ACS (Asia Classification Society)

Rules for Building and Classing Offshore Installations (Offshore Installations Rules)

2015

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PART

1

Conditions of Classification

(Supplement to the ACS Generic Rules for Conditions of Classification – Offshore Units and Structures)

Chapter 1 Scope and Conditions of Classification

SECTION 1 Classification

1 Process

The requirements for conditions of classification are contained in the separate, ACS Generic Rules for Conditions of Classification – Offshore Units and Structures (Part 1).

Additional requirements specific to Offshore Installations are contained in the following Sections of this Part.

2 Application of Rules

These Rules are applicable to offshore installations as defined in 1-2-1/1 and are generally intended to remain at a particular site for support of offshore facilities.

These Rules are applicable to those features of the system that are permanent in nature and can be verified by plan review, calculation, physical survey or other appropriate means. Any statement in the Rules regarding other features is to be considered as guidance to the designer, builder, owner, etc.

SECTION 2 Classification Symbols and Notations

1 General

List of Classification Symbols and Notations for Offshore Installations is available from ACS Generic Rules for Conditions of Classification – Offshore Units and Structures (Part 1).

2 Offshore Installations Built Under Survey

2.1

Offshore Installations which have been built under the supervision of the ACS Surveyors to the requirements of these Rules or to their equivalent, where approved by the Classification Committee, will be classed and distinguished in the Record by the symbols ☸ **A1, Offshore Installation**.

2.2

The following special feature notations shall be assigned according to a type of the structure:

(a) Pile Supported Platform
(b) Gravity Structure
(c) Compliant Tower
(d) Articulated Buoyant Tower
(e) Tension Leg Platform
(f) Special feature notations according to other types of the structure

2.3

The following special feature notations shall be assigned according to a purpose of the structure:

(A) Drilling
(B) Production
(C) Special feature notations according to other purposes of the structure

3 Offshore Installations Not Built Under Survey

Offshore Installations which have not been built under the supervision of the ACS Surveyors, but which are submitted for classification, will be subject to a special classification survey. Where found satisfactory, and thereafter approved by the Classification Committee, they will be classed and distinguished in the Record, but the mark ☸ signifying the survey during construction will be omitted.

For Offshore Installations which have been built under survey and according to the rules of any IACS member, the mark ☸ will be assigned.

4 Classification Data

Data on offshore installations will be published in the Record as to the latitude and longitude of the location of the structure, structure type, structural dimensions and the depth of water at the site.

SECTION 3 Plans and Design Data to be Submitted

1 Submission of Site Condition Reports

As required in subsequent sections of these Rules, site condition reports are to be submitted. The principal purpose of these reports is to demonstrate that site conditions have been evaluated in establishing design criteria. Among the items to be discussed are:

- Environmental conditions of waves, winds, currents, tides, water depth, air and sea temperature and ice;
- Seabed topography, stability, and pertinent geotechnical data;
- Seismic conditions;

Where appropriate, data established for a previous installation in the vicinity of the installation proposed for classification may be utilized if acceptable in the opinion of ACS.

2 Submission of Design Data and Calculations

Information is to be submitted for the offshore installation which describes the methods of design and analysis which were employed to establish its design.
The estimated design service life of an offshore installation is also to be stated. Where model testing is used as a basis for a design, the applicability of the test results will depend on the demonstration of the adequacy of the methods employed, including enumeration of possible sources of error, limits of applicability, and methods of extrapolation to full scale data. Preferably, procedures should be reviewed and agreed upon before model testing is done.

As required in subsequent sections, calculations are to be submitted to demonstrate the sufficiency of the proposed design. Such calculations are to be presented in a logical and well-referenced fashion employing a consistent system of units. Where the calculations are in the form of computer analysis the submitted is to provide input and output data with computer generated plots for the structural model. A program description (not listings), user manuals, and the results of program verification sample problems may be required to be submitted.

3 Submission of Plans and Specifications

Plans or specifications depicting or describing the arrangements and details of the major items of the offshore installation are to be submitted for review or approval in a timely manner.
Where deemed appropriate, and when requested by the Owner, a schedule for information submittal and plan approval can be jointly established by the Owner and ACS. This schedule, which ACS will adhere to as far as reasonably possible, is to reflect the construction schedule and the complexity of the platform as it affects the time required for review of the submitted data.

4 Information Memorandum

An information memorandum on the offshore installation is to be prepared and submitted to ACS. ACS will review the contents of the memorandum to establish consistency with other data submitted for the purpose of obtaining classification.
ACS will not review the contents of the memorandum for their accuracy or the features described in the memorandum for their adequacy.
An information memorandum is to contain, as appropriate to the installation, the following:

- Site plan indicating the general features at the site and the exact location of the installation;
- Environmental design criteria, including the recurrence interval used to assess environmental phenomena (see 3-1-1/3.1);
- Plans showing the general arrangement of the offshore installation;
- Description of the safety and protective systems provided;
- The number of personnel to be normally stationed at the installation;
- Listing of governmental authorities having cognizance over the installation;
- Listing of any novel features;
- Brief description of any monitoring proposed for use on the installation;
- Description of transportation and installation procedures.

Chapter 2 Definitions and Design Documentation

SECTION 1 Definitions

1 General

For the purpose of ACS Offshore Installations Rules, the following definitions and explanations shall apply:

Recurrence Period
The recurrence period is a specified period of time which is used to establish design values of random parameters such as wave height.

Owner
An owner is any person or organization who owns the platform.

Operator
An operator is any person or organization empowered to conduct operations on behalf of the Owners of an installation.

Constructor
A constructor is any person or organization having the responsibility to perform any or all of the following: fabrication, erection, inspection, testing, load-out, transportation, and installation.

Consultant
A consultant is any person who, through education and experience, has established credentials of professionalism and expertise in the stated field.

Surveyor
A Surveyor is a person employed by ACS whose principal functions are the surveillance during construction and the survey of marine structures and their components for compliance with ACS Rules or other standards deemed suitable by ACS.

Offshore Installations

A buoyant or nonbuoyant structure, supported by or attached to the sea floor, whose design is based on foundation and long term environmental conditions at a particular installation site where it is intended to remain. The sea floor attachment afforded to the platform may be obtained by pilings, direct bearing, mooring lines, anchors, etc. The site-specific data for an offshore installation employed by the designer and submitted for review by ACS will form a part of its classification.

Examples of structures covered by these Rules are the types of fixed structures characterized as pile supported or gravity platforms, various forms of compliant structures, and other moored buoyant structures. Specifically excluded from the coverage of these Rules are mobile units, which are treated in separate Rules issued by ACS. Where doubt exists concerning the applicability of these Rules clarification may be obtained from ACS.

An offshore installation consists of one or more of the following:

I) Platform Structure

II) Undersea Pipeline Systems and Risers

III) Offshore Facilities:

a. Machinery, Electrical and Piping Systems

b. Production Equipment

Platform Structures

Various types of offshore structures to which these Rules may be applied are defined below.

Pile Supported Platform: This type of structure is characterized by slender foundation elements, or piles, driven into the sea floor.

Gravity Structure: This type of structure rests directly on the sea floor. The geometry and weight of the structure are selected to mobilize the available cohesive and frictional strength components of the sea floor soil to resist loadings.

Compliant Tower: This type of structure consists of a slender tower supported at the sea floor by an installed foundation (or by a large spud can) and may also be partially supported by buoyancy aids. Guy lines may or may not be used for lateral restraint.

Various provisions of these Rules are to be applied to partially or fully buoyant structures which are permanently (see 1-1-1/2) connected to the sea floor by mooring lines or other non-rigid means. Structural types including the articulated buoyant tower and the tension leg platform, which are defined below, are included in this category. For these buoyant structures, classification will be based on compliance with the applicable portions of these Rules, those of ACS Rules for Building and Classing Mobile Offshore Drilling Units, and other requirements which ACS, in consultation with the Owner, deems appropriate.

Articulated Buoyant Tower: This type of structure depends on buoyancy acting near the water surface to provide necessary righting stability. Because of its tendency towards relatively large horizontal displacements, the articulated buoyant structure can be provided with a pivot near the sea floor.

Tension Leg Platform: This type of structure is fully buoyant and is restrained below its natural flotation line by mooring elements which are attached in tension to gravity anchors or piles at the sea floor.

Additionally, these Rules may be employed, as applicable, in the classification of structural types not mentioned above; when they are to be used as permanent offshore installations.

Extension of Use

An existing platform to be used at the same location for a specified period of time beyond its original design life. See 1-5-1.

Reuse

An existing platform to be moved to a new location to continue its operation for a specified period of time. See 1-5-2.

SECTION 2 Design Documentation

1 General

The design documentation to be submitted is to include the reports, calculations, plans, and other documentation necessary to verify the structural design. The extensiveness of the submitted documentation should reflect the uniqueness of the structure or the lack of experience with conditions in the area where the structure is to be located. In general, significantly less detailed documentation is required for a pile supported platform in calm, shallow waters than for an unusual structural configuration sited in deep waters. Existing documentation may be used where applicable.

2 Reports

Reports by consultants and other specialists used as a basis for design are to be submitted for review. The contents of reports on environmental considerations, foundation data, and materials are, in general, to comply with the recommended list of items given below.

2.1 Environmental Considerations

Reports on environmental considerations are to describe all environmental phenomena appropriate to the areas of construction, transportation, and installation. The types of environmental phenomena to be accounted for, as appropriate to the type and location of the structure, are: wind, waves, current, temperature, tide, marine growth, chemical components of air and water, snow and ice, earthquake, and other pertinent phenomena.

The establishment of the environmental parameters is to be based on appropriate original data or, when permitted, data from analogous areas. Demonstrably valid statistical models to extrapolate to long-term values are to be employed, and any calculations required to establish the pertinent environmental parameters should be submitted.

Preferably, a report on the various environmental considerations is to present data and conclusions on the relevant environmental phenomena. The report is, however, required to separately present a summary showing the parameters necessary to define the Design Environmental Condition and Operating Environmental Conditions, as defined in 3-1-1; where applicable, the likely environmental conditions to be experienced during the transportation of the structure to its final site; and where necessary, the Strength and Ductility Level Earthquakes, as defined in 3-1-1/3.1.

