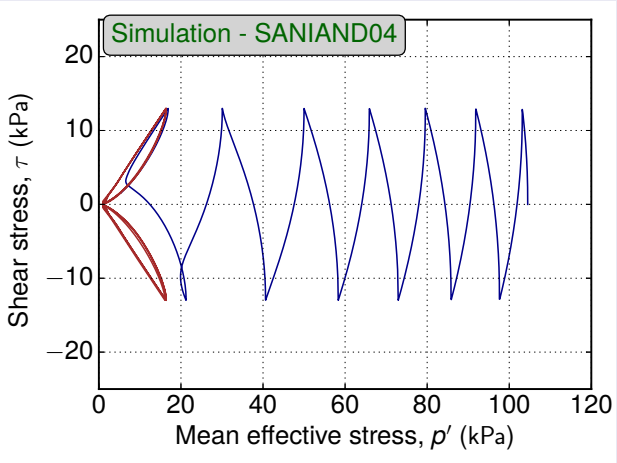


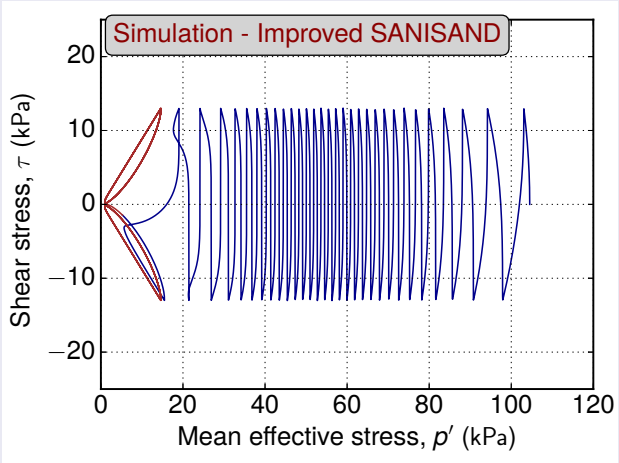


Undrained cyclic torsional on Ottawa-F65 sand cont'd

CSR=0.13







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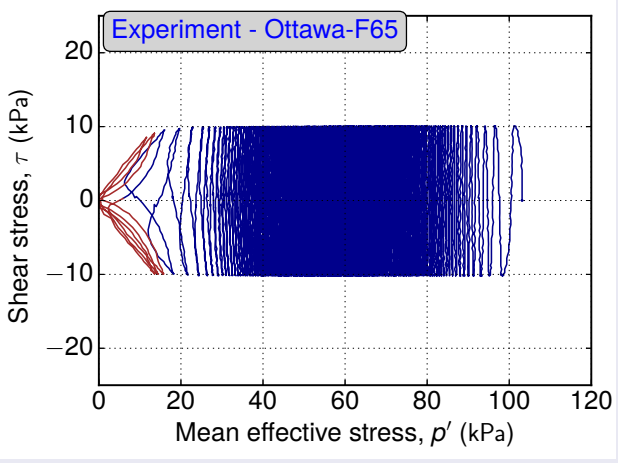
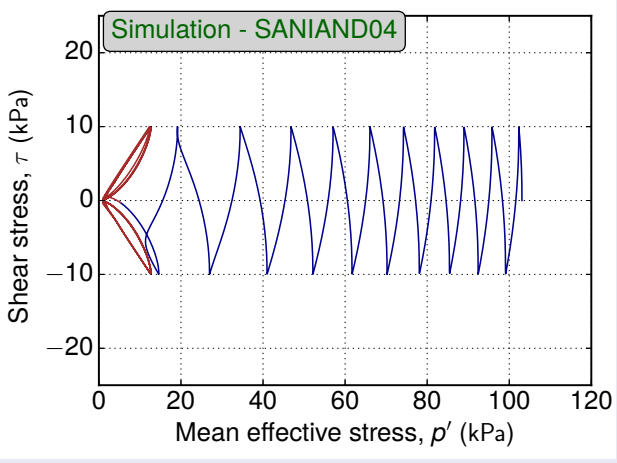
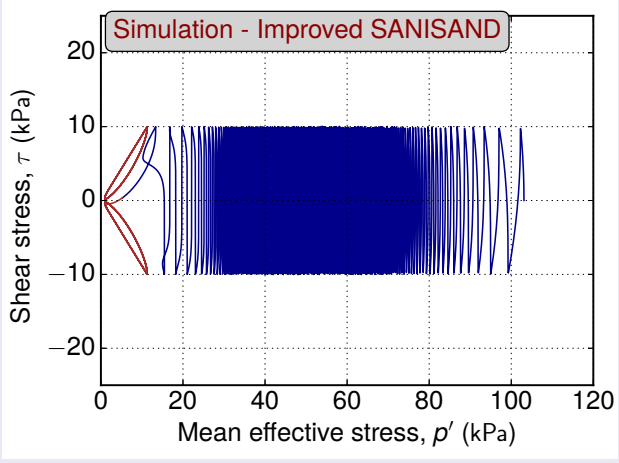
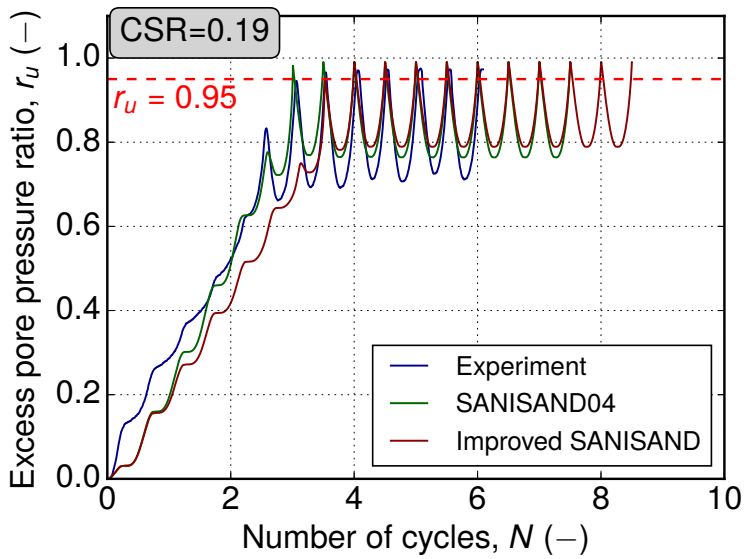


