

DIN EN ISO 19901-4:2025-05 (E)

Oil and gas industries including lower carbon energy - Specific requirements for offshore structures - Part 4: Geotechnical design considerations (ISO 19901-4:2025); English version EN ISO 19901-4:2025

| 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 |
| | 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 jetted conductors and top tension risers | 70 |
| 10.5.1 | General | 70 |
| 10.5.2 | Jetted 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 |