

# Cyclic Plastic Deformation Characteristics of Subgrade under Moving Train Wheel Load



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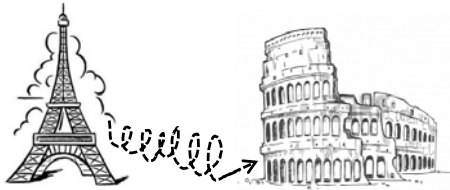




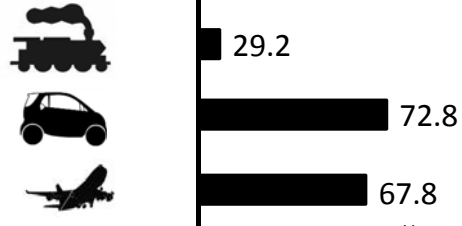
# Background

## Train as a Sustainable Mode.....

### Eco-Passenger

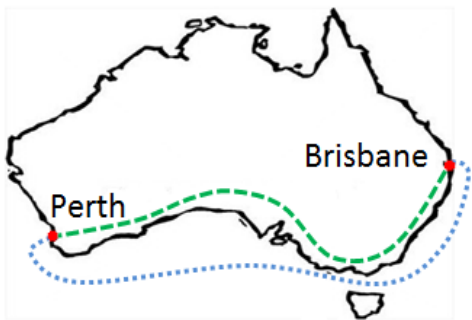


### Energy consumption (l)/Passenger

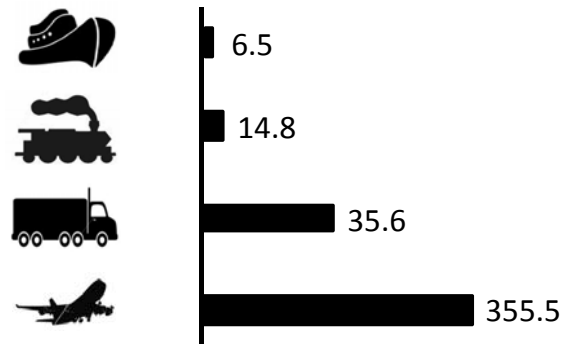


<http://www.ecopassenger.org/>

### Eco-Transit



### Energy consumption (TJ)/10000 Tons



<http://www.ecotransit.org/>

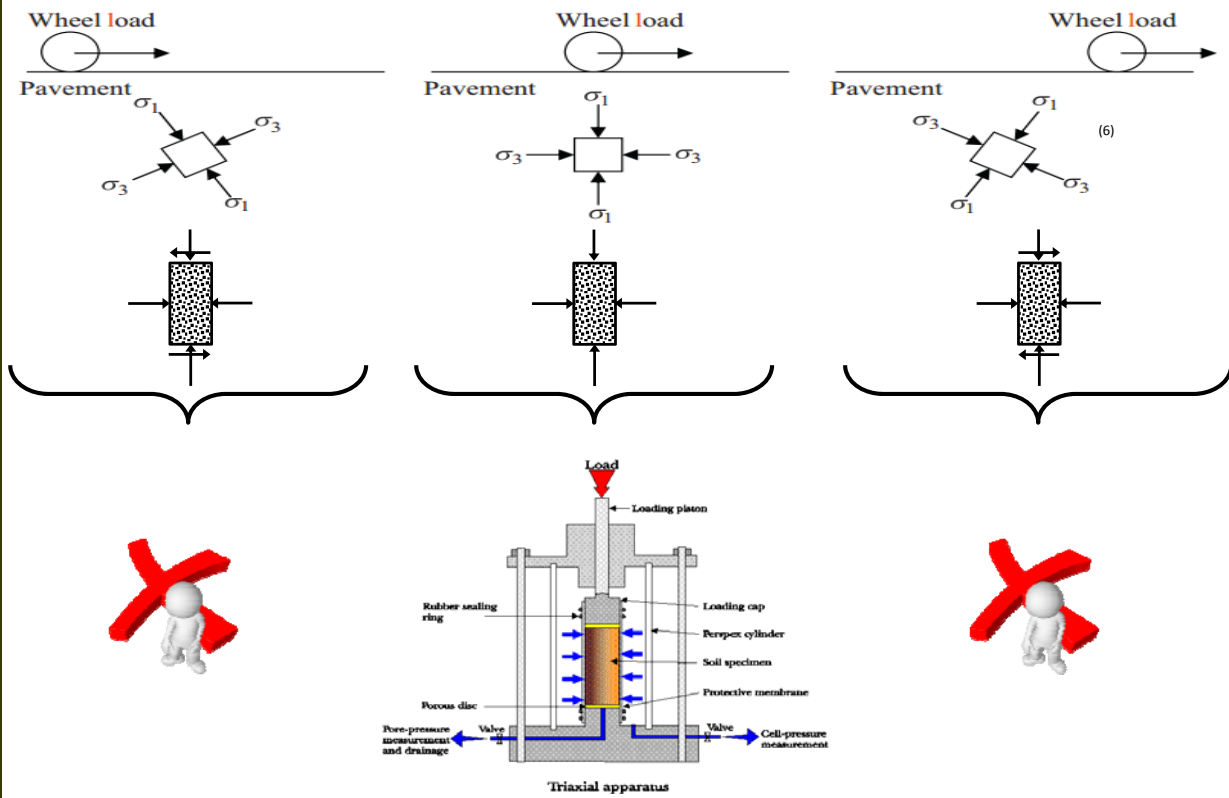


# Background<sub>(cont.)</sub>

Design Parameter	Chinese Guidelines <sup>(1,2)</sup>	UIC 719R Guideline <sup>(3)</sup>			ARTC Guidelines <sup>(4)</sup>	Li & Selig Approach (USA) <sup>(5)</sup>
		DB Approach	MAV Approach	SNCF Approach		
Static wheel load	No information	Yes	Yes	Yes	Vary with track class	Yes
Dynamic wheel load	No	No	No	No	No	Quasi-Static
Train speed	Vary with track class	Yes	Yes	Yes	Vary with track class	Yes
Train direction	No	No	No	No	No	No
Annual tonnage	Vary with track class	Yes	Yes	Yes	Vary with track class	Yes
Cumulative tonnage	No	No	No	No	No	Yes
Subgrade condition	No information	Yes, Soil quality class from percentage of fine	Yes, Soil quality class from percentage of fine	Yes, Soil quality class from percentage of fine	Yes, different bearing capacity classes	Yes
Principal stress rotation	No	No	No	No	No	No
Stiffness variation	Yes	Yes	Yes	Yes	No	No