The report on environmental considerations may also contain the calculations which quantify the effects or loadings on the structure where these are not provided in other documentation.

2.2 Foundation Data

A report on foundation data is to present the results of investigations or, when applicable, data from analogous areas on geophysical, geological and geotechnical considerations existing at and near the platform site. The manner in which such data is established and the specific items to be assessed are to be in compliance with 3-6-2.

The report is to contain a listing of references to cover the investigation, sampling, testing, and interpretive techniques employed during and after the site investigation.

The report is to include a listing of the predicted soil-structure interaction, such as p-y data, to be used in design. As appropriate to the planned structure, the items which may be covered are: axial and lateral pile capacities and response characteristics, the effects of cyclic loading on soil strength, scour, settlements and lateral displacements, dynamic interaction between soil and structure, the capacity of pile groups, slope stability, bearing and lateral stability, soil reactions on the structure, and penetration resistance.

Recommendations relative to any special anticipated problem regarding installation are to be included in the report. Items such as the following are to be included, as appropriate: hammer sizes, soil erosion during installation, bottom preparation, and procedures to be followed should pile installation procedures significantly deviate from those anticipated.

2.3 Materials and Welding

Reports on structural materials and welding may be required for metallic structures, concrete structures or welding procedures where materials and procedures are used which do not conform to those provided for in Part 2 of these rules.

For metallic structures, when it is intended to employ new alloys not defined by a recognized specification, reports are to be submitted indicating the adequacy of the material’s metallurgical properties, fracture toughness, yield and tensile strengths, and corrosion resistance, with respect to their intended application and service temperatures.

For concrete structures, when it is not intended to test or define material properties in accordance with applicable standards of the American Society for Testing and Materials (ASTM) as listed in Section 2/1, a report is to be provided indicating the standards actually to be employed and their relative adequacy with respect to the corresponding ASTM standards.

3 Calculations

Design and analysis calculations are to be submitted for items relating to loadings, structural stresses and deflections for in-place and marine operations. In this regard, calculations are to be in general compliance with the items listed below. Calculations which may be required in association with environmental considerations, and foundation data have been discussed in 1.2.2/2.

3.1 Loadings

Calculations for loadings are to be submitted in accordance with 3-2.

3.2 Structural Stresses and Deflections

The stress and deflection calculations to be submitted are to include, those required for nominal element or member stresses and deflections. As applicable, and where required in subsequent sections of these Rules, calculations may also be required for the stresses in localized areas and structural joints, the dynamic response of the structure, and fatigue life of critical members and joints. For pile supported structures, calculations for the stresses in piles and the load capacity of the connection between the structure and the pile are to be submitted. Similarly, for gravity structures, calculations are to be submitted for the effects of the soil's reaction on the structure. When accounting for the stress resultants described above, and those resulting from consideration of marine operations (see 3-7), calculations are to demonstrate the adequacy of the structural elements, members or local structure. Also, the calculations are to demonstrate, as applicable, that the deflections resulting from the applied loadings and overall structural displacement and settlement do not impair the structural performance of the platform.

3.3 Marine Operations

As applicable, calculations are to be submitted in compliance with 3-7.

3.4 Other Calculations

As required, additional calculations which demonstrate the adequacy of the overall design are to be submitted. Such calculations should include those performed in the design of the corrosion protection system.

4 Plans and Other Data

Generally, structural plans and other data are to be submitted in quadruplicate. These plans are to include the following, where applicable:

- Arrangement plans, elevations, and plan views clearly showing in sufficient detail the overall configuration, dimensions and layout of the structure, its facilities and foundation.

- Layout plans indicating the locations of equipment and locations of the equipment loads and other design deck loads, fender loads, etc., which are imposed on the structure.

- Structural plans indicating the complete structural arrangement, dimensions, member sizes, plating and framing, material properties, and details of connections and attachments; for concrete structures, arrangements and descriptions of reinforcement procedures for construction are to be indicated.

- Pile plans indicating arrangements, nominal sizes, thicknesses and penetration.

- Welding details and procedures, and schedule of nondestructive testing.

- Corrosion control systems.

- Structural plans indicating the complete arrangements of structures, such as helidecks, crane pedestals, equipment foundations and manner of reinforcement, fendering, various houses and other structures which are not normally considered vital to the overall structural integrity of the offshore structure.

- Various information in support of novel features utilized in the offshore structure design, such as hydrostatic and stability curves, elements of any mooring system, etc.

Chapter 3 Surveys during Construction and Installations

SECTION 1 General

1 Scope

This Chapter pertains to surveys during the construction and installation of an offshore structure. The requirements of 1-3-1 are to apply to all structures covered by these Rules regardless of structural type.

Additional requirements specifically for steel structures are contained in 1-3-2 and additional requirements for concrete structures are contained in 1-3-3.

The phases of construction covered by this Chapter include: material manufacture, fabrication, load-out, transportation, positioning, installation and final field erection.

2 Quality Control Program

A quality control program compatible with the type, size and intended function of the planned structure is to be developed and submitted to ACS for review.

ACS will review, approve and, as necessary, request modification of this program. The Fabricator is to work with the attending Surveyor to establish the required hold points on the quality control program to form the basis for all future surveys at the fabrication yard. As a minimum, the items enumerated in the various applicable subsections below are to be covered by the quality control program. Surveyors will be assigned to monitor the fabrication of classed structures and assure that all tests and inspections specified in the quality control program are being carried out by competent personnel. It is to be noted that the monitoring provided by ACS is a supplement to and not a replacement for inspections to be carried out by the Fabricator or Operator.

3 Access and Notification

During construction, Surveyors are to have access to structures at all reasonable times. The attending Surveyor is to be notified as to when and where parts of the structure may be examined.

If, at any visit, Surveyors find occasion to recommend repairs or further inspection, notice is to be made to the Fabricator or his representatives.

4 Identification of Materials

The fabricator is to maintain a system of material traceability to the satisfaction of the attending Surveyor, for all special and primary application structures. Data as to place of origin and results of relevant material tests for structural materials shall be retained and made readily available during all stages of construction (see 1-3-2/12and 1-3-3/9). Such data are to be available to the Surveyors upon request.

SECTION 2 Steel Structures

1 Quality Control Program

The quality control program (see 1-3-1/2) for the construction of a steel structure is to include the following items, as appropriate:

- Material quality and traceability
- Steel Forming
- Welder qualification and records
- Welding procedure specifications and qualifications
- Weld inspection
- Tolerances alignments and compartment testing
- Corrosion control systems
- Tightness and hydrostatic testing procedures
- Nondestructive testing Installation of main structure

The items which are to be considered for each of the topics, mentioned above are indicated in 1-3-2/2 through 1-3-2/11.

2 Material Quality and Traceability

The properties of the material are to be in accordance with Chapter 1 of Part 2. Manufacturer's certificates are to be supplied with the material. Verification of the material's quality is to be done by the Surveyor at the plant of manufacture, in accordance with Part 2 of ACS Rules for Classification of Vessels. Alternatively material manufactured to recognized standards may be accepted in lieu of the above Steel Requirements provided the substitution of such materials is approved by ACS. Materials used are to be in accordance with those specified in the approved design and all materials required for classification purposes are to be tested in the presence of an ACS Surveyor. The Constructor is to maintain a material traceability system for all the Primary and Special application structures.

3 Steel Forming

When forming changes base plate properties beyond acceptable limits, appropriate heat treatments are to be carried out to reestablish required properties. Unless approved otherwise, the acceptable limits of the reestablished properties should meet the minimums specified for the original material before forming.

ACS will survey formed members for their compliance with the forming dimensional tolerances required by the design.

4 Welder Qualification and Records

Welders who are to work on the structure are to be qualified in accordance with the welder qualification tests specified in a recognized code or, as applicable, ACS Rules for Classification of Vessels to the satisfaction of the attending Surveyor. Certificates of qualification are to be prepared to record evidence of the qualification of each welder qualified by an approved standard/code, and such certificates are to be available for the use of the Surveyors. In the event that welders have been previously tested in accordance with the requirements of a recognized code and provided that the period of effectiveness of the previous testing has not lapsed, these welder qualification tests may be accepted.

5 Welding Procedure Specifications and Qualifications

Welding procedures are to be approved in accordance with ACS Rules for Classification of Vessels. Welding procedures conforming to the provisions of a recognized code may, at the Surveyor's discretion, be accepted. A written description of all procedures previously qualified may be employed in the structure's construction provided it is included in the quality control program and made available to the Surveyors. When it is necessary to qualify a welding procedure, this is to be accomplished by employing the methods specified in the recognized code, and in the presence of the Surveyor.

6 Weld Inspection

As part of the overall quality control program, a detailed plan for the inspection and testing of welds is to be prepared and this plan is to include the applicable provisions of this Chapter of these Rules.

7 Tolerances and Alignments

The overall structural tolerances, forming tolerances, and local alignment tolerances are to commensurate with those considered in developing the structural design. Inspections are to be carried out to ensure that the dimensional tolerance criteria are being met.

Particular attention is to be paid to the out-of-roundness of members for which buckling is an anticipated mode of failure. Structural alignment and fit-up prior to welding shall be monitored to ensure consistent production of quality welds.

8 Corrosion Control Systems

The details of any corrosion control systems employed for the structure are to be submitted for review. Installation and testing of the corrosion control systems are to be carried out to the satisfaction of the attending Surveyor in accordance with the approved plans.

9 Tightness and Hydrostatic Testing Procedures

Compartments which are designed to be permanently watertight or to be maintained watertight during installation are to be tested by a procedure approved by the attending Surveyor. The testing is also to be witnessed by the attending Surveyor.

10 Nondestructive Testing

A system of nondestructive testing is to be included in the fabrication specification of the structures. The minimum extent of nondestructive testing shall be in accordance with these Rules or recognized design Code. All nondestructive testing records are to be reviewed and approved by the attending Surveyor. Additional nondestructive testing may be requested by the attending Surveyor if the quality of fabrication is not in accordance with industry standards.

