THE UNIVERSITY OF BRITISH COLUMBIA

Bidirectional monotonic and cyclic shear testing of soils: State of Knowledge

Ming Yang Mahdi Taiebat Yogi Vaid

Theoretical & Applied Geomechanics (TAG) Group
Department of Civil Engineering, University of British Columbia, Vancouver, BC, Canada

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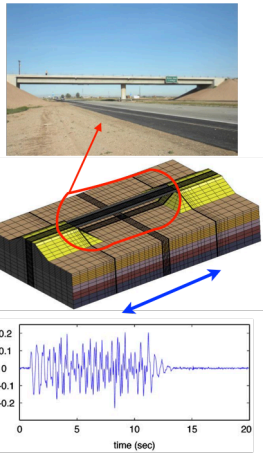
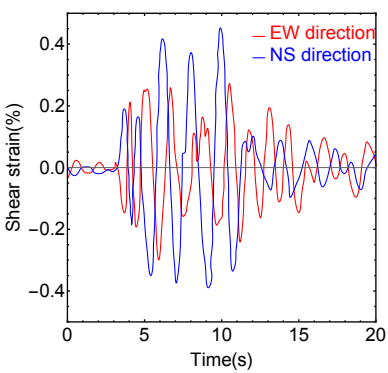
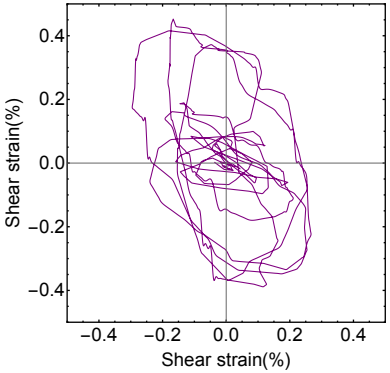
Motivation



Modified from Bebamzadeh et al. (2014); Rahmani et al. (2014)



(a) Strain history



(b) Strain orbit

Nanbu earthquake, 1995 (Matsuda et al., 2012)

Outline

1. Bidirectional shear test
2. Initial stress state
3. Undrained shearing
   - Monotonic shear test
   - Cyclic shear test
4. Summary and ongoing research

Laboratory bidirectional shear test

Fig. 1.1 Bidirectional shear device (Kammerer, 2002)

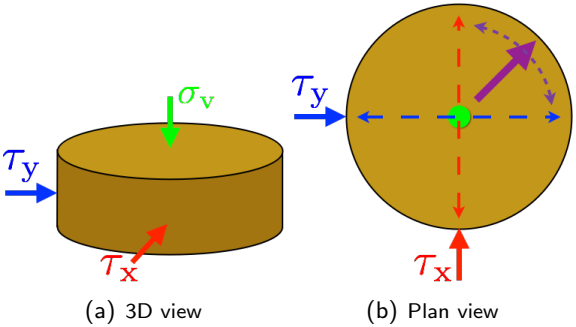


Fig. 1.2 Modified from GDS instruments

Initial stress state

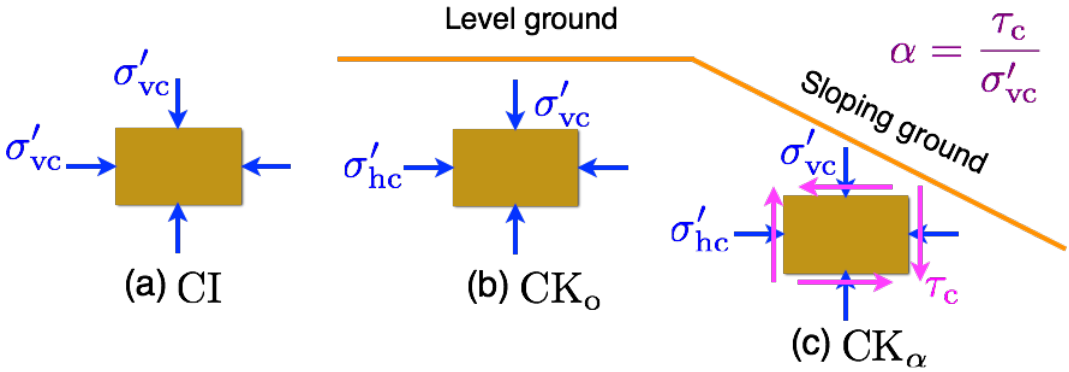
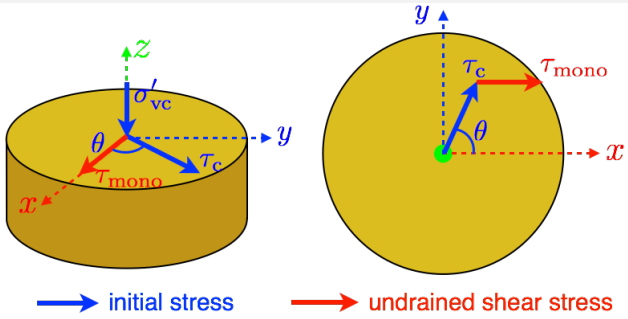