# Cyclic triaxial tests



# Current available options

➤ Model test



➤ Wheel tracker

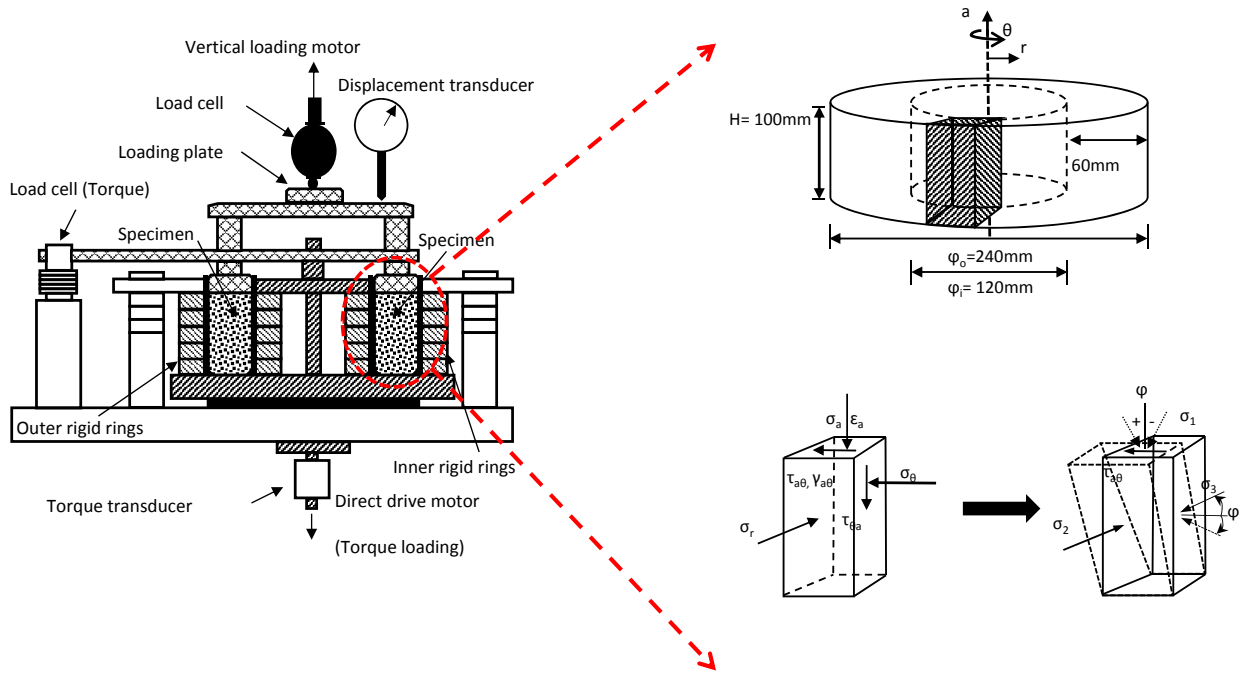


➤ Hollow cylindrical apparatus

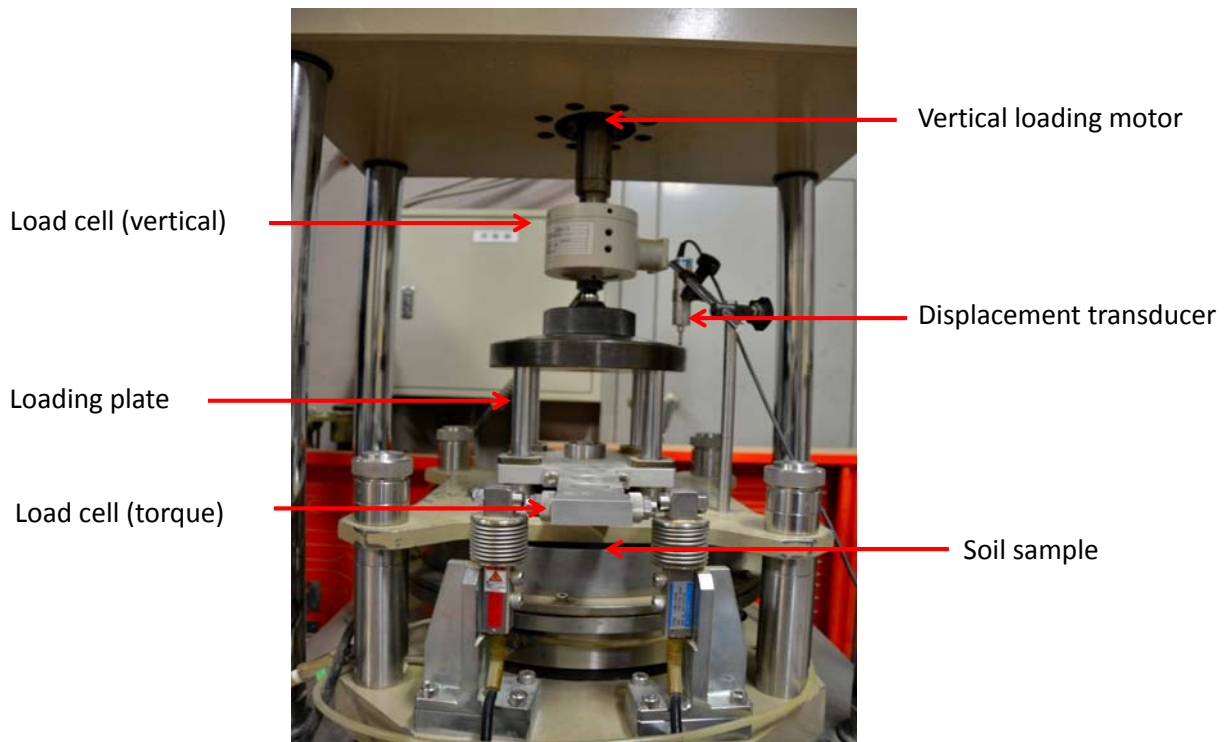




# Modified Multi-Ring Shear (MMRS) apparatus

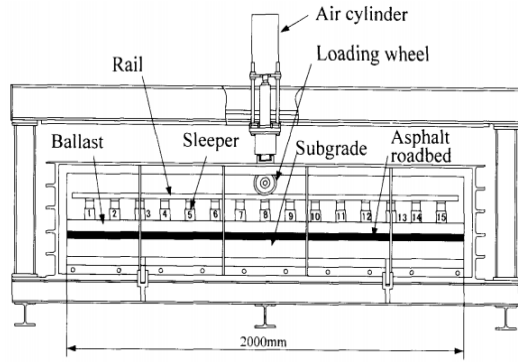