11 Installation of Main Structure

Upon completion of fabrication and when the structure is to be loaded and transported to site for installation, the load-out, tie-down and installation are to be surveyed by an attending Surveyor from ACS.

All load-out, transportation and installation procedures are to be submitted to ACS for review and approval as described in 3-7.

The Surveyor is to verify the following activities, as applicable to the planned structure, to ascertain whether they have been accomplished in a manner conforming to the approved procedures:

- Load-out and Tie-down
- Launching, flotation, lifting and up-ending

- Positioning at the site and leveling
- Installation of Decks and Modules
- Piling and Grouting
- Welding and Nondestructive Testing
- Final field erection and leveling
- Pre-Tensioning

Significant deviations from approved plans and procedures or any incidents such as excessive titling of the jacket or abnormal vibrations during pile driving may require to resubmit of supporting documentation to provide an assessment of the significance of deviation and any necessary remedial actions to be taken.

To ensure that overstressing of the structure during transportation has not occurred, ACS is to have access to towing records to ascertain if conditions during the towing operations exceeded those employed in the analyses required in 3-7.

12 Records

A data book of the records of construction activities is to be developed and maintained so as to compile a record as complete as practicable. The pertinent records are to be adequately prepared and indexed to assure their usefulness, and they are to be stored so that they may be easily recovered.

For a steel structure, the construction record is to include, as applicable, the following: material traceability records including mill certificates, welding procedure specification and qualification records, shop welding practices, welding inspection records, construction specifications, structural dimension check records, nondestructive testing records, records of completion of items identified in the quality control program and towing and pile driving records, position and orientation records, leveling and elevation records, etc. The compilation of these records is a condition of classing the structure.

After fabrication and installation, these records are to be retained by the Operator or Fabricator for future references. The minimum time for record retention is not to be less than the greatest of the following: the warranty period, the time specified in construction agreements, or the time required by statute or governmental regulations.

SECTION 3 Concrete Structures

1 Quality Control Program

The quality control program (see 1-3-1/2) for a concrete structure is to cover the following items, as appropriate:

- Inspections prior to concreting Inspection of batching, mixing and placing concrete
- Inspections of form removal and concrete curing
- Inspection of prestressing and grouting
- Inspection of joints
- Inspection of finished concrete
- Installation of Main Structure
- Tightness and Hydrostatic testing as applicable (see 1-3-2/9)

The items which are to be considered for each of the topics mentioned above are indicated in 1-3-3/2 through 1-3-3/8.

2 Inspections Prior to Concreting

Prior to their use in construction, the manufacturers of cement, reinforcing rods, prestressing tendons and appliances are to provide documentation of the pertinent physical properties. These data are to be made available to the attending Surveyor who will check conformity with the properties specified in the approved design.

As applicable, at the construction site, the Surveyor is to be satisfied that proper consideration is being given to the support of the structure during construction, the storage of cement and prestressing tendons in weathertight areas, the storage of admixtures and epoxies to manufacturer's specifications, and the storage of aggregates to limit segregation, contamination by deleterious substances and moisture variations within the stock pile.

Forms and shores supporting the forms are to be inspected to insure that they are adequate in number and type, and that they are located in accordance with the approved plans. The dimensions and alignment of the forms are to be verified by the attending Surveyor, and the measurements are to be within the allowable finished dimensional tolerances specified in the approved design.

Reinforcing steel, prestressing tendons, post-tensioning ducts, anchorages and any included steel are to be checked, as appropriate to the planned structure, for size, bending, spacing, location, firmness of installation, surface condition, vent locations, proper duct coupling, and duct capping.

3 Inspection of Batching, Mixing and Placing Concrete

The production and placing of the concrete are to employ procedures which will provide a well mixed and well compacted concrete. Such procedures are also to limit segregation, loss of material, contamination, and premature initial set during all operations.

Mix components of each batch of concrete are to be measured by a method specified in the quality control program. The designer is to specify the allowable variation of mix component proportions, and the constructor is to record the actual proportions of each batch.

Testing during the production of concrete is to be carried out following the procedures specified in the quality control program. As a minimum, the following concrete qualities are to be measured by the constructor:

- Consistency
- Air content
- Density or Specific Gravity
- Strength

Field testing of aggregate gradation, cleanliness, moisture content, and unit weight is to be performed by the constructor following standards and schedules specified in the quality control program. The frequency of testing is to be determined taking into account the uniformity of the supply source, volume of concreting, and variations of atmospheric conditions. Mix water is to be tested for purity following methods and schedules specified in the quality control program.

4 Inspections of Form Removal and Concrete Curing

The structure is to have sufficient strength to bear its own weight, construction loads and the anticipated environmental loads without undue deformations before forms and form supports are removed. The schedule of form removal is to be specified in the quality control program, giving due account to the loads and the anticipated strength.

Curing procedures for use on the structure are to be specified in the quality control program. When conditions at the construction site cause a deviation from these procedures, justification for these deviations is to be fully documented and included in the construction records.

Where the construction procedures require the submergence of recently placed concrete, special methods for protecting the concrete from the effects of salt water are to be specified in the quality control program. Generally, concrete should not be submerged until 28 days after placing. (See also 3-5-6/2.5)

5 Inspection of Prestressing and Grouting

A schedule indicating the sequence and anticipated elongation and stress accompanying the tensioning of tendons is to be prepared. Any failures to achieve proper tensioning are to be immediately reported to the designer to obtain guidance as to needed remedial actions.

Pre- or post-tensioning loads are to be determined by measuring both tendon elongation and tendon stress. These measurements are to be compared, and should the variation of measurements exceed the specified amount, the cause of the variation is to be determined and any necessary corrective actions are to be accomplished.

The grout mix is to conform to that specified in the design. The constructor is to keep records of the mix proportions and ambient conditions during grout mixing. Tests for grout viscosity, expansion and bleeding, compressive strength, and setting time are to be made by the constructor using methods and schedules specified in the quality control program. Employed procedures are to ensure that ducts are completely filled.

Anchorages are to be inspected to ensure that they are located and sized as specified in the design. Anchorages are also to be inspected to assure that they will be provided with adequate cover to mitigate the effects of corrosion.

6 Inspection of Joints

Where required, leak testing of construction joints is to be carried out using procedures specified in the quality control program. When deciding which joints are to be inspected, consideration is to be given to the hydrostatic head on the subject joint during normal operation, the consequence of a leak at the subject joint, and the ease of repair once the platform is in service.

7 Inspection of Finished Concrete

The surface of the hardened concrete is to be completely inspected for cracks, honeycombing, pop-outs, spalling and other surface imperfections. When such defects are found, their extent is to be reported to the Surveyor and to the designer for guidance on any necessary repairs.

The structure is to be examined using a calibrated rebound hammer or a similar nondestructive testing device. Where the results of surface inspection, cylinder strength tests or nondestructive testing do not meet the design criteria, the designer is to be consulted regarding remedial actions which are to be taken.

The completed sections of the structure are to be checked for compliance to specified design tolerances for thickness, alignment, etc., and to the extent practicable, the location of reinforcing and prestressing steel and post-tensioning ducts. Variations from the tolerance limits are to be reported to the designer for evaluation and guidance as to any necessary remedial actions.

8 Installation of Main Structure

Upon completion of fabrication and when the structure is to be loaded and transported to site for installation, the load-out, tie-down and installation procedures are to be surveyed by an attending Surveyor from ACS. All load-out, transportation and installation procedures are to be submitted to ACS for review and approval.

The Surveyor is to witness the following operations, as applicable to the planned structure, to verify that they have been accomplished in a manner conforming to plans or drawings covering these operations:

- Load-out and tie-down
- Towing arrangements
- Positioning at the site
- Installation
- Final field erection
- Pre-Tensioning

Significant deviations from approved plans and procedures may require to resubmit of supporting documentation to provide an assessment of the significance of the deviation and the remedial actions to be taken.

To ensure that overstressing of the structure during transportation has not occurred, ACS is to have access to towing records to ascertain if conditions during the towing operations exceeded those employed in the analyses required in 3-7. Results are to be submitted to demonstrate compliance with the reviewed design analysis.

9 Records

Reference is to be made to 1-3-2/12 regarding the need to compile construction records. For a concrete structure, the construction records are to include, as applicable, all material certificates and test reports, tensioning and grouting records, concrete records including weight, moisture content and mix proportions, a listing of test methods and results, ambient conditions during the pours, calibration data for test equipment, towing records, data on initial structural settlements, and the inspector's logs. These records are to be retained by the Operator.

Chapter 4 Surveys after Construction

SECTION 1 Condition for Surveys after Construction

1 General

Structures classed with ACS are to be subjected to the following surveys to maintain the classification:

(1) Special Surveys
(2) Annual Surveys
(3) Continuous Surveys
(4) Alteration Surveys
(5) Occasional Surveys

2 Damages, Failure and Repair

Damage, failure, deterioration or repair to the classed structure is to be submitted by the Owner for examination by the Surveyor at first opportunity. All repairs found necessary by the Surveyor are to be carried out to Surveyor's satisfaction.

Where repairs to the structure are intended to be carried out at site, complete repair procedure including the extent of proposed repair and the need for Surveyor's attendance on site is to be submitted to and agreed upon by the Surveyor reasonably in advance.

SECTION 2 Annual Surveys

1 Due Range

Annual Surveys are to be carried out within three months before or after each anniversary date.

Where Surveyors are engaged in the survey of a grouping of structures of similar design and location, and where requested by the operator, special consideration will be given to the timing of Annual Surveys such that all Periodical Survey due dates can be harmonized.

2 Survey items

Each Annual Survey is to include a thorough visual examination of all above water structures. Special attention will be given to the splash zone for possible damage or deterioration from corrosion.

Additionally, where it appears that significant deterioration or damage has occurred to an installation since the last survey, a general examination, by the diver, underwater camera, submersible, or other suitable means, of the underwater structure, the sea floor, and the corrosion control system shall be carried out. Underwater examinations are to be contracted by the Operator and monitored by a Surveyor.

