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Petroleum and natural gas industries - Specific requirements for offshore structures - Part 4: Geotechnical and foundation design considerations (ISO/DIS 19901-4:2015)

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Industries du pétrole et du gaz naturel - Exigences spécifiques relatives aux structures en mer - Partie 4: Bases conceptuelles des fondations (ISO/DIS 19901-4:2015)

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Petroleum and natural gas industries — Specific requirements for offshore structures —

Part 4: Geotechnical and foundation design considerations

*Industries du pétrole et du gaz naturel — Exigences spécifiques relatives aux structures en mer —
Partie 4: Bases conceptuelles des fondations*

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ISO/CEN PARALLEL PROCESSING

This draft has been developed within the International Organization for Standardization (ISO), and processed under the **ISO lead** mode of collaboration as defined in the Vienna Agreement.

This draft is hereby submitted to the ISO member bodies and to the CEN member bodies for a parallel five month enquiry.

Should this draft be accepted, a final draft, established on the basis of comments received, will be submitted to a parallel two-month approval vote in ISO and formal vote in CEN.

To expedite distribution, this document is circulated as received from the committee secretariat. ISO Central Secretariat work of editing and text composition will be undertaken at publication stage.



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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO-specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: [Foreword - Supplementary information](#)

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 19901-4 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for the petroleum, petrochemical and natural gas industries*, Subcommittee SC 7, *Offshore structures*.

This second/third/... edition cancels and replaces the first/second/... edition (), [clause(s) / subclause(s) / table(s) / figure(s) / annex(es)] of which [has / have] been technically revised.

ISO 19901 consists of the following parts, under the general title *Petroleum and natural gas industries — Specific requirements for offshore structures*:

- *Part 4: Geotechnical and foundation design considerations*
- *Part [n]:*
- *Part [n+1]:*

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ISO 19901 consists of the following parts, under the general title *Petroleum and natural gas industries — Specific requirements for offshore structures*:

- *Part 1: Metocean design and operating considerations*
- *Part 2: Seismic design procedures and criteria*
- *Part 3: Topsides structure*
- *Part 4: Geotechnical and foundation design considerations*
- *Part 5: Weight control during engineering and construction*
- *Part 6: Marine operations*
- *Part 7: Stationkeeping systems for floating offshore structures and mobile offshore units*
- *Part 8: Marine soil investigations.*

ISO 19901 is one of a series of standards for offshore structures. The full series consists of the following International Standards:

- ISO 19900, *Petroleum and natural gas industries — General requirements for offshore structures*
- ISO 19901 (all parts), *Petroleum and natural gas industries — Specific requirements for offshore structures*
- ISO 19902, *Petroleum and natural gas industries — Fixed steel offshore structures*
- ISO 19903, *Petroleum and natural gas industries — Fixed concrete offshore structures*
- ISO 19904, *Petroleum and natural gas industries — Floating offshore structures*
- ISO 19905-1, *Petroleum and natural gas industries — Site-specific assessment of mobile offshore units — Part 1: Jack-ups*
- ISO/TR 19905-2, *Petroleum and natural gas industries — Site-specific assessment of mobile offshore units — Part 2: Jack-ups commentary and detailed sample calculation*
- ISO 19906, *Petroleum and natural gas industries — Arctic offshore structures*

Other ISO standards can have implications for the geotechnical design of foundations for offshore structures, in particular:

- ISO 13623 (all parts), *Petroleum and natural gas industries — Pipeline transportation systems*
- ISO 13628 (all parts), *Petroleum and natural gas industries — Design and operation of subsea production systems*

Introduction

The International Standards for offshore structures, ISO 19900 through to ISO 19906, constitute a common basis covering those aspects that address design requirements and assessments of all offshore structures used by the petroleum and natural gas industries worldwide. Through their application the intention is to achieve reliability levels appropriate for manned and unmanned offshore structures, whatever the type of structure and the nature of the materials used.

It is important to recognize that structural integrity is an overall concept comprising models for describing actions, structural analyses, design rules, safety elements, workmanship, quality control procedures and national requirements, all of which are mutually dependent. The modification of one aspect of design in isolation can disturb the balance of reliability inherent in the overall concept or structural system. The implications involved in modifications, therefore, need to be considered in relation to the overall reliability of all offshore structural systems.

