



Site Investigations

OFFSHORE TECHNOLOGY REPORT 2001/012



Site Investigations

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FOREWORD

This document provides technical information previously contained in the Fourth Edition of the Health and Safety Executive's '*Offshore Installations: Guidance on Design, Construction and Certification*' (1990 edition plus amendments)⁽¹⁾. The 'Guidance' was originally published in support of the certification regime under SI289, the Offshore Installations (Construction and Survey) Regulations 1974⁽²⁾. However, SI289 was revoked by the Offshore Installations (Design and Construction, etc) Regulations, 1996, which also introduced the verification provisions into the Offshore Installations (Safety Case) Regulations, 1992. The 'Guidance' was formally withdrawn in its entirety on 30 June 1998 (see HSE OSD Operations Notice 27⁽³⁾).

The withdrawal of the 'Guidance' was not a reflection of the soundness (or otherwise) of the technical information it contained; some sections (or part of sections) of the 'Guidance' are currently referred to by the offshore industry. For this reason, after consultation with industry, relevant sections are now published as separate documents in the HSE Offshore Technology (OT) Report series.

It should be noted that the technical content of the 'Guidance' has not been updated as part of the re-formatting for OTO publication, although prescriptive requirements and reference to the former regulatory regime have been removed. **The user of this document must therefore assess the appropriateness and currency of the technical information for any specific application. Additionally, the user should be aware that published sections may cease to be applicable in time and should check with Operations Notice 27, which can be viewed at http://www.hse.gov.uk/hid/osd/notices/on_index.htm, for their current status.**

1. INTRODUCTION AND SCOPE

1.1 SOURCE OF INFORMATION

This Offshore Technology (OT) Report provides technical information on site investigation and selection of design soil parameters for Offshore Installations supported by the seabed. It is based on guidance previously contained in Section 14 of the Fourth Edition of the Health and Safety Executive's 'Offshore Installations : Guidance on Design, Construction and Certification'⁽¹⁾ which was withdrawn in 1998. As discussed in the Foreword, whilst the text has been re-formatted for Offshore Technology publication, the technical content has not been updated. The appropriateness and currency of the information in this document must therefore be assessed by the user for any specific application.

1.2 BACKGROUND WORKING GROUP DOCUMENT

This report should be read in conjunction with the background document produced by a Working Group when revising the Guidance Notes in 1986. The background document, which was edited by Semple⁽⁴⁾, contains detailed commentary on the information provided in this OT Report.

2. PLANNING, NATURE AND AREAL EXTENT OF SITE INVESTIGATION

2.1 PRELIMINARY INVESTIGATION

Prior to site investigation, the geological and geotechnical literature should be researched with a view to ascertaining the geological history and soil conditions of the area.

2.2 NATURE OF THE SITE INVESTIGATION

Foundation design and installation planning should be based on results of soil investigations that determine geotechnical characteristics of the actual site. The data should be acquired with due regard to design and installation requirements. The investigation should provide information on seabed topography, and on the surface and subsurface conditions within the zone influenced by the Installation. In addition to establishing the soil profile, strength and deformation characteristics for assessing foundation capacity and behaviour, information should be acquired with which to assess risks to the structure from mudslides, shallow gas, sediment transport, and soil resistance changes caused by sustained and repeated foundation loads.

2.3 AREA OF SITE INVESTIGATION

In selecting the size of area to be investigated, allowances should be made for likely positioning errors during site investigation and structure placement. The positioning system used should ensure that all surveys and investigations are made at the intended platform site. The repeatability of positioning should be determined. Wherever possible positioning should be related to local fixed points such as wellheads or other fixed structures.

3. FIELD PROCEDURES

3.1 DESIGN DATA FOR FOUNDATIONS

Foundation design data should be developed from results of in situ testing and laboratory testing of samples. Bathymetric and side-scan sonar surveys should be performed to assess seafloor characteristics. Consideration should be given to high-resolution geophysical surveying as an aid to initial site selection, understanding the soil distributions away from borehole positions, and to detecting subsurface anomalies such as shallow gas.

Investigations should be supervised and the results interpreted by competent persons aware of the way in which geotechnical conditions will affect the design.

3.2 BOREHOLE DRILLING

Borehole drilling operations should minimise soil disturbance. Drilling systems deployed from a vessel should be compensated for heave. Consideration should be given to using a drilling fluid that will minimise soil stress relief, help remove cuttings, and stabilise the borehole. Sampling and testing depths below seafloor should be accurately determined.

3.3 SAMPLING

Cohesive soil samples should be as undisturbed as possible since their laboratory test results are the basis for foundation analyses. Sampling tubes should have the largest diameter compatible with the drilling system, a minimum area ratio and well tapered cutting edges. Cohesive samples should be carefully transported to the laboratory and tested without undue delay. Where samples are primarily intended for classification testing, as for example with granular soils, disturbance is less critical (see also Section 5.1).

3.4 IN SITU TESTING

Testing systems deployed from vessels should be isolated from vessel motion. Instrument calibrations should be checked throughout the investigation. Some tests should be made immediately adjacent to sampling positions to aid correlation with laboratory test results, where these form the basis for the design procedure.

3.5 REMOTE SENSING

Bathymetric and side-scan sonar surveys should provide detailed information on the seabed configuration including the presence of any features, such as slopes or obstructions, that would affect siting the structure. For fixed structures, consideration should be given to visual inspection of the foundation area by submersible.

Geophysical surveys should generally be performed to help formulate requirements for sampling and testing at the site. Selection of high resolution profiling equipment should consider the various frequency responses

and energy contents required to optimise recovery of sub-bottom information. Particular attention should be given to selection of appropriate equipment and procedures, as quality in data acquisition is sensitive to these factors. If possible, borings should be placed on survey line crossings or at locations of engineering interest disclosed by the survey, to aid correlation of geophysical reflectors with observed soil profiles.

