

# ISO 19901-4:2016-07 (E)

## Petroleum and natural gas industries - Specific requirements for offshore structures - Part 4: Geotechnical and foundation design considerations

---

<b>Contents</b>		<b>Page</b>
Foreword .....		v
Introduction .....		vii
1	Scope .....	1
2	Normative references .....	1
3	Terms and definitions .....	2
4	Symbols and abbreviated terms .....	4
4.1	General .....	4
4.2	Symbols for shallow foundations design .....	4
4.3	Symbols for pile foundations design .....	7
4.4	Symbols for soil-structure interaction for auxiliary subsea structures, risers and flowlines .....	10
4.5	Symbols for design of anchors for stationkeeping systems .....	11
4.6	Abbreviated terms .....	12
5	General requirements .....	13
5.1	General .....	13
5.2	Design cases and safety factors .....	14
5.3	Characteristic values of soil properties .....	14
5.4	Testing and instrumentation .....	15
6	Geotechnical data acquisition and identification of hazards .....	16
6.1	General .....	16
6.2	Shallow geophysical investigation .....	16
6.3	Geological modelling and identification of hazards .....	17
6.3.1	General .....	17
6.3.2	Earthquakes .....	17
6.3.3	Fault planes .....	17
6.3.4	Seafloor instability .....	17
6.3.5	Scour and sediment mobility .....	18
6.3.6	Shallow gas .....	18
6.3.7	Seabed subsidence .....	18
6.4	Carbonate soils .....	19
7	Design of shallow foundations .....	19
7.1	General .....	19
7.2	Principles .....	20
7.2.1	General principles .....	20
7.2.2	Sign conventions, nomenclature and action reference point .....	21
7.2.3	Action transfer .....	21
7.2.4	Idealization of foundation area and the effective area concept .....	21
7.3	Acceptance criteria and design considerations .....	22
7.3.1	Action and material factors .....	22
7.3.2	Use in design .....	22
7.3.3	Special cases .....	23
7.3.4	Additional design considerations .....	24
7.3.5	Alternative method of design based on yield surfaces .....	26

7.3.6	Selection of soil parameter values for design .....	27
7.4	Stability of shallow foundations .....	27
7.4.1	Assessment of bearing capacity .....	27
7.4.2	Assessment of sliding capacity .....	29
7.4.3	Assessment of torsional capacity .....	31
7.5	Serviceability (displacements and rotations) .....	31
7.5.1	General .....	31
7.5.2	Displacement under static loading .....	31
7.5.3	Displacement under dynamic and cyclic actions .....	34
7.5.4	Other contributors to foundation settlement .....	34
7.6	Other design considerations .....	34
7.6.1	Hydraulic stability .....	34
7.6.2	Installation, retrieval and removal .....	34
8	Pile foundation design .....	35
8.1	Pile capacity for axial compression .....	35
8.1.1	General .....	35
8.1.2	Axial pile capacity .....	36
8.1.3	Skin friction and end bearing in cohesive soils .....	37
8.1.4	Skin friction and end bearing in cohesionless soils .....	38
8.1.5	Skin friction and end bearing of grouted piles in rock .....	40
8.2	Pile capacity for axial tension .....	41
8.3	Axial pile performance .....	41
8.3.1	Static axial behaviour of piles .....	41
8.3.2	Cyclic axial behaviour of piles .....	41
8.4	Soil reaction for piles under axial compression .....	41
8.4.1	Axial shear transfer t-z curves .....	41
8.4.2	End bearing resistance-displacement, Q-z, curve .....	42
8.5	Soil reaction for piles under lateral actions .....	44
8.5.1	General .....	44
8.5.2	Lateral capacity for soft clay .....	45
8.5.3	Lateral soil resistance-displacement p-y curves for soft clay .....	45
8.5.4	Lateral capacity for stiff clay .....	45
8.5.5	Lateral soil resistance-displacement p-y curves for stiff clay .....	46
8.5.6	Lateral capacity for sand .....	47
8.5.7	Lateral soil resistance - displacement p-y curves for sand .....	48
8.6	Pile group behaviour .....	49
8.6.1	General .....	49
8.6.2	Axial behaviour .....	49
8.6.3	Lateral behaviour .....	50
9	Pile installation assessment .....	50
9.1	General .....	50
9.2	Drivability studies .....	51
9.3	Obtaining required pile penetration .....	51
9.4	Driven pile refusal .....	52
9.5	Pile refusal remedial measures .....	52
9.5.1	Review of hammer performance .....	52
9.5.2	Re-evaluation of design penetration .....	52
9.5.3	Modifications to piling procedures .....	52
9.6	Selection of pile hammer and stresses during driving .....	53
9.7	Use of hydraulic hammers .....	53
9.8	Drilled and grouted piles .....	54
9.9	Belled piles .....	55
9.10	Grouting pile-to-sleeve connections .....	55
9.11	Pile installation data .....	55
9.12	Installation of conductors and shallow well drilling .....	55
10	Soil-structure interaction for auxiliary subsea structures, risers and flowlines .....	56
11	Design of anchors for floating structures .....	56
	Annex A (informative) Additional information and guidance .....	57
	Bibliography .....	175