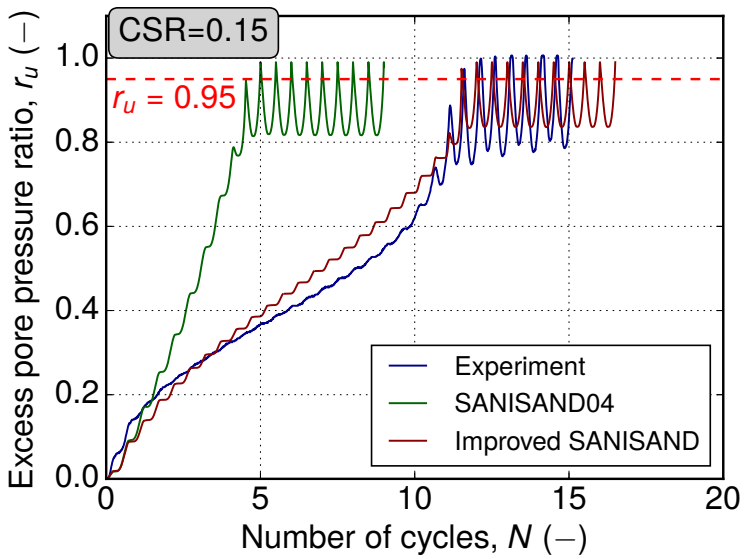


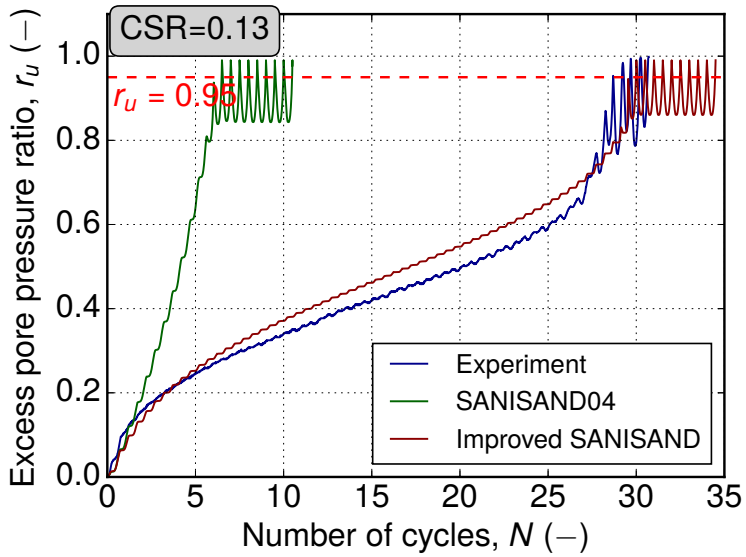


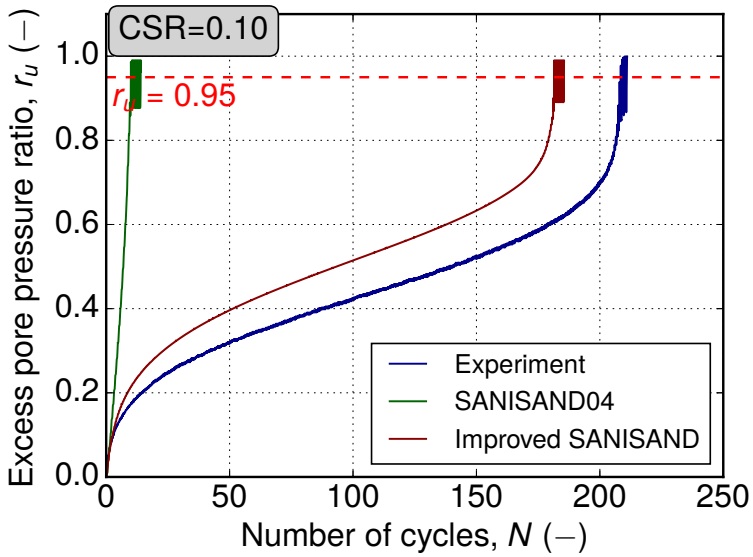
Undrained cyclic torsional on Ottawa-F65 sand cont'd