4. SCOPE OF FIELD WORK

4.1 GENERAL

The investigation undertaken should reflect the size and purpose of the Installation, experience with similar structures in the area, and the consistency and variability of the foundation soils. The site investigation should focus on the particular type of information required to analyse the foundation, which differs in detail for shallow and deep foundations.

Consideration should be given to performing site investigation in preliminary and detailed phases, the latter being undertaken once the foundation system has been selected. A staged approach should also be considered for major developments or in unexplored areas as it is unlikely that all necessary information will be obtained in one site visit.

In view of inherent variability in sub-seafloor conditions, arrangements for investigations should permit on-site changes to the planned programme of site work. Personnel conversant with the investigation requirements should be present offshore.

4.2 SAMPLING AND TESTING

Stability of a gravity base may be governed by the shallow soil conditions which should be explored in such detail that there is no possibility of missing a significant feature. At least one boring should be taken to a depth equal to the width of the foundation plus its expected penetration below the seafloor.

In exploration for a piled foundation, the frequency of sampling and testing should be increased in critical depth zones such as potential end bearing strata or soil layers that are likely to cause piling problems. Some of the borings should extend to at least the depth influenced by the pile or pile group.

4.3 REMOTE SENSING

For a fixed structure, consideration should be given to surveying at fairly wide intervals the total area within which the structure could be placed. At the actual site, the survey grid spacing should be reduced to avoid missing significant features such as boulders, pock marks, or buried channels. Obstacles detected on the seafloor should be mapped and identified.

Consideration should be given to repeating the survey if significant sand waves are present in order to check whether the sand waves are moving.

The foundation area for a gravity base should be inspected in detail by a submersible equipped for video tape recording and precision bathymetric measurements.

Geophysical survey records should extend to depths not less than the foundation width for a gravity base, the depth of influence of piles or pile groups as defined above, and to one footing width below the expected maximum leg penetration of a jack-up Installation.

5. LABORATORY TESTING OF SOILS

5.1 PLANNING THE TESTING PROGRAMME

The laboratory testing programme should be planned to develop input data for engineering calculations and a general understanding of site conditions including the stress history. The order and position of each sample in a borehole should be recorded so they can be examined and classified in the correct sequence under laboratory conditions. Some or all of the samples should be extruded from the sampling tubes in the field to permit soil classification and checking sample quality. Consideration should be given to performing part of the laboratory test programme onboard to provide soil engineering properties prior to the disturbance that occurs in transporting the sample onshore. Cohesive samples should be protected against moisture change before they are tested (see also Section 3.3).

5.2 CLASSIFICATION OF SOILS

In addition to visual-manual classification, tests should be performed to determine the consistency, density, water content and plasticity characteristics of cohesive samples, and the predominant mineralogy and textural characteristics of granular soils. The soil fabric should be examined and documented in detail. Where laminated soils are encountered, emphasis should be placed on visual description of undisturbed samples.

5.3 ENGINEERING PROPERTIES OF SOILS

Strength and deformation properties should be measured under conditions most representative of the actual site and relevant to the design.

Gravity base design is particularly reliant on good soil data and this should be recognised in planning laboratory programmes. Testing should be directed towards providing an accurate assessment of the likely in situ shear strength. Tests with cyclic loading should be performed to assess its effect on soil properties. Laboratory testing for a piled or jack-up foundation in clay should include quick undrained triaxial tests performed on specimens at natural water content.

Where applicable, consideration should be given to the various other laboratory procedures such as oedometer, plane strain, and dynamic testing of soil elements, or testing at model scale.

6. INTERPRETATION OF SOILS DATA

In situ resistance measurements can be related to several of the engineering parameters required for offshore foundation design. The results should be interpreted so as to provide the most appropriate values for the design application.

Due consideration should be given to fabric effects on sample shear strength and on in situ mass shear strength in interpreting results of laboratory measurements on clays.

Pile design procedures are empirical and are based on reference undrained shear strengths that were largely measured by unconfined compression tests on high quality samples. The nature of this reference strength measurement should be taken into account in developing the undrained shear strength profile for pile design.

The stability of a gravity base can be critically affected by the presence of a thin layer of soil that is significantly weaker than the average in situ strength. Careful consideration should be given to the significance of low measurements, obtained in the laboratory or in the field, that may reflect the presence of a weak zone in the soil profile.

7. SITE INVESTIGATIONS FOR JACK-UP INSTALLATIONS

If a similar jack-up has previously been installed at a site then the investigation can be limited to an inspection of the seabed. In other circumstances bathymetric, side-scan sonar and geophysical surveys should be performed.

Sampling and testing should be performed at the proposed location prior to installation unless there is adequate soils information, or experience indicates satisfactory performance of similar foundations in the vicinity. Adequate soils information comprises geotechnical data from existing borings in the vicinity plus good geophysical correlations indicating stratigraphic continuity between the site and boreholes.

8. OPERATIONAL DATA (SITE INVESTIGATIONS)

Mobile Installations which are supported by the seabed should have information concerning the different seabed conditions acceptable for that Installation including the varying capacity of the seabed, limiting values of seabed slope and maximum and minimum penetrations of footing.

9. REFERENCES

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4. Semple, R M. Background to Guidance on Foundations and Site Investigations for Offshore Structures. Report of the Department of Energy Guidance Notes Revision Working Group, HMSO, 1986.



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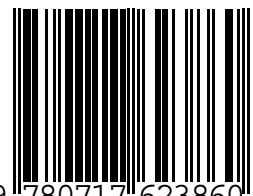
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