Any novel features incorporated in the design are to be given special attention according to procedures agreed to during review of the design. Particular attention is to be given to significant modifications or repairs made as a result of findings at the previous survey.

The Annual Survey is also to include verification that the approved design life has not been exceeded. If the end of the design life has been reached then the provisions of 1-5 of these Rules are to be applied and specific requirements for maintaining the class of the structure are to be obtained from the technical office.

Assessment of the degree of marine growth shall be carried out. Should marine growth be found to be thicker than the original approved design, it is to be removed. If the Operator decides to leave the marine growth greater than what is allowed in the approved design, the Operator is to show justification that the higher hydrodynamic loading due to the additional marine growth will not affect the structural integrity of the structure.

SECTION 3 Special Surveys

1 Due Range

1.1

Special Surveys are to be carried out at least once every five years.

If a Special Survey is not completed at one time, it will be credited as of the completion date of the survey provided the due date of the Special Survey is not overdue by more than six months.

Where Surveyors are engaged in the survey of a grouping of structures of similar design and location, and where requested by the operator, special consideration will be given to the timing of Special Surveys such that all Periodical Survey due dates can be harmonized.

1.2 Continuous Survey

At the request of the Owner and upon ACS approval of the proposed arrangements, a system of Continuous Surveys may be undertaken whereby the Special Survey requirements are carried out in regular rotation to complete all of the requirements of the particular Special Survey within a 5-year period. Each part (item) surveyed becomes due again for survey approximately five (5) years from the date of survey. The due parts (items) are generally to be completed each year. Continuous items that are three (3) months or more overdue at the time of Annual Survey attendance will be basis for the Annual Survey not to be credited and for non-endorsement of the Certificate of Classification. Consideration may be given by ACS to an extension to complete survey items. If any defects are found during the survey, they are to be dealt with to the satisfaction of the Surveyor.

2 Survey items

The requirements of the Annual Survey are to be met during the Special Survey. Additionally, underwater inspection of selected areas of the installation is to be carried out. Also, nondestructive testing is to be carried out on representative joints of the structures and if found necessary, structural supports of conductors and risers.

The extent and methods to be employed in such testing, cleaning, and inspection of the structure are to be in accordance with an approved inspection plan.

The inspection plan, which is to be submitted for approval, is to cover all Special Surveys for the design life of the structure. It is to enumerate in detail the items to be surveyed, the testing and inspection procedures to be employed, and where necessary, cleaning and nondestructive testing procedures.

The plan is to include sufficiently detailed drawings which can be used by the Surveyor to reference and locate the items to be surveyed.

Divers carrying out structural inspections and nondestructive testing on the underwater structures are to be suitably qualified.

The Special Survey is also to include monitoring of the effectiveness of the corrosion protection system. The effectiveness of the corrosion protection system is to be monitored by taking measurements of the potential voltages generated by such systems.

Scour in way of platform legs, tilt and subsidence are also to be checked and witnessed by the attending Surveyor.

If the end of the design life has been reached then the provisions of 1-5 are to be applied and specific requirements for maintaining the class of the structure are to be obtained from the technical office.

For the following areas, thickness measurements are required to be taken:

(a) Structures in way of the splash zone

(b) Suspect areas

Fixed Offshore Structures consisting of converted self-elevating units will require thickness measurements where accessible in accordance with ACS MODU Rules.

SECTION 4 Occasional Surveys

1 Reactivating Surveys

In the case of structures which have been out of service for an extended period, the requirements for surveys on reactivation are to be specially considered in each case, due regard being given to the status of surveys at the time of the commencement of the deactivation period, the length of the period, and conditions under which the structure had been maintained during that period.

2 Incomplete Surveys

When a survey is not completed, the Surveyors are to report immediately upon the work done in order that the Operator and ACS's Head Office may be advised of the parts still to be surveyed.

3 Self-elevating Units Deployed as Fixed Offshore Structure

Self-elevating Mobile Offshore Units which have been converted to site dependent platform structures will be subjected to surveys as applicable in this Chapter in addition to the applicable structural examinations required by ACS MODU Rules.

Surveys are to include Annual and Special Surveys with an underwater exam in lieu of drydocking of the above mud line sections of the legs, mats, spud cans and platform twice in each five year Special Survey period in accordance with applicable sections of ACS MODU Rules.

Spud cans and mats which will be located below the mud line will be considered inaccessible and fatigue, structural and corrosion analyses shall be provided to justify the integrity of these inaccessible areas for the design life of the structure.

4 Survey for extension of use

Existing structures to be used at the same location for an extended period of time beyond their original design life are subject to additional surveys to determine the actual condition of the structure.

The extent of the survey will depend on the completeness of the existing survey documents. ACS will review and verify maintenance manual, logs and records. Any alterations, repairs or installation of equipment since installation should be included in the records.

Those survey requirements in 1-4-3 for the Special Survey have to be included in the survey for extension of use:

- Splash zone
- Inspection of above water and under water structural members and welds for damages and deteriorations
- Examination of corrosion protection systems
- Measurements of marine growth
- Sea floor condition survey
- Examination of secondary structural attachments, risers and riser clamps

Special attention should be given to the following critical areas:

- Areas of high stress
- Areas of low fatigue
- Damage incurred during installation or while in service
- Repairs or modifications made while in service
- Abnormalities found during previous surveys

An inspection report of the findings is to be submitted to ACS for review and evaluation of the condition of the structure.

The need for more frequent future Periodical Surveys will be determined based on the calculated remaining fatigue life and past inspection results.

5 Relocation of existing structures

Existing structures that are classed at a specified location require special consideration when relocation to a new site is proposed.

The Owner is to advise ACS of the proposal to change locations addressing removal, transportation and re-installation aspects of the change.

Survey requirements described in 1-3 and 1-5 wherever applicable, are to be complied with in addition to engineering analyses required to justify the integrity of the structure for the design life at the new location.

Chapter 5 Extension of Use and Reuse

SECTION 1 Extension of Use

1 Application

This Chapter pertains to the classification or continuance of classification of an existing structure for extension of service beyond the design life. However, if the structure is currently classed with ACS, the requirements are to be in accordance with 1-4-4/4.

2. Extension of use

The approach for the classification of an existing structure for extended service is as follows:

(A) Review original design documentation, plans, structural modification records and Survey Reports.
(B) Survey structure to establish condition of structure.
(C) Review the result of the structural analysis utilizing results of survey, original plans, specialist geotechnical and oceanographic reports and proposed modifications which affect the dead, live, environmental and earthquake loads, if applicable, on the structures.
(D) Resurvey structure utilizing results from structural analysis. Make any alterations necessary for extending the service of the structure.
(E) Review a program of continuing surveys to as-sure the continued adequacy of the structure.

Items (A) and (B) above are to assess the structure to determine the possibility of continued use. If the conclusion is favorable from this assessment, structural analyses should be carried out.

The in-place analysis is to follow 1-5-1/5 and is to be in accordance with 3-4-4.

The fatigue life can be calculated by means of analysis as described in 3-4-7 or 3-5-3/4 and the remaining fatigue lives of all the structural members and joints are not to be less than twice the extended service life. The fatigue analysis may not be needed provided all of the following conditions are satisfied:
(i) The original fatigue analysis indicates that the fatigue lives of all joints are sufficient to cover the extension of use.

(ii) The fatigue environmental data used in the original fatigue analysis remain valid or deemed to be more conservative.

(iii) Cracks are not found during the condition survey or damaged joints and members are being repaired.

(iv) Marine growth and corrosion is found to be within the allowable design limits.

Surveys on a periodic basis based on 1-4 should be undertaken to ascertain the satisfactory condition of the structure.

3 Review of structure design documents

Structure design information is to be collected to allow an engineering assessment of a structure's overall structural integrity.

The operator should ensure that any assumptions made are reasonable and information gathered is both accurate and representative of actual conditions at the time of the assessment. If the information can not be provided, actual measurements or tests should be carried out to establish a reasonable and conservative assumption.

4 Survey of structures

Surveying an existing structure witnessed and monitored by a Surveyor is necessary to determine a base condition upon which justification of continued service can be made. Reports of previous surveys and maintenance will be reviewed, and a complete underwater inspection required to an accurate assessment of the structure's condition is obtained.

The corrosion protection system is to be re-evaluated to ensure that existing anodes are capable of serving the extended design life of the structure. If found necessary by the re-evaluation, replacement of the existing anodes or additional new anodes may have to be carried out. If the increase in hydrodynamic loads due to the addition of new anodes is significant, this additional load should be taken into account in the structural analysis.

The condition of protective coatings in the splash zone shall be rectified and p1aced in satisfactory condition.

The requirements for survey are to be in accordance with 1-4-4/4.

5 Structural analyses

The structural analyses of an existing structure must incorporate the results of the structure survey. Specifically, deck loads, wastage, marine growth, scour, and any structure modifications and damages must be incorporated into the analysis model.

The original fabrication materials and fit-up details must be established.

The pile driving records should be made available so that the foundation can be accurately modelled.

For areas where the design is controlled by earthquake or ice conditions, the analyses for such conditions should also be carried out.

Possible alterations of structures to allow continued use are developed by altering the analysis model to evaluate the effect of the alterations.

An analysis based on an ultimate strength method is also acceptable if the method and safety factors used are proven to be appropriate.

Members and joints indicated overstressed or low in fatigue life may be improved by reducing deck load and removing unused structures such as conductors, conductor guides framing, and boat landing. The results of these load reduction on the structure should be evaluated to determine whether the repairs/alterations is needed.

6 Repairs and reinspection

A second survey may be necessary to inspect areas where the analysis results indicate as being the more highly stressed regions of the structure.

Members and joints found overstressed should be strengthened. Joints with low fatigue lives may be improved either by strengthening or grinding the welds. If grinding is used, the details of the grinding are to be submitted to ACS for review and approval.

Interval of future Periodical Surveys should be determined based on the remaining fatigue lives of these joints.