For foundations, some additional considerations apply. These include the time, frequency and rate at which actions are applied, the method of foundation installation, the properties of the surrounding soil, the overall behaviour of the seabed, effects from adjacent structures and the results of drilling into the seabed. All of these, and any other relevant information, need to be considered in relation to the overall reliability of the foundation.

These International Standards are intended to provide wide latitude in the choice of structural configurations, materials and techniques without hindering innovation. The design practice for the foundations of offshore structures has proved to be an innovative and evolving process over the years. This evolution is expected to continue and is encouraged. Therefore, circumstances can arise when the procedures described herein or in ISO 19900 to ISO 19906 (or elsewhere) are insufficient on their own to ensure that a safe and economical foundation design is achieved.

Seabed soils vary. Experience gained at one location is not necessarily applicable at another, and extra caution is necessary when dealing with unfamiliar soils or foundation concepts. Sound engineering judgment is therefore necessary in the use of this part of ISO 19901.

For an offshore structure and its foundations, the action effects at the interface between the structure's subsystem and the foundation's subsystem(s) are internal forces, moments and deformations. When addressing the foundation's subsystem(s) in isolation, these internal forces, moments and deformations can be considered as actions on the foundation's subsystem(s) and this approach is followed in this part of ISO 19901.

Some background to and guidance on the use of this part of ISO 19901 is provided for information in informative Annex A. Guidance on foundations in carbonate soils is provided for information in A.6.5, but there is, as yet, insufficient knowledge and understanding of such soils to produce normative requirements.

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

1 Scope

This part of ISO 19901 contains requirements and recommendations for those aspects of geoscience and foundation engineering that are applicable to a broad range of offshore structures, rather than to a particular structure type. Such aspects are:

- site and soil characterization,
- identification of hazards,
- design and installation of shallow foundations supported by the seabed,
- design and installation of pile foundations
- soil–structure interaction for auxiliary structures, e.g. subsea production systems, risers and flowlines (guidance given in A.10);
- design of anchors for the stationkeeping systems of floating structures (guidance given in A.11).

Particular requirements for marine soil investigations are detailed in ISO 19901-8.

Aspects of soil mechanics and foundation engineering that apply equally to offshore and onshore structures are not addressed. The user of this part of ISO 19901 is expected to be familiar with such aspects.

ISO 19901-4 outlines methods developed primarily for the design of shallow foundations with an embedded length (L) to diameter (D) ratio $L/D < 1$ (Clause 7) or relatively long and flexible pile foundations with $L/D > 10$ (Clause 8). This standard does not apply to intermediate foundations with $1 < L/D < 10$. Such intermediate foundations, often known as 'caisson foundations', comprise either shallow foundations with skirts penetrating deeper into the seabed than the width of the foundation, or shorter, more rigid and larger diameter piles than those traditionally used for founding offshore structures. The design of such foundations can require specific analysis methods, and any extrapolation from the design methods described in this standard to intermediate foundations shall be treated with care and assessed by a geotechnical specialist on a case by case situation.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 19900, *Petroleum and natural gas industries — General requirements for offshore structures*

ISO 19901-2, *Petroleum and natural gas industries — Specific requirements for offshore structures — Part 2: Seismic design procedures and criteria*

ISO 19901-7, *Petroleum and natural gas industries — Specific requirements for offshore structures — Part 7: Stationkeeping systems for floating offshore structures and mobile offshore units*

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ISO 19901-8, *Petroleum and natural gas industries — Specific requirements for offshore structures — Part 8: Marine soil investigations*

ISO 19902, *Petroleum and natural gas industries — Fixed steel offshore structures*

ISO 19903, *Petroleum and natural gas industries — Fixed concrete offshore structures*

ISO 19905-1, *Petroleum and natural gas industries — Site-specific assessment of mobile offshore units — Part 1: Jack-ups*

ISO/TR 19905-2, *Petroleum and natural gas industries — Site-specific assessment of mobile offshore units — Part 2: Jack-ups commentary and detailed sample calculation*

ISO 19906, *Petroleum and natural gas industries — Arctic offshore structures*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 19900, the ISO 19901 series and the following apply.