Pore pressure generation



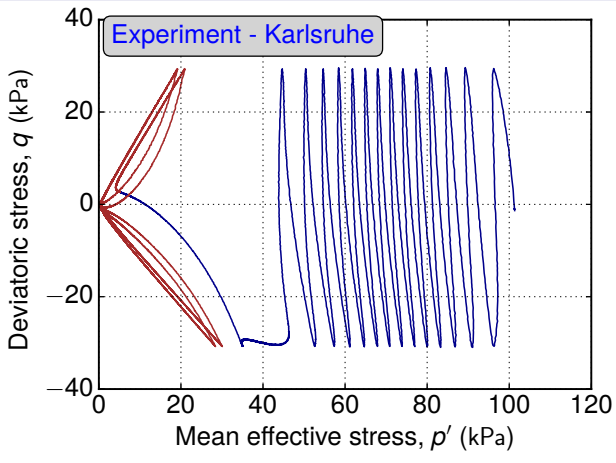


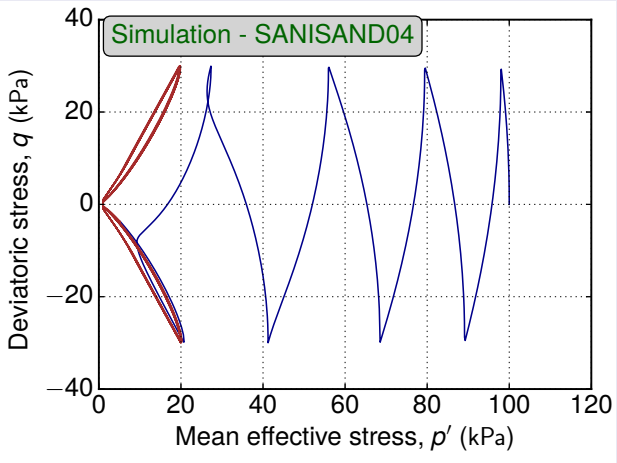


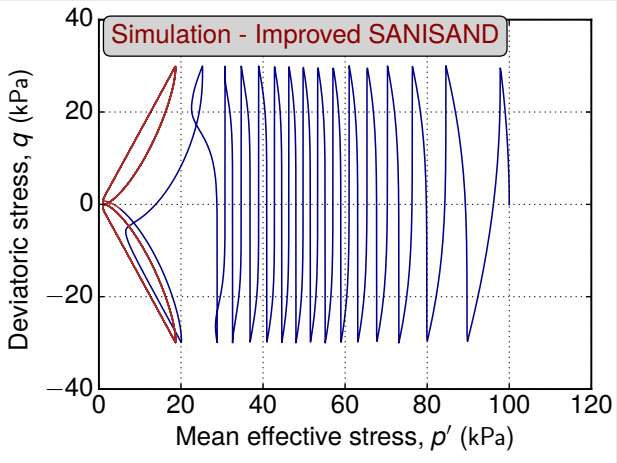


Undrained cyclic triaxial on Karlsruhe fine sand

CSR=0.15