SECTION 2 Reuse

1 General

The classification of a platform to be reused requires special considerations with respect to the review, surveys, structural analyses, and the removal and reinstallation operation.

In general, the design requirements stated in these Rules should be followed particularly, the requirements described in 1-5-1, whenever applicable and survey requirements given in 1-4-4/4 for platform reuse.

Since the platform is to be reused at a new site, the environmental and geotechnical data used in the analysis should be in accordance with those for the new site.

The structure reuse involves the structure removal and reinstallation process which requires special plans in order to achieve its intended services.

2 Removal and reinstallation operation

The structure removal procedure shall be well planned and analyzed to verify that the integrity of the structure has not been compromised.

Structure removal plans, procedures, sea-fastening drawings, transportation, together with the analysis calculations should be submitted to ACS for review.

In general, 3-7 should be followed for the reinstallation of used structures.

PART

2

Materials and Welding

Chapter 1 Materials

SECTION 1 Structural Steels

1 General

1.1 Scope

This subsection covers specifications for materials used for the construction of offshore steel structures. It is not intended for metals used in reinforced or prestressed concrete. (See 2.1.2)

All materials are to be suitable for intended service conditions; they are to be of good quality, defined by a recognized specification and free of injurious imperfections.

The requirements, other than those specified in these rules, are to be in accordance with the related requirements of Part 2 of ACS Rules for Classification of Vessels.

1.2 Materials Characteristics

Materials used are required to exhibit satisfactory formability and weldability characteristics.

As required, documentation is to be submitted to substantiate the applicability of proposed steel.

Reference can be made to Tables 2-1 (a) and 2-1 (b) for ASTM and API steel grades.

When material other than steel is to be used as a structural material, documentation is to indicate the tensile, toughness, fatigue and corrosion characteristics of the proposed material.

1.3 Corrosion Control

Details of corrosion control systems (such as coatings, sacrificial anodes or impressed current systems) are to be submitted with adequate supporting data to show their suitability.

Such information is to indicate the extent to which the possible existence of stress corrosion, corrosion fatigue, and galvanic corrosion due to dissimilar metals to be considered. Where the intended sea environment contains unusual contaminants, any special corrosive effects of such contaminants should also be considered. Appropriate coatings may be used to achieve satisfactory corrosion protection for miscellaneous parts such as bolts and nuts.

1.4 Toughness

Materials are to exhibit fracture toughness which is satisfactory for the intended application as supported by previous satisfactory service experience or appropriate toughness tests. Where the presence of ice is judged as a significant environmental factor, material selection may require special consideration.

1.5 Through Thickness Stress

In cases where principal loads, from either service or weld residual stresses, are imposed perpendicular to the surface of a structural member, the use of special steel with improved through thickness (Z-direction) properties may be required.

2 Steel Properties

2.1 General

Material specifications are to be submitted for review or approval. Due regard is to be given to established practices in the country in which material is produced and the purpose for which the material is intended.

2.2 Tensile Properties

Steels are classified as follows according to their tensile strength:

Group I : 275 N/mm^2 max.
Group II : 276~ 415 N/mm^2
Group III: 416~690 N/mm^2

2.3 Toughness

Appropriate supporting information or test data are to indicate that the toughness of the steels will be adequate for their intended application and minimum service temperature. Criteria indicative of adequate toughness are contained in 2-1-1/3.

2.4 Bolts and Nuts

Bolts and nuts are to have mechanical and corrosion characteristics comparable to the structural elements being joined and are to be manufactured and tested in accordance with recognized material standards.

3 Toughness Criteria for Steel Selection

3.1 General

When members are subjected to significant tensile stress, fracture toughness is to be considered in the selection of materials.

3.2 Steel Classification

Steels are to be classified as Groups I, II or III according to their tensile properties as listed in 2-1-1/2.2. It should be noted that the yield strengths given in 2-1-1/2.2 are provided only as a means of categorizing steels.

Some of the typical ASTM and API steels belonging to the groups given in 2-1-1/2.2 are shown in Tables 2-1(a) and 2-1(b).

Table 2-1(a): Structural Steel Plates and Shapes

Group	Grades & Thickness (mm)	Average Yield Strength (N/mm^2)	Tensile Strength (N/mm^2)
I	ASTM A36-94 (to 50 mm thick.)	250	400-550
	ASTM A131-94 Grade A (to 12.5 mm thick) (ACS Grade A)	235	400-515
	ASTM A285-90 Grade C (to 19 mm thick)	205	380-515
	ASTM A131-94 Grades B, D (ACS Grades B, D)	235	400-515
	ASTM A516-90 Grade 65	240	450-585
	ASTM A573-93a Grade 65	240	450-530
	ASTM A709-93a Grade 36T2	250	400-550
	ASTM A131-94 Grade E (ACS Grade E)	235	400-515
II	ASTM A572-94b Grade 42 (to 50 mm thick)	290	415 min.
	ASTM A572-94b Grade 50 (to 12.5 mm thick)	345	450 min.
	ASTM A588-94 (to 5o mm thick)	345	485 min.
	ASTM A709-93a Grades 50T2, 50T3	345	450 min.
	ASTM A131-94 Grade AH32 (ACS Grade AH32)	345	470-585
	ASTM A131-94 Grade AH36 (ACS Grade AH36)	350	490-620
	API Spec 2H-Grade 42	290	425-550
	API Spec 2H-Grade 50 (to 64 mm thick)	345	485-620
	API Spec 2H-Grade 50 (over 64 mm thick)	325	485-620
	API Spec 2W-Grade 42 (to 25 mm thick)	290-460	425 min
	API Spec 2W-Grade 42 (over 25 mm thick)	290-430	425 min.
	API Spec 2W-Grade 50 (to 25 mm thick)	345-515	450 min.
	API Spec 2W-Grade 50 (over 25 mm thick)	345-485	450 min.
	API Spec 2W-Grade 50T (to 25 mm thick)	345-550	485 min.
	API Spec 2W-Grade 50T (over 25 mm thick)	345-515	485 min.
	API Spec 2Y-Grade 42 (to 25 mm thick)	290-460	425 min.
	API Spec 2Y-Grade 42 (over 25 mm thick)	290-430	425 min.
	API Spec 2Y-Grade Grade 50 (to 25 mm thick)	345-515	450 min.
	API Spec 2Y-Grade Grade 50 (over 25 mm thick)	345-485	450 min.
	API Spec 2Y-Grade Grade 50T (to 25 mm thick)	345-550	485 min.
	API Spec 2Y-Grade Grade 50T (over 25 mm thick)	345-515	485 min.
	ASTM A131-94 Grades DH32, EH32 (ACS Grades DH32,EH32)	315	470-585
	ASTM A131-94 Grades DH36, EH36 (ACS Grades DH36,EH36)	350	490-620
	ASTM A537-91 Class 1 (to 64 mm thick)	345	485-620
	ASTM A633-94a Grade A	290	435-570
	ASTM A633-94a Grades C, D	345	480-620
	ASTM A678-94a (80) Grade A	345	485-620
III	ASTM A537-91 Class 2	415	550-690
	ASTM A633-94a Grade E	415	550-690
	ASTM A678-94a (80) Grade B	415	550-690
	API Spec 2W-Grade 60 (to 25 mm thick)	415-620	515 min.
	API Spec 2W-Grade 60 (over 25 mm thick)	415-585	515 min.
	API Spec 2Y-Grade 60 (to 25 mm thick)	415-620	515 min.
	API Spec 2Y-Grade 60 (over 25 mm thick)	415-585	515 min.
	ASTM A710-Grade A Class 3 (to 50 mm thick)	515	585 min.

Table 2-1(b): Structural Steel Pipes

Group	Specification & Grades	Average Yield Strength (N/mm^2)	Tensile Strength (N/mm^2)
I	API 5L-Grade B	240	415 min.
	ASTM A53-93a Grade B	240	415 min.
	ASTM A135-93 Grade B	240	415 min.
	ASTM A139-93a Grade B	240	415 min.
	ASTM A381-93 Grade Y35	240	415 min.
	ASTM A500-93 Grade A	230-270	310 min.
	ASTM A501-93	250	400 min.
	ASTM A106-94 Grade B	240	415 min.
	ASTM A524-93 (strength varies with thickness)	205-240	380-585
II	API 5L95 Grade X42 (2% max. cold expansion)	290	415 min.
	API 5L95 Grade X52 (2% max. cold expansion)	360	455 min.
	ASTM A500-93 Grade B	290-320	400 min.
	ASTM A618-93 Grade I a, I b & II (to 19 mm thick)	345	485 min.
	API 5L95 Grade X52 (with SR5, SR6, or SR8)	360	455 min.

4 Material Selection

4.1 General

For the classification of offshore fixed structures it is necessary to take into account minimum expected service temperature, the structural element category and material thickness when selecting structural materials. The various parts of the structure are to be grouped according to their material application categories. The structural elements falling into these categories are described, in general, in 2-1-1/4.3 .

4.2 Classification of Applications

The application of structural members in an offshore fixed structure is to be in accordance with the categories listed in this paragraph.

Special application refers to highly stressed materials, located at intersections of main structural elements and other areas of high stress concentration where the occurrence of a fracture could induce a major structural failure.

Primary application refers to primary load carrying members of a structure where the occurrence of a fracture could induce a major structural failure.

Secondary application refers to less critical members due to a combination of lower stress and favorable geometry or where an incidence of fracture is not likely to induce a major structural failure.

4.3 Examples of Applications

The following are typical examples of application categories:

(a) Secondary Application Structure (Least Critical)

Internal structure including bulkheads and girders in legs or columns;

Deck plating not essential for overall structural integrity;

Low-stressed deck beams in parallel and bracing, except where structure is considered primary or special application;

Plating of certain columns with low slenderness ratios, except at intersections.

(b) Primary Application Structure (Intermediate)

Plating of lattice legs;

External shell plating of caissons;

Deck plating and structure which is not considered special or secondary;

Main braces, jacket legs and deck legs, except where considered special;

Heavy flanges and deep webs of major load supporting members, which form box or I type supporting structure, and which do not receive major concentrated loads;

Members which provide local reinforcement or continuity of structure in way of intersections, including main deck load plating where the structure is considered special application.