3.1 action

external loading applied to the structure (direct action) or an imposed deformation or acceleration (indirect action)

Note 1 to entry: An imposed deformation can be caused by fabrication tolerances, differential settlement, temperature change or moisture variation. An earthquake typically generates imposed accelerations.

Note 2 to entry: See ISO 19900.

3.2 basic variable

one of a specified set of variables representing physical quantities which characterize material properties including soil properties

Note 1 to entry: See ISO 19900.

3.3 characteristic value

value assigned to a basic variable associated with a prescribed probability of not being violated by unfavourable values during some reference period

Note 1 to entry: The characteristic value is the main representative value.

Note 2 to entry: See ISO 19900.

3.4 design actions

combination of representative actions and partial safety factors representing a design situation for use in checking the acceptability of a design

3.5 design value

value derived from the representative value for use in the design verification procedure

Note 1 to entry: In some design situations, two design values can be defined, an upper and a lower value.

Note 2 to entry: See ISO 19900.3.6

drained condition

condition whereby the applied stresses and stress changes are supported by the soil skeleton and do not cause a change in pore pressure

3.7

effective foundation area

reduced foundation area having its geometric centre at the point where the resultant action vector intersects the foundation base level

3.8

limit state

state beyond which the structure no longer satisfies the relevant design criteria

Note 1 to entry: See ISO 19900.

3.9

material factor

partial safety factor applied to the strength of the soil

3.10

representative value

value assigned to a basic variable for verification of a limit state

Note 1 to entry: See ISO 19900.

3.11

resistance

resistance of a component to withstand action effects without failure

Note 1 to entry: See ISO 19900.

3.12

resistance factor

partial safety factor applied to the resistance of a foundation

3.13

scour

removal of seabed soils caused by currents, waves or ice

3.14

seabed

materials below the sea in which a structure is founded, whether of soils such as sand, silt or clay, cemented materials or of rock

Note 1 to entry: The seabed can be considered as the half-space below the seafloor.

Note 2 to entry: Offshore foundations are most commonly installed in soils, and the terminology in this part of ISO 19901 reflects this. However, the requirements equally apply to cemented seabed materials and rocks. Thus, the term 'soil' does not exclude any other material at or below the seafloor.

Note 3 to entry: As yet there are no universally accepted definitions of the various types of soil and rock, see ISO 19901-8.

3.15

seafloor

interface between the sea and the seabed

3.16

serviceability

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ability of a structure or structural component to perform adequately for normal functional use

Note 1 to entry: See ISO 19902.

3.17**settlement**

permanent downward movement of a structure as a result of its own weight and other actions

3.18**strength**

mechanical property of a material indicating its ability to resist actions, usually given in units of stress

Note 1 to entry: See ISO 19902.

3.19**undrained condition**

condition whereby the applied stresses and stress changes are supported by both the soil skeleton and the pore fluid and do not cause a change in volume

3.20**undrained shear strength**

maximum shear stress at yielding or at a specified maximum strain in an undrained condition

Note 1 to entry: Yielding is the condition of a material in which a large plastic strain occurs at little or no stress increase.

4 Symbols and abbreviated terms**4.1 General**

Commonly used symbols are listed below; other symbols are defined in the text following the applicable formula. It should be noted that symbols can have different meanings between formulae.

4.2 Symbols for shallow foundations design

A	actual (cross-sectional plan) foundation area
A'	effective foundation area of foundation depending on eccentricity of actions
A_h	embedded vertical cross-sectional area of foundation
A_p	end area of skirt tip
A_s	side surface area of foundation skirt embedded at a particular depth (including both sides)
$A_{idealized}$	idealized rectangular foundation area, for irregular foundation shapes
b_c, b_q, b_γ	individual correction factors related to foundation base inclination
B	minimum lateral foundation dimension (also foundation width)
B'	minimum effective lateral foundation dimension (also foundation effective width)
C	compression index of soil over loading range considered
d_c, d_q, d_γ	individual correction factors related to foundation embedment depth
D	foundation diameter (for circular foundations)