

ISO 19901-4:2025-02 (E)

Oil and gas industries including lower carbon energy - Specific requirements for offshore structures - Part 4: Geotechnical design considerations

Contents		Page
Foreword		vi
Introduction		vii
1	Scope	1
2	Normative references	1
3	Terms and definitions	2
4	Symbols and abbreviated terms	4
4.1	Symbols for shallow and intermediate foundation design	4
4.2	Symbols for pile foundation design	6
4.3	Symbols for soil-structure interaction for auxiliary subsea structures, risers and flowlines	9
4.4	Symbols for design of anchors for stationkeeping systems	10
4.5	Abbreviated terms	12
5	General requirements	13
5.1	General	13
5.2	Design cases and partial factors	13
5.3	Representative and design values of geotechnical parameters	14
5.3.1	Guidelines	14
5.3.2	Determination of representative and design values of soil parameters	14
5.4	Reliability-based geotechnical design	16
5.5	Testing and instrumentation	16
6	Site investigation, identification of geohazards and carbonate soils	17
6.1	General	17
6.2	Geological modelling and identification of hazards	17
6.2.1	General	17
6.2.2	Assessment of site geohazards	18
6.3	Carbonate soils	18
6.3.1	General	18
6.3.2	Characteristic features and properties of carbonate soils	18
6.3.3	Foundations in carbonate soils	18
7	Design of shallow and intermediate foundations for fixed structures	19
7.1	General	19
7.2	Principles	20
7.2.1	General principles	20
7.2.2	Foundation embedment	20
7.2.3	Sign conventions, nomenclature and action reference point	21
7.3	Acceptance criteria	21
7.3.1	Material and action factors	21
7.3.2	Use of partial factors in design	22
7.4	Design considerations	23
7.4.1	Adjusting for soil plug weight	23
7.4.2	Skirt spacing	23
7.4.3	Foundation base perforations	24
7.4.4	Skirtless foundations penetrating soft soils	24

7.4.5	Tensile stresses beneath foundations	24
7.4.6	Omni-directional actions	24
7.4.7	Interaction with other structures	24
7.4.8	Multiple foundations	24
7.4.9	Hydraulic stability	25
7.4.10	Unconventional soils or soil profiles	25
7.4.11	Selection of soil parameter values for design	25
7.5	Ultimate limit state (stability)	26
7.5.1	Assessment of bearing capacity of shallow foundations	26
7.5.2	Assessment of sliding capacity of shallow foundations	29
7.5.3	Assessment of capacity of intermediate foundations	31
7.6	Serviceability limit state (displacements and rotations)	32
7.6.1	General	32
7.6.2	Serviceability of shallow foundations under static loading	32
7.6.3	Serviceability of intermediate foundations	34
7.6.4	Serviceability in response to dynamic and cyclic actions	34
7.7	Alternative methods of design	34
7.7.1	Yield surface approach	34
7.7.2	Risk-informed decision making	35
7.8	Installation	35
7.8.1	General	35
7.8.2	Skirt penetration resistance	35
7.8.3	Required and allowable under-pressure	36
7.9	Relocation, retrieval and removal	37
8	Pile foundation design	37
8.1	Pile capacity for axial compression	37
8.1.1	General	37
8.1.2	Axial pile capacity	38
8.1.3	Skin friction and end bearing in clay soils	39
8.1.4	Skin friction and end bearing in sands	41
8.1.5	Skin friction and end bearing in gravels	42
8.1.6	Skin friction and end bearing of grouted piles in rock	43
8.1.7	Skin friction and end bearing of driven piles in intermediate soils	43
8.2	Pile capacity for axial tension	43
8.3	Axial pile performance	43
8.3.1	Static axial behaviour of piles	43
8.3.2	Cyclic axial behaviour of piles	44
8.4	Soil reaction for piles under axial actions	44
8.4.1	Axial shear transfer t-z curves	44
8.4.2	End bearing resistance-displacement, Q-z curve	45
8.5	Soil reaction for piles under lateral actions	46
8.5.1	General	46
8.5.2	Lateral soil reaction for clay	47
8.5.3	Lateral capacity for sand	54
8.5.4	Lateral soil resistance - displacement p-y curves for sand	55
8.5.5	p-y curves for fatigue actions for sands	56
8.5.6	Refined assessment of lateral pile response	57
8.5.7	Lateral soil resistance-displacement curves in calcareous soil, cemented soil and weak rock	57
8.6	Pile group behaviour	57
8.6.1	General	57
8.6.2	Axial behaviour	57
8.6.3	Lateral behaviour	57
8.7	Pile installation assessment	58
8.7.1	General	58
8.7.2	Drivability studies	58
8.7.3	Obtaining required pile penetration	59
8.7.4	Driven pile refusal	59
8.7.5	Pile refusal remedial measures	59
8.7.6	Selection of pile hammer and stresses during driving	60

8.7.7	Use of hydraulic hammers	61
8.7.8	Drilled and grouted piles	62
8.7.9	Grouting pile-to-sleeve connections	62
8.7.10	Pile installation data	62
8.7.11	Installation of conductors and shallow well drilling	63
9	Assessment of pile capacity for existing structures	63
9.1	General	63
9.2	Geotechnical and foundation data	64
9.2.1	Geotechnical data	64
9.2.2	Design data	64
9.2.3	Installation data	64
9.2.4	Condition data	64
9.2.5	Operational data	65
9.3	Evaluation	65
9.4	Assessment	65
9.4.1	General	65
9.4.2	Pushover response of pile foundation systems	65
9.5	Time-dependent effects on pile foundations	66
10	Geotechnical design input to subsea structures, risers and flowlines	67
10.1	General	67
10.2	Geotechnical investigation	67
10.3	Foundations for subsea production structures	67
10.4	Steel catenary risers	67
10.4.1	General	67
10.4.2	Seabed characterisation	68
10.4.3	Design for ultimate limit state	68
10.4.4	Design for fatigue limit state	68
10.5	Geotechnical design for jettted conductors and top tension risers	70
10.5.1	General	70
10.5.2	Jettted conductors	71
10.5.3	Soil-structure interaction for well integrity assessment	73
10.5.4	Geotechnical input to well strength assessment	73
10.5.5	Geotechnical input to well fatigue assessment	74
10.5.6	Geotechnical considerations in conductor driving analysis	78
10.6	Foundation design for riser towers	78
10.6.1	General	78
10.6.2	Foundation options	78
10.6.3	Loading actions and safety factors	79
10.6.4	Design challenges	79
10.7	Offshore pipelines and flowlines	79
10.7.1	Geotechnical pipe-soil interaction (PSI) analysis	79
10.7.2	Submarine slides and density flows: simulation and pipeline impact analysis	80
11	Design of anchors for floating structures	81
	Annex A (informative) Additional information and guidance	82
	Bibliography	207