(c) Special Application Structure (Most Critical)

External shell or deck structure in way of intersections of vertical columns;

Portions of deck plating, heavy flanges, and deep webs at major load supporting members within the deck, which form box or 1 type supporting structure, and which receive major concentrated loads;

Intersection of major bracing members and critical joint nodes;

Members which receive immediate concentrated loads at intersections of major structural members.

SECTION 2 Materials for Concrete Construction

1 General

1.1 Scope

This subsection covers specifications for materials for concrete used in the construction of offshore platforms. It includes the metals used in reinforced or prestressed concrete. All materials are to be suitable for intended service conditions and are to be of good quality, defined by recognized specifications and free of injurious defects. Materials used in the construction of concrete structures are to be selected with due attention given to their strength and durability in the marine environment. Materials which do not conform to the requirements of this subsection may be considered for approval upon presentation of sufficient evidence of satisfactory performance.

1.2 Zones

Particular attention should be given in each of the following zones (see 3-3-3/5) to the considerations indicated.

Submerged zone: chemical deterioration of the concrete, corrosion of the reinforcement and hardware, and abrasion of the concrete.

Splash zone: freeze-thaw durability, corrosion of the reinforcement and hardware, chemical deterioration of the concrete, and fire hazards.

Ice zone: freeze-thaw durability, corrosion of the reinforcement and hardware, chemical deterioration of the concrete, fire hazards, and abrasion of the concrete.

Atmospheric zone: freeze-thaw durability, corrosion of reinforcement and hardware, and fire hazards.

2 Cement

2.1 Type

Cement is to be equivalent to Types I or II Portland cement as specified by ASTM C150 or portland-pozzolan cement as specified by ASTM C595. ASTM C150 Type III Portland cement may be specially approved for particular applications.

2.2 Tricalcium Aluminate

The tricalcium alminate content of the cement is generally to be in the 5% to 10% range.

2.3 Oil Storage

For environments which contain detrimental sulfur bearing materials (such as where oil storage is planned and the oil is expected to contain sulphur compounds which are detrimental to concrete durability), the maximum content of tricalcium aluminate is to be at the lower end of the 5% to 10% range. Alternatively, pozzolans or pozzolans and fly ash may be added or a suitable coating employed to protect the concrete.

3 Water

3.1 Cleanliness

Water used in mixing concrete is to be clean and free from injurious amounts of oils, acids, alkalis, salts, organic materials or other substances that may be deleterious to concrete or steel.

3.1 Nonpotable Water

If nonpotable water is proposed for use, the selection of proportions of materials in the concrete is to be based on test concrete mixes using water from the same source. The strength of mortar test cylinders made with nonpotable water is not to be less than 90% of the strength of similar cylinders made with potable water. Strength test comparisons should include 7-day and 28-day strength data on mortars prepared and tested in accordance with recognized standards such as ASTM C109.

4 Chloride or Sulphide Content

4.1 General

Water for structural concrete or grout should not contain more than 0.07% chlorides as Cl by weight of cement, nor more than 0.09% sulfates as SO_4 when tested by ASTM D512. Chlorides in mix water for prestressed concrete or grout should be limited to 0.04% by weight of cement.

Total chloride content, as Cl, of the concrete prior to exposure shall not exceed 0.10% by weight of the cement for normal reinforced concrete and 0.06% by weight of cement for prestressed concrete.

5 Aggregates

5.1 General

Aggregates are to conform to the requirements of ASTM C33 or equivalent. Other aggregates may be used if there is supporting evidence that they produce concrete of satisfactory quality. When specially approved, lightweight aggregates similar to ASTM C330 may be used for conditions that do not pose durability problems.

5.2 Washing

Marine aggregates are to be washed with fresh water before use to remove chlorides and sulphates so that the total chloride and sulphate content of the concrete mix does not exceed the limits defined in 2-1-2/4.

5.3 Size

The maximum size of the aggregate is to be such that the concrete can be placed without voids. It is recommended that the maximum size of the aggregate should not be larger than the smallest of the following: one-fifth of the narrowest dimension between sides of forms; one-third of the depth of slabs; three-fourths of the minimum clear spacing between individual reinforcing bars, bundles of bars, prestressing tendons or post-tensioning ducts.

6 Admixtures

6.1 General

The admixture is to be shown capable of maintaining essentially the same composition and performance throughout the work as the product used in establishing concrete proportions. Admixtures containing chloride ions are not to be used if their use will produce a deleterious concentration of chloride ions in the mixing water.

6.2 Recognized Standards

Admixtures are to be in accordance with applicable recognized standards such as ASTM C260, ASTM C494, ASTM C618 or equivalents.

6.3 Pozzolan Content

Pozzolan or pozzolan and fly ash content is not to exceed 15% by weight of cement unless specially approved.

7 Steel Reinforcement

7.1 General

Steel reinforcement used in offshore concrete structures is to be suitable for its intended service and in accordance with recognized standards.

7.2 Reinforcement for Non-Prestressed Concrete

Non-prestressed reinforcement is to be in accordance with one of the following specifications or its equivalents:

Deformed reinforcing bars and plain bars: ASTM A615

Bar and rod mats: ASTM A184

Plain wire for spiral reinforcement: ASTM A82, ASTM A704

Welded plain wire fabric: ASTM A185

Deformed wire: ASTM A496

Welded deformed wire fabric: ASTM A497

7.3 Welded Reinforcement

Reinforcement which is to be welded is to have the properties needed to produce satisfactory welded connections. Welding is to be in accordance with recognized specifications such as the American Welding Society (AWS) D1.l, or is to be proven to produce connections of satisfactory quality.

7.4 Steel Reinforcement for Prestressed Concrete

Steel reinforcement for prestressed concrete is to be in accordance with one of the following specifications or equivalent:

Seven-wire strand: ASTM A416

Wire: ASTM A421

7.5 Other Materials

Other prestressing tendons may be approved upon presentation of evidence of satisfactory properties.

8 Concrete

8.1 General

The concrete is to be designed to assure sufficient strength and durability. A satisfactory method for quality control of concrete is to be used which is equivalent to ACI 318 (ACI ≡ American Concrete Institute). Mixing, placing and curing of concrete shall conform to recognized standards.

9 Water-Cement Ratios

9.1 General

Unless otherwise approved, water-cement ratios and 28-day compressive strengths of concrete for the three exposure zones are to be in accordance with Table 2-2.

Table 2-2: Water-Cement Ratios and Compressive Strength		
Zone	**Maximum Water-Cement Ration**	**Minimum 28-day Cylinder Compressive Strength**
Submerged	0.45	35 N/mm^2
Splash and Atmospheric	0.40 to 0.45 (Depending upon severity of exposure)	35 N/mm^2

10 Other Durability Requirements

10.1 Cement Content

Minimum cement content should insure an adequate amount of paste for reinforcement protection and generally be not less than 355 kg/m^3.

10.2 Freeze-Thaw Durability

When freeze-thaw durability is required, the concrete is to contain entrained air in accordance with a recognized standard such as ACI 211.1. Attention is to be paid to the appropriate pore distribution of the entrained air and the spacing between pores in the hardened concrete. The calculated spacing factors are not to exceed 0.25 mm.

10.3 Scouring

When severe scouring action is expected, the coarse aggregate should be as hard as the material causing the abrasion, the sand content of the concrete mix should be kept as low as possible, and air entrainment is to be limited to the minimum appropriate to the application.

11 Grout for Bonded Tendons

11.1 General

Grout for bonded tendons is to conform to ACI 318 or equivalent.

11.2 Chlorides and Sulphates

Grout is not to contain chlorides or sulfates in amounts which are detrimental to the structure. Limitations are included in 2-1-2/4.

11.3 Contents

Grout is to consist of Portland cement and potable water, or Portland cement, sand, and potable water. Admixtures may be used only after sufficient testing to indicate that their use is beneficial and that they are free of harmful quantities of chlorides, nitrates, sulfides, sulphates or any other material which has been shown to be detrimental to the steel or grout.

11.4 Sand

Sand, if used, is to conform to ASTM C144 or equivalent, except that gradation may be modified as necessary to obtain increased workability.

11.5 Preparation

Proportions of grouting materials are to be based on results of tests on fresh and hardened grout prior to beginning work. The water content shall be the minimum necessary for proper placement but in no case more than 50% of the content of cement by weight. Grout is to be properly mixed and screened.

11.6 Temperature

Temperature of members at the time of grouting is to be above 10°C and is to be maintained at this temperature for at least 48 hours.

Chapter 2 Welding

SECTION 1 General

1 Application

1.1

Welding for steel structures is to comply with these requirements and Part 2 of ACS Rules for Classification of Vessels.

1.2

Where deemed appropriate by ACS, National Standards, internationally recognized codes or standards considered as equivalent for those may be applied instead of requirements of these rules.

2 Plans and Specifications

2.1

Submitted plans or specifications are to be in accordance with 1-2-2 and they are to indicate clearly the extent of welding for the main parts of the structure. The plans or specifications should indicate the extent of nondestructive inspection of the weld. The welding process, filler metal and joint design are to be indicated on plans or in separate specifications submitted for approval, which are to distinguish between manual and automatic welding. The Surveyor is to be informed of the planned sequences and procedures to be followed in the erection and welding of the main structural members. In all instances, welding procedures and filler metals are to be applied which will produce sound welds that have strength and toughness comparable to that of the base material.

2.2

Connection details of the welded structural members, including type and size of the welds are to be clearly indicated on the plans submitted for approval. An explanation of all symbols or abbreviations used in detailing the weld connections should be included in the plans.

2.3

Details of proposed welding procedure are to be submitted indicating preheating temperature and any post-welding treatment, if employed. Extent to which automatic welding, including deep penetration welding, is employed should also be indicated.

2.4

The actual sizes of fillet welds are to be indicated on detail drawings or on a separate welding schedule and submitted for approval in each individual case.