# Multi-ring shear apparatus (cont.)

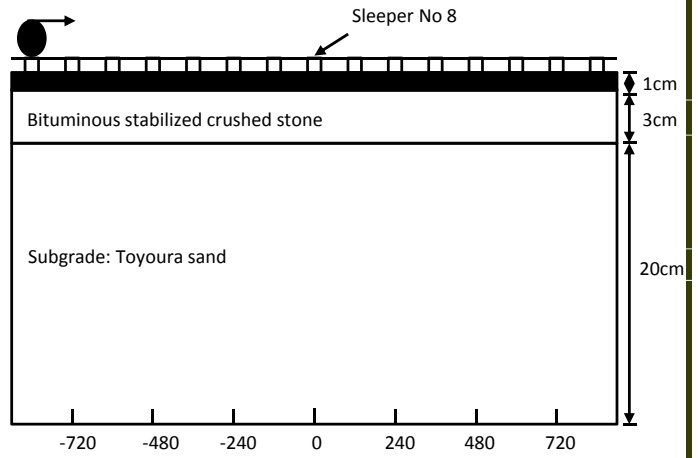




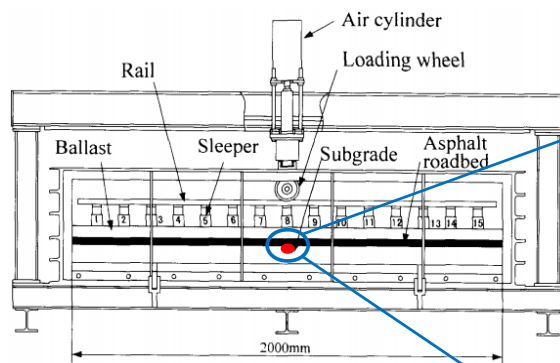
# Model experiments



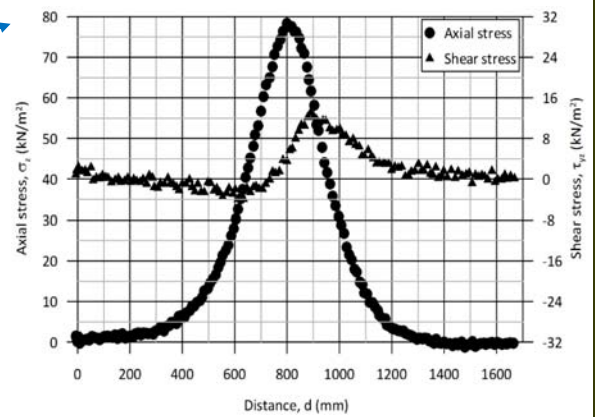
Model test setup



# Model experiments (cont.)



Model test setup



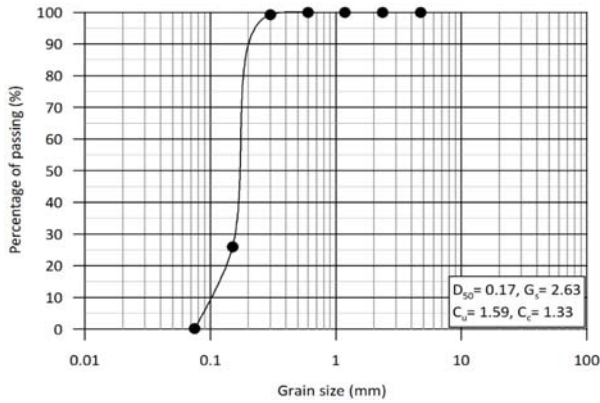
Rail seat stress - wheel position relationship