Fig. 2.1 Initial stress conditions: (a) isotropic condition; (b) K_o condition; (c) K_α condition. (modified from Boulanger et al. (1991))

Monotonic shear test

- Initial stress state: CK_α
- Angle between τ_c and τ_mono: θ



Tab. 1 Bidirectional monotonic shear tests on soils

Data source	Material	σ'_{vc}[kPa]	$\tau_\mathrm{c}/\sigma'_{\mathrm{vc}}$	θ[°]	Shear rate[%/hr]
DeGroot (1989)	Boston blue clay	294.2	0.2	0, 30, 60, 90, 120, 150, 180	5
Li et al. (2016)	Leighton Buzzard sand	200	0.05, 0.1	0, 30, 60, 90, 120, 150, 180	3.53

Cyclic shear test - loading paths

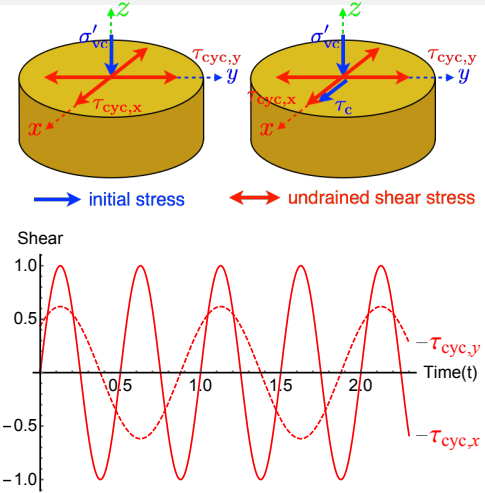


Fig. 3.1 Illustration

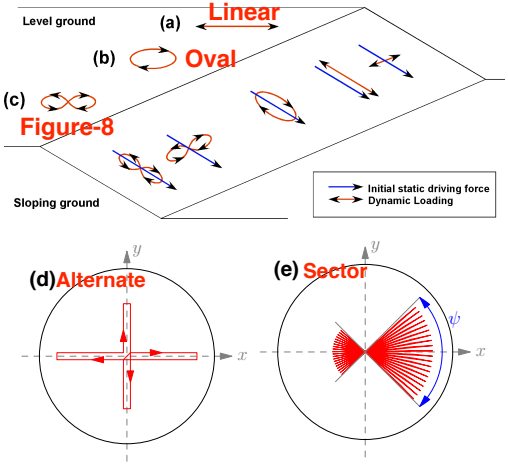


Fig. 3.2 Loading paths (modified from Kammerer (2002))

Cyclic shear test - database

Tab. 2 Bidirectional cyclic shear tests on soils: database

Data source	Material	Initial State	σ'_{vc}[kPa]	α	Test Type	f[Hz]	CSR_x	CSR_y
Ishihara and Yamazaki (1980)	Fuji River sand	CI	200	0	Oval	0.25	0.092	0.081
			200	0	Alternate	0.25	0.144	0.143
Ishihara and Nagase (1988)	Fuji River sand	CI	196	0	Irregular	-	-	-
Boulanger et al. (1991)	Sacramento River sand	CK_α	206	0.1	Linear	0.2	0	0.1,0.15,0.118 0.141,0.16,0.18 0.082,0.1,0.109 0.124,0.125
			206	0.2	Linear	0.2	0	0.135,0.139,0.15 0.15,0.157,0.187 0.187 0.05,0.08,0.082 0.082,0.1,0.1 0.11,0.115,0.131
			206	0.3	Linear	0.2	0	0.131,0.143,0.15 0.15,0.15,0.163 0.17,0.21,0.211 0.218
Kammerer (2002)	Monterey 0/30 sand	CK_o	87	0	Oval	0.1	0.24	0.239
			79	0	Oval	0.1	0.274	0.26
			83	0	Oval	0.1	0.133	0.124
		CK_α	87	0.02	Oval	0.1	0.134	0.227
			83	0.02	Oval	0.1	0.365	0.185

Summary and ongoing research

Summary

- Experimental data about bidirectional shear test is available within two categories
  - *Monotonic shearing on specimens with* CK_α
  - *Cyclic shearing on specimens with* CI, CK_o *and* CK_α
- A comprehensive database is collected in a well organized way

Ongoing research

- Simulate element tests with complex loading paths to evaluate numerical models
- Model boundary value problems

Thank you!

Figure-8 path

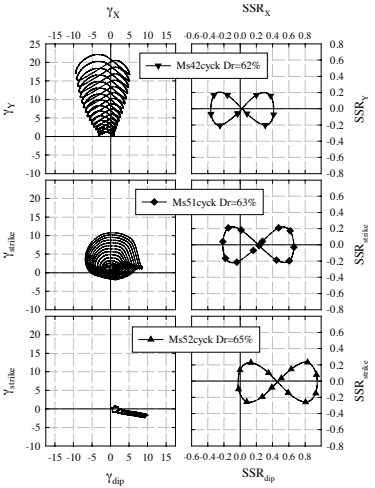


Fig. 4.1 Figure-8 from Kammerer (2002)

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