3 Inspection of Welds

3.1

All welds are to be subject to visual inspection. Representative nondestructive testing is to be carried out to the satisfaction of the Surveyor. Such testing is to be carried out after all forming and post weld heat treatment. Welds which are inaccessible or difficult to inspect in service may be subjected to increased levels of nondestructive inspection. A plan for nondestructive testing is to be submitted.

PART

3

Design

Chapter 1 Environmental Conditions

SECTION 1 General

1 General

The environmental conditions to which an offshore installation may be exposed during its life are to be described using adequate data for the areas in which the structure is to be transported and installed. For structures requiring substantial near-shore construction (e.g., concrete gravity installations), environmental studies are to be commensurate with the duration of construction operations and the relative severity of expected conditions.

The environmental phenomena which may influence the transport, installation, and operation of the structure are to be described in terms of the characteristic parameters relevant to the evaluation of the structure. Statistical data and realistic statistical and mathematical models which describe the range of pertinent expected variations of environmental conditions are to be employed. All data used are to be fully documented with the sources and estimated reliability of data noted.

Methods employed in developing available data into design criteria are to be described and submitted in accordance with 1-2-1. Probabilistic methods for short-term, long-term and extreme-value prediction are to employ statistical distributions appropriate to the environmental phenomena being considered, as evidenced by relevant statistical tests, confidence limits and other measures of statistical significance. Hindcasting methods and models are to be fully documented.

Generally, suitable data and analyses supplied by consultants will be accepted as the basis for design. For installations in areas where published design standards and data exist, such standards and data may be cited as documentation.

2 Environmental Factors to be considered

In general, the design of an offshore installation will require investigation of the following environmental factors:
Waves
Wind
Currents

Tides and storm surges
Air and sea temperatures
Ice and snow
Marine growth
Seismicity
Sea ice

Other phenomena, such as tsunamis, submarine slides, seiche, abnormal composition of air and water, air humidity, salinity, ice drift, icebergs, ice scouring, etc. may require investigation depending upon the specific installation site. The required investigation of seabed and soil conditions is described in 3-6.

3 Environmental Design Criteria

The combination and severity of environmental conditions for use in design are to be appropriate to the installation being considered and consistent with the probability of simultaneous occurrence of the environmental phenomena. It is to be assumed that environmental phenomena may approach the installation from any direction unless reliable site-specific data indicate otherwise. The direction, or combination of directions, which produces the most unfavorable effects on the installation is to be accounted for in the design.

3.1 Design Environmental Condition

In these Rules, the combination of environmental factors producing the most unfavorable effects on the structure, as a whole and as defined by the parameters given below, is referred to as the Design Environmental Condition. This condition is to be described by a set of parameters representing an environmental condition which has a high probability of not being exceeded during the life of the structure and will normally be composed of:

1. The maximum wave height corresponding to the selected recurrence period together with the associated wind, current and limits of water depth, and appropriate ice and snow effects
2. The extreme air and sea temperatures
3. The maximum and minimum water level due to tide and storm surge

However, depending upon site-specific conditions, consideration should be given to the combinations of events contained in item **1** above. The recurrence period chosen for events **1**, **2**, and **3** above is normally not to be less than one hundred years, unless justification for a reduction can be provided. For platforms that are unmanned, or can be easily evacuated during the design event, or platforms with shorter design life than typical 20 years may use a recurrence interval less than 100 years for events **1**, **2** and **3** above. However, the recurrence interval is not to be less than 50 years.

For installation sites located in seismically active areas (see 3-1-1/4.8), an earthquake of magnitude which has a reasonable likelihood of not being exceeded during the platform life to determine the risk of damage, and a rare intense earthquake to evaluate the risk of structural collapse are to be considered in the design. The earthquakes so described are herein referred to as the Strength Level and Ductility Level Earthquakes respectively. The magnitudes of the parameters characterizing these earthquakes having recurrence periods appropriate to the design life of the structure are to be determined. The effects of the earthquakes are to be accounted for in design but, generally, need not be taken in combination with other environmental factors.

For installations located in areas susceptible to tsunami waves, submarine slides, seiche or other phenomena, the effects of such phenomena are to be based on the most reliable estimates available and, as practicable, the expected effects are to be accounted for in design. Generally, for such phenomena, suitable data and recommendations submitted by consultants will be accepted as a basis for design.

3.2 Operating Environmental Conditions

For each intended major function or operation of the installation, a set of characteristic parameters for the environmental factors which act as a limit on the safe performance of an operation or function is to be determined. Such operations may include, as appropriate, transportation, offloading and installation of the structure, drilling or producing operations, evacuation of the platform, etc. These sets of conditions are herein referred to as Operating Environmental Conditions.

4 Specific Environmental Conditions

4.1 Waves

1. General
Statistical wave data from which design parameters are determined are normally to include the frequency of occurrence of various wave height groups, associated wave periods and directions.
Published data and previously established design criteria for particular areas may be used where such exist. Hindcasting techniques which adequately account for shoaling and fetch limited effects on wave conditions at the site may be used to augment available data. Analytical wave spectra employed to augment available data are to reflect the shape and width of the data, and they are to be appropriate to the general site conditions.

2. Long-Term Predictions
All long-term and extreme-value predictions employed for the determination of design wave conditions are to be fully described and based on recognized techniques. Design wave conditions

may be formulated for use in either deterministic or probabilistic methods of analysis, but the method of analysis is to be appropriate to the specific topic being considered.

3. Data

The development of wave data to be used in required analyses is to reflect conditions at the installation site and the type of structure. As required, wave data may have to be developed to determine the following:

Provision for air gap;
Maximum mud line shear force and overturning moment;
Dynamic response of the structure;
Maximum stress;
Fatigue;
Impact of local structure

Breaking wave criteria are to be appropriate to the installation site and based on recognized techniques. Waves which cause the most unfavorable effects on the overall structure may differ from waves having the most severe effects on individual structural components. In general, more frequent waves of lesser heights, in addition to the most severe wave conditions, are to be investigated when fatigue and dynamic analyses are required.

4.2 Wind

1. General Statistical

Wind data is normally to include information on the frequency of occurrence, duration and direction of various wind speeds. Published data and data from nearby land and sea stations may be used if available. If on-site measurements are taken, the duration of individual measurements and the height above sea-level of measuring devices is to be stated. Sustained winds are to be considered those having durations equal to or greater than one minute, while gust winds are winds of less than one minute duration.

2. Long-Term and Extreme-Value Predictions

Long-term and extreme-value predictions for sustained and gust winds are to be based on recognized techniques and clearly described. Preferably, the statistical data used for the long-term distributions of wind speed should be based on the same averaging periods of wind speeds as are used for the determination of loads. Vertical profiles of horizontal wind are to be determined on the basis of recognized statistical or mathematical models.

3. Vertical Profiles of Horizontal Wind

Vertical profiles of horizontal wind for use in design can be determined using the following equation:

$$V_y = V_H \left(\frac{y}{H} \right)^{\frac{1}{n}}$$

where:

V_y = wind speed at height y above a reference water depth, in m/s

V_H = wind speed at reference height H, usually 10 m above a reference water depth, in m/s

$\frac{1}{n}$ = exponent dependent upon the time-averaging period of the measured wind speed V_H

n = The value of n typically ranges from 7 for sustained winds to 13 for gust winds of brief duration. For sustained winds of 1-minute duration, n equal to 7 may be used; for gust winds of 3-second duration, n equal to 12 may be used.

4. Lack of Data

In the event that wind speed data is not available for the time-averaging periods desired for use in design, conversions to the desired time-averaging periods may be made on the basis of Table 3-1.

Table 3-1: Wind Speed for Time-Averaging Period, t

t	1 hr.	10 min.	1 min.	15 sec.	5 sec.	3 Sec.
Factor	1.00	1.04	1.16	1.26	1.32	1.35

Linear interpolation may be used with Table 3-1 to determine the factor to be applied to the time-averaging period wind speed relative to the 1- hour wind speed.

For wind speeds given in terms of the "fastest meter of wind", V_f , the corresponding time-averaging period t in seconds is given by:

$$t = \frac{8054}{V_f}$$

where V_f is the fastest meter of wind at a reference height of 10 m, in m/s.

4.3 Currents

1. General

Data for currents are generally to include information on current speed, directions and variation with depth. The extent of information needed is to be commensurate with the expected severity of current conditions at the site in relation to other load causing phenomena, past experience in adjacent or analogous areas and the type of structure and foundation to be installed. On-site data collection may be indicated for previously unstudied areas and/or areas expected to have unusual or severe conditions.

Consideration is to be given to the following types of current, as appropriate to the installation site: tidal, wind-generated, density, circulation and river-outflow.

2. Velocity Profiles

Current velocity profiles are to be based on site-specific data or recognized empirical relationships. Unusual profiles due to bottom currents and stratified effects due to river outflow currents are to be accounted for.

4.4 Tides

1. General

Tides, when relevant, are to be considered in the design of an offshore fixed structure. Tides may be classified as lunar or astronomical tides, wind tides, and pressure differential tides. The combination of the latter two is commonly called the storm surge. The water depth at any location consists of the mean depth, defined as the vertical distance between the sea bed and an appropriate near-surface datum, and a fluctuating component due to astronomical tides and storm surges. Astronomical tide variations are bounded by highest astronomical tide, HAT, and lowest astronomical tide, LAT, still water level (SWL) should be taken as the sum of the highest astronomical level plus the storm surge.

Storm surge is to be estimated from available statistics or by mathematical storm surge modeling.

2. Design Environmental Wave Crest

For design purposes, the design environmental wave crest elevation is to be superimposed on the SWL. Variations in the elevation of the daily tide may be used in determining the elevations of boat landings, barge fenders and the corrosion prevention treatment of structure in the splash zone. Water depths assumed for various topics of analysis are to be clearly stated.

4.5 Temperature

Extreme values of air, sea and seabed temperatures are to be expressed in terms of recurrence Periods and associated highest and lowest values. Temperature data is to be used to evaluate selection of structural materials, ambient ranges and conditions for machinery and equipment design, and for determination of thermal stresses, as relevant to the installation.