$\sigma_{a(max)} : 80.12 \text{ kPa}$

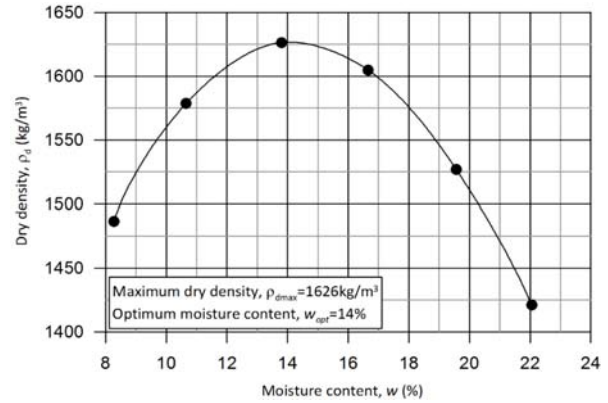
$\tau_{yz(max)} : 13.12 \text{ kPa}$



## Material used



Particle size distribution



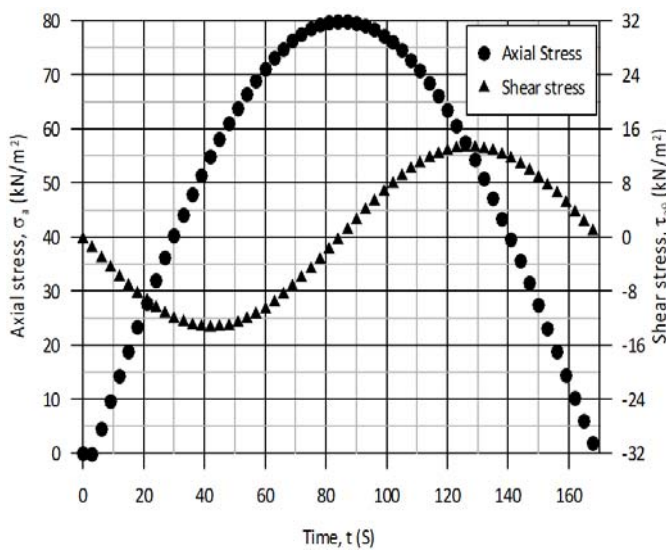
Moisture-density relationship