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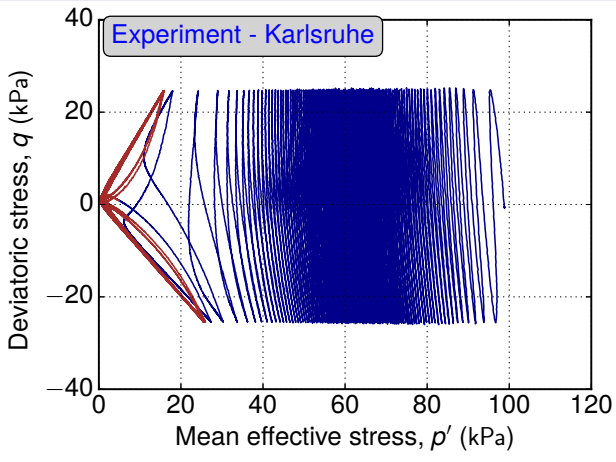
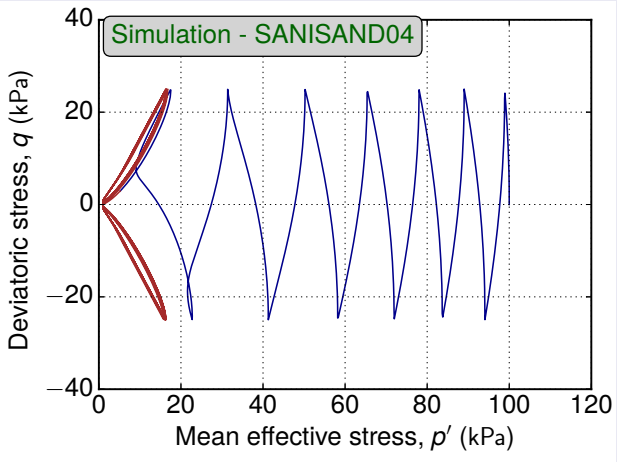
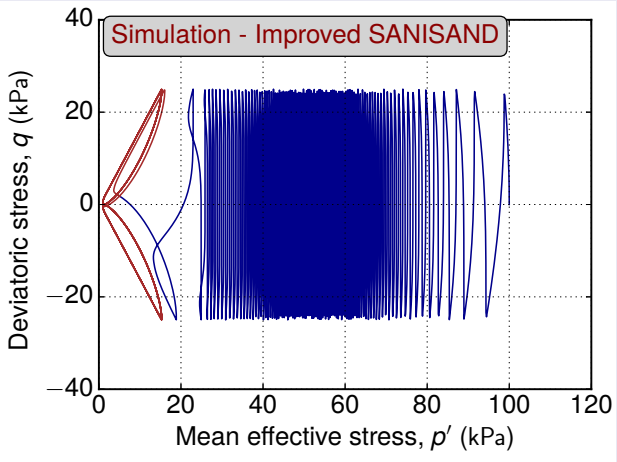
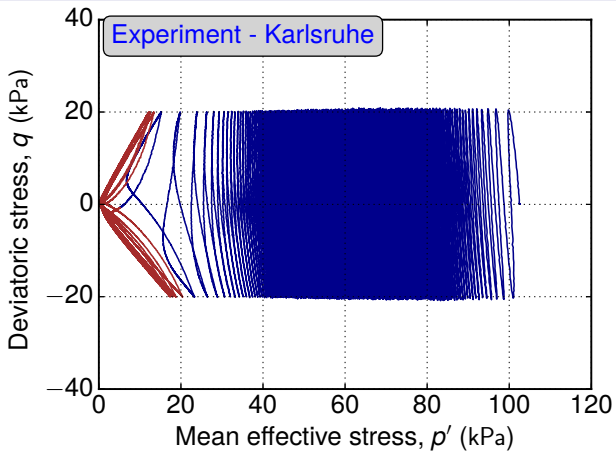


