Cyclic Fundamentals Checklist

Things to work through when faced with a cyclic loading problem

Type of Cyclic Loading	External	Wave/ Temperature cycles	'Simple' stress conditions	Minimal kinematic SSI			
	'Soil Defined'	Seismic	'Complex' stress conditions	Kinematic SSI generally important – depends on structure			
Soil Drainage Conditions during cycling	Undrained during single cycle	Undrained over full cycling duration	Worst case- most degradation				
	Undrained during single cycle	Partially drained over full cycling duration	Need to account for drainage to get better results	Can be done using reduced numbers of cycles (total stress models)	Or, on-the fly drainage (effective stress models)		
	Partially drained or drained during single cycle	Drained over full cycling duration	Not usually problematic	Drained cyclic shear strains small	Some drained volumetric compaction		
Soil Type (check; PI)	Most sands	Liquefiable	Initial Liquefaction (dense soil)	Reduction in soil stiffness	Displacement limited	Damage is reversible after drainage	Very common offshore
			Flow Liquefaction (loose soil)	Reduction in soil stiffness and strength	Strength limited (can lead to catastrophic failure)	Damage is reversible after drainage	Very rare offshore - but beware high confining stresses
	Most clays	Non-liquefiable	Low Sensitivity (check LI)	Reduction in soil stiffness and strength	Often offset by strain rate effects	Damage is reversible after drainage	Very common offshore
			High Sensitivity	Reduction in soil stiffness and strength	Strength limited (can lead to catastrophic failure)	Damage is reversible after drainage	Moderately common offshore
	Problem soils -silts, 'mixtures, carbonates	Liquefiable or non-liquefiable	Low or High sensitivity	Reduction in soil stiffness and maybe strength	Maybe strength limited (can lead to catastrophic failure)	Damage is reversible after drainage	Common offshore
	Cemented Soils	Low confining stress	Brittle failure	Reduction in soil stiffness and strength	Maybe strength limited (can lead to catastrophic failure)	Damage is irreversible	Common in shallow water, rare in deep water
		High confining stress	Responds like uncemented soil	Reduction in soil stiffness and strength	Displacement limited	Some damage is reversible after drainage, but cementation compromised	
Soil Behaviour	Shear strains	Generally control co-event displacements					
	Reconsolidation strains	Generally control post-event displacements					
	Excess pore pressures	May control interface friction					
Nature of Static and cyclic loads	Static dominated	Less cyclic degradation	Rate effects may improve performance	Static anisotropy may be important	Catastrophic failures may occur with post-peak strain softening		
	Cyclic dominated	More cyclic degradation	Rate effects likely to improve performance		Catastrophic failures may occur with post-peak strain softening		
Constitutive Models	Effective Stress	Best in theory	May include partially drained behaviour (but beware)	Difficult to fully calibrate & mesh dependent results with strain softening	Convergence may be difficult in boundary value problems	Includes 'on-the-fly' degradation and effective stress changes	
	Total Stress	Less theoretical rigour	Needs special treatment for partially drained behaviour	Easier to fully calibrate & easy to adjust for mesh dependency with strain softening	Generally numerically robust	HARM type	Includes 'on-the-fly' degradation
						'Iterative degradation' type	No on the fly degradation, but through post-processing and iteration, full suite of results can be obtained (shear strain, pore pressure, reconsolidation strains)
Engineering Model	'Engineers model'	Uses simplified models (e.g. bearing capacity or 1D pile models; may include simple FEA)	Can be Effective Stress or Total Stress based	Can provide limited results (e.g. just bearing capacity) or full results (e.g. displacement histories)	May require several 'Engineers models' to resolve all required information	Can be equivalent cycle or full time history	Appropriate model selection is critical
	2D and 3D FEA	'Complete' model of soil and foundations possible	Can be Effective Stress or Total Stress based	Generally, provides full results within model limits	One model generally provides most/ all required information	Can be equivalent cycle or full time history	Appropriate model selection is critical