Selected dry density from model test : 1.56 g/cm<sup>3</sup>

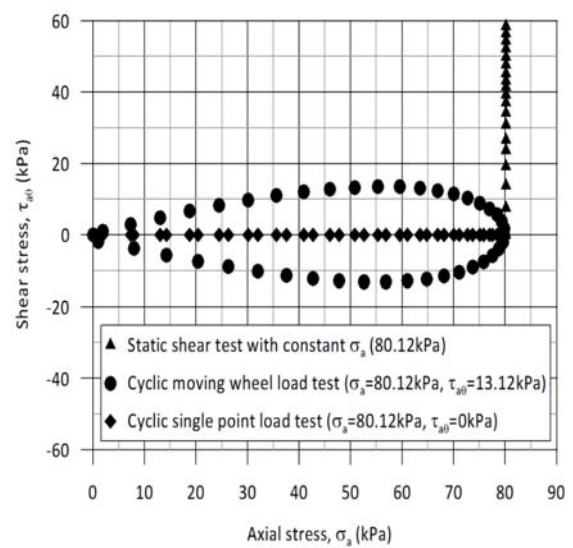
Used water content : Air-dried



## Loading conditions



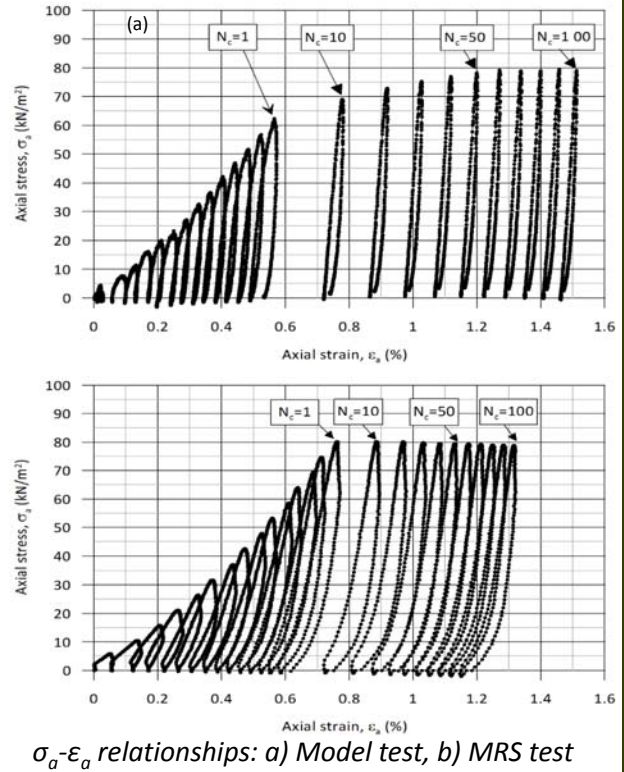
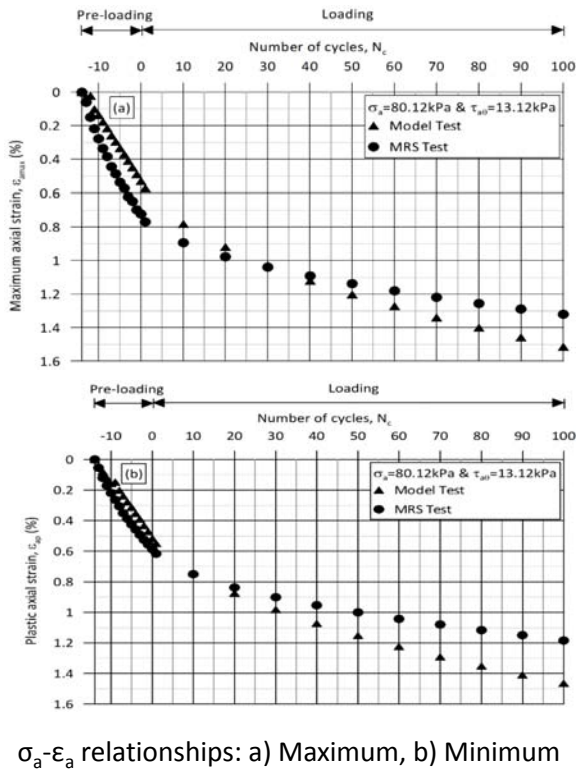
$\sigma_a$ - $\tau_{a\theta}$  time relationships