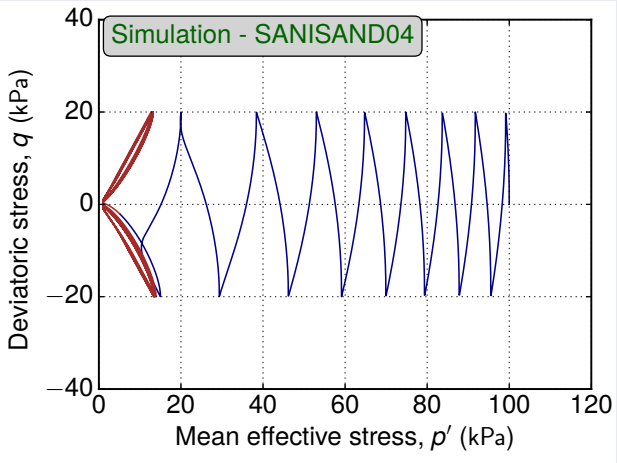


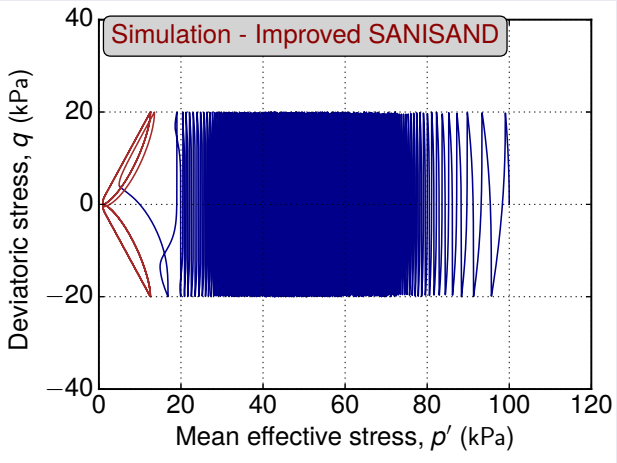


Undrained cyclic triaxial on Karlsruhe fine sand cont'd

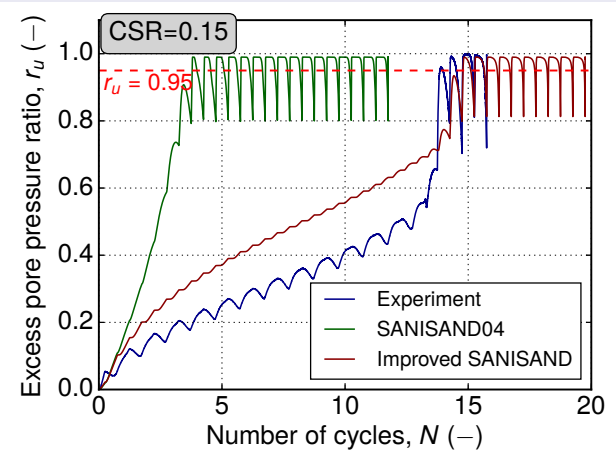
CSR=0.10

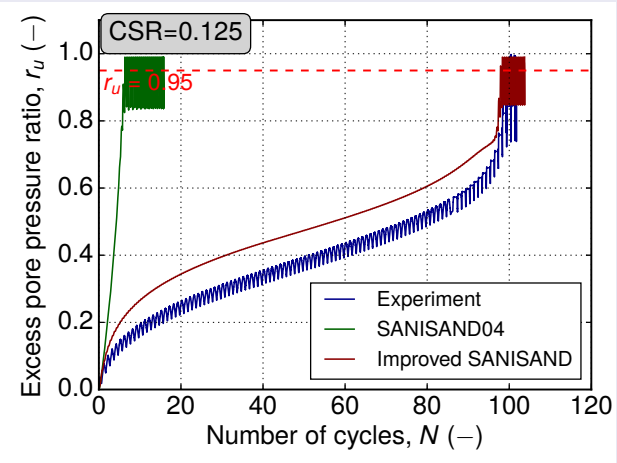


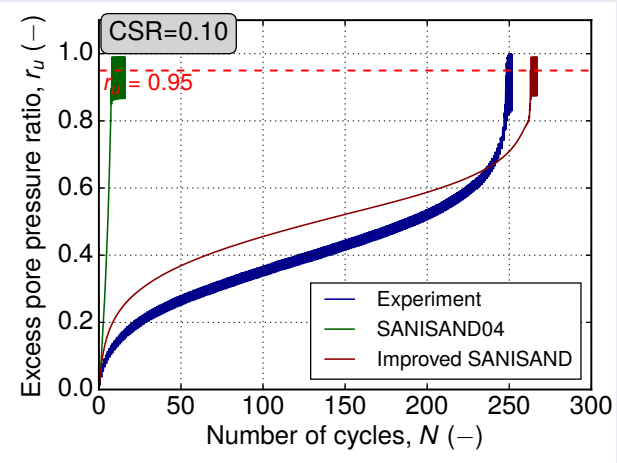




Pore pressure generation



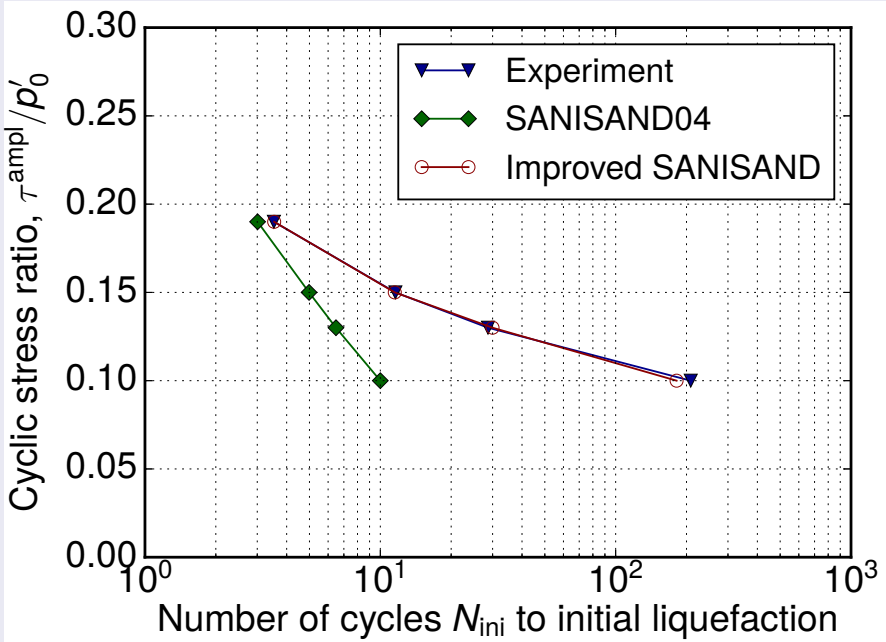




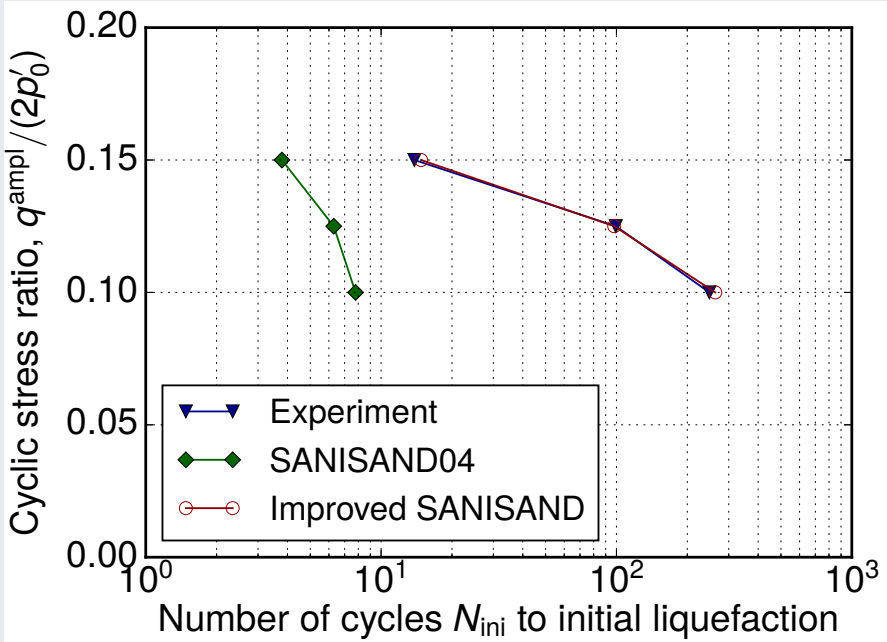
Liquefaction strength curve

- Initial liquefaction: $r_u = 0.95$

Undrained cyclic torsional on Ottawa-F65



Undrained cyclic triaxial on Karlsruhe



Conclusions

- Memory surface:
  - Isotropic and kinematic hardening; size influencing plastic stiffness
- Improved SANISAND:
  - Pace of excess pore pressure generation for low CSRs
  - Balance between high CSRs and low CSRs
  - Excellent capturing the number of cycles to reach liquefaction triggering
- Ongoing works:
  - Exploring the effects of confinement, initial static shear bias and different types of loading

Thank you!