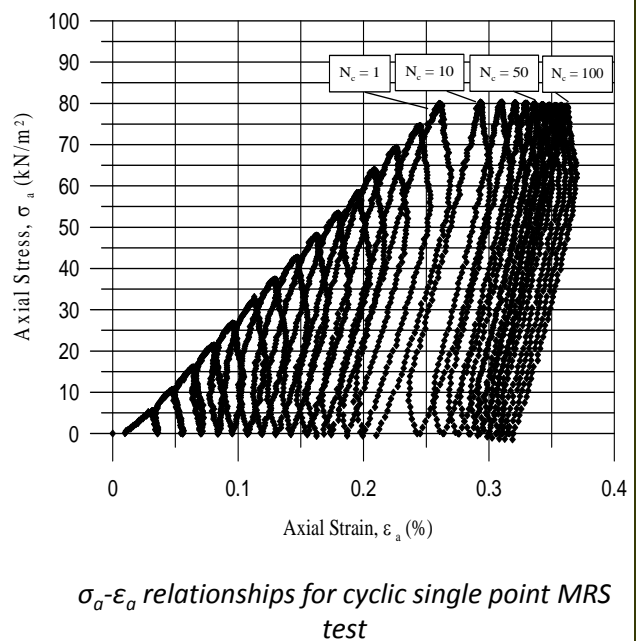
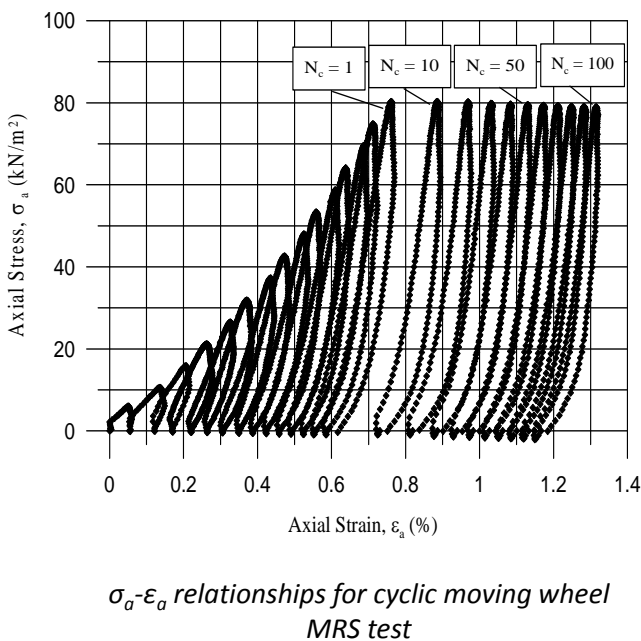
$\sigma_a$ - $\tau_{a\theta}$  relationships for static torsional shear loading and cyclic loading tests



## Deformation relationships



## Effects of loading method





## Conclusion

- Multi-ring shear apparatus suitable to replicate subgrade response under rail loads.
- Cyclic single point loadings underestimates deformation characteristics of rail track subgrades.



## Reference

- (1) Professional Standard of the People's Republic of China. TB10001-2005. *Code for design on subgrade of railway*. Beijing: China railway publishing house; 2005.
- (2) Professional Standard of the People's Republic of China. TB10082-2005. *Code for design of railway track*. Beijing: China railway publishing house; 2005.
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- (4) Engineering Practices Manual Civil Engineering. RTS 3430. *Track reconditioning guidelines*. Australia: Australian Rail Track Corporation LTD (ARTC); 2006.
- (5) Li, D. and E. Selig (1998). "Method for railroad track foundation design. I:Development." *Journal of Geotechnical and Geoenvironmental Engineering* 124(4): 316-322.
- (6) Lekarp, F., Isacsson, U., Dawson, A., 2000. State of the art. I: Resilient response of unbound aggregates. *Journal of Transportation Engineering* 126 (1), 66–75.





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*Thank you*