4.6 Ice and Snow

For structures intended to be installed in areas where ice and snow may accumulate or where sea ice hazards may develop, estimates are to be made of the extent to which ice and snow may accumulate on the structure. Data may be derived from actual field measurements, laboratory data or data from analogous areas.

4.7 Marine Growth

Marine growth is to be considered in the design of an offshore installation. Estimates of the rate and extent of marine growth may be based on past experience and available field data. Particular attention is to be paid to increases in hydrodynamic loading due to increased diameters and surface roughness of members caused by marine fouling as well as to the added weight and increased inertial mass of submerged structural members. Consideration should be given to the types of fouling likely to occur and their possible effects on corrosion protection coatings.

4.8 Seismicity and Earthquake Related Phenomena

1. Effects on Structures

The effects of earthquakes on structures located in areas known to be seismically active are to be taken into account. The anticipated seismicity of an area is, to the extent practicable, to be established on the basis of regional and site specific data including, as appropriate, the following:

Magnitudes and recurrence intervals of seismic events;
Proximity to active faults;
Type of faulting;
Attenuation of ground motion between the faults and the site;
Subsurface soil conditions;
Records from past seismic events at the site where available, or from analogous sites

2. Ground Motion

The seismic data are to be used to establish a quantitative strength level and ductility level earthquake criteria describing the earthquake induced ground motion expected during the life of the structure. In addition to ground motion, and as applicable to the site in question, the following earthquake related phenomena should be taken into account:

Liquefaction of subsurface soils;

Submarine slides;
Tsunamis;
Acoustic overpressure shock waves

4.9 Sea Ice

The effects of sea ice on structures must consider the frozen-in condition (winter), break-out in the spring, and summer pack ice invasion as applicable. Impact, both centric and eccentric, must be considered where moving ice may impact a structure.

Impact should consider both that of large masses (multi-year floes and icebergs) moving under the action of current, wind, and Coriolis effect, and that of smaller ice masses which are accelerated by storm waves.

The interaction between ice and the structure produces responses both in the ice and the structure-soil system, and this compliance should be taken into account as applicable.

The mode of ice failure (tension, compression, shear, etc.) depends on the shape and roughness of the surface and the presence of adfrozen ice, as well as the ice character, crystallization, temperature, salinity, strain rate and contact area. The force exerted by the broken or crushed ice in moving past the structure must be considered. Limiting force concepts may be employed if thoroughly justified by calculations.

Chapter 2 Loads

SECTION 1 General

1 General

This Chapter pertains to the identification, definition and determination of the loads to which an offshore structure may be subjected during and after its transportation to site and its installation. As appropriate to the planned structure, the types of loads described in 3-2-1/2 are to be accounted for in design.

2 Types of Loads

2.1

Loads applied to an offshore structure are, for purposes of these Rules, categorized as follows.

2.2 Dead Loads

Dead loads are loads which do not change during the mode of operation under consideration.

Dead loads include the following:

- Weight in air of the structure including, as appropriate, the weight of the principal structure (e.g. jacket, tower, caissons, gravity foundation, piling), grout, module support frame, decks, modules, stiffeners, piping, helideck, skirt, columns and any other fixed structural parts;
- Weight of permanent ballast and the weight of permanent machinery;
- External hydrostatic pressure and buoyancy calculated on the basis of the still water level;
- Static earth pressure

2.3 Live Loads

Live loads associated with the normal operation and use of the structure, are loads which may change during the mode of operation considered. (Though environmental loads are live loads, they are categorized separately; see 3-2-1/2.5) Live loads acting after construction and installation include the following:

- The weight of drilling or production equipment which can be removed, such as derrick, draw works, mud pumps, mud tanks, rotating equipment, etc.
- The weight of crew and consumable supplies, such as mud, chemicals, water, fuel, pipe, cable, stores, drill stem, casing, etc.
- Liquid in the vessels and pipes during operation
- Liquid in the vessels and pipes during testing
- The weight of liquids in storage and ballast tanks
- The forces exerted on the structure due to operations, e.g., maximum derrick reaction
- The forces exerted on the structure during the operation of cranes and vehicles
- The forces exerted on the structure by vessels moored to the structure or accidental impact consideration for a typical supply vessel that would normally service the installation
- The forces exerted on the structure by helicopters during take-off and landing, or while parked on the structure

Where applicable, the dynamic effects on the structure of items d through g are to be taken into account. Where appropriate, some of the items of live load listed above may be adequately accounted for by designing decks, etc. to a maximum, uniform area load as specified by the Operator, or past practice for similar conditions.
Live loads occurring during transportation and installation are to be determined for each specific operation involved and the dynamic effects of such loads are to be accounted for as necessary (see 3-7).

2.4 Deformation Loads

Deformation loads are loads due to deformations imposed on the structure. The deformation loads include those due to temperature variations (e.g., hot oil storage) leading to thermal stress in the structure and, where necessary, loads due to soil displacements (e.g., differential settlement or lateral displacement) or due to deformations of adjacent structures. For concrete structures, deformation loads due to prestress, creep, shrinkage and expansion are to be taken into account.

2.5 Environmental Loads

Environmental loads are loads due to wind, waves, current, ice, snow, earthquake, and other environmental phenomena. The characteristic parameters defining an environmental load are to be appropriate to the installation site and in accordance with the requirements of 3-1. Operating Environmental Loads are those loads derived from the parameters characterizing Operating Environmental Conditions (see 3-1-1/3.2). Design Environmental Loads are those loads derived from the parameters characterizing the Design Environmental Condition (see 3-1-1/3.1).
The combination and severity of Design Environmental Loads are to be in accordance with 3-1-1/3.1.

Environmental loads are to be applied to the structure from directions producing the most unfavorable effects on the structure, unless site-specific studies provide evidence in support of a less stringent requirement. Directionality may be taken into account in applying the environmental criteria.

Earthquake loads and loads due to accidents or rare occurrence environmental phenomena need not be combined with other environmental loads, unless site-specific conditions indicate that such combinations are appropriate.

3 Determination of Environmental Loads

3.1 General

Model or field test data may be employed to establish environmental loads. Alternatively, environmental loads may be determined using analytical methods compatible with the data established in compliance with 3-1. Any recognized load calculation method may be employed provided it has proven sufficiently accurate in practice, and it is shown to be appropriate to the structure's characteristics and site conditions. The calculation methods presented herein are offered as guidance representative of current acceptable methods.

3.2 Wave Loads

1. Range of Wave Parameters

A sufficient range of realistic wave periods and wave crest positions relative to the structure are to be investigated to ensure an accurate determination of the maximum wave loads on the structure. Consideration should be given to other wave induced effects such as wave impact loads, dynamic amplification and fatigue of structural members. The need for analysis of these effects is to be assessed on the basis of the configuration and behavioral characteristics of the structure, the wave climate and past experience.

2. Determination of Wave Loads

For structures composed of members having diameters which are less than 20% of the wave lengths being considered, semi-empirical formulations such as Morison's equation are considered to be an acceptable basis for determining wave loads. For structures composed of members whose diameters are greater than 20% of the wave lengths being considered, or for structural configurations which substantially alter the incident flow field, diffraction forces and the hydrodynamic interaction of structural members are to be accounted for in design.

3. Morison's Equation

The hydrodynamic force acting on a cylindrical member, as given by Morison's equation, is expressed as the sum of the force vectors indicated in the following equation:

$F_W = F_D + F_I$

where:

$F_W \equiv$ Hydrodynamic force vector per unit length along the member, acting normal to the axis of the member.

$F_D \equiv$ Drag force vector per unit length

$F_I \equiv$ Inertia force vector per unit length

The drag force vector for a stationary, rigid member is given by:

$$F_D = \frac{1}{2}\rho C_D D\, u_n\, |u_n| \qquad (kN/m)$$

where:

$\rho = 1.025\ tonnes/m^3$, Sea Water Density

$C_D \equiv$ Drag Coefficient (dimensionless)

$D \equiv$ Projected Width of the member in the direction of the cross-flow component of velocity (in the case of a circular cylinder, D denotes the diameter), (m)

$u_n \equiv$ Component of the Velocity Vector, normal to the axis of the member

$|u_n| \equiv$ Absolute Value of u_n, (m/s)

The inertia force vector for a stationary, rigid member is given by:

$$F_I = \rho C_I \left(\pi \frac{D^2}{4}\right) a_n \qquad (kN/m)$$

where:

$C_I \equiv$ Inertia Coefficient based on the displaced mass of fluid per unit length (dimensionless),

$a_n \equiv$ Component of the Fluid Acceleration Vector normal to the axis of the member, (m/s^2)

For compliant structures which exhibit substantial rigid body oscillations due to the wave action, the modified form of Morison's equation given below may be used to determine the hydrodynamic force:

$$F_W = F_D + F_I = \frac{1}{2}\rho C_D D(u_n - q_n)|u_n - q_n| + \rho\left(\pi \frac{D^2}{4}\right)\{a_n + C_M (a_n - \dot{q}_n)\}$$

where:

$q_n \equiv$ Component of the Velocity Vector of the Structural Member normal to its axis, (m/s)

$\dot{q}_n \equiv$ Component of the Acceleration Vector of the Structural Member normal to its axis, (m/s^2)

$C_M \equiv$ Added Mass Coefficient, i.e. $C_M = C_I - 1$

For structural shapes other than circular cylinders, the term (π D^2/4) in the above equations is to be replaced by the actual cross-sectional area of the shape.

Values of u_n and a_n for use in Morison's equation are to be determined using a recognized wave theory appropriate to the wave heights, wave periods, and water depth at the installation site. Values for the coefficients of drag and inertia to be used in Morison's equation are to be determined on the basis of model tests, full scale measurements, or previous studies which are appropriate to the structural configuration, surface roughness, and pertinent flow parameters (e.g. Reynolds number).

Generally, for pile-supported template type structures, values of C_D range between 0.6 and 1.2; values of C_I range between 1.5 and 2.0.

4. Diffraction Theory

For structural configurations which substantially alter the incident wave field, diffraction theories of wave loading are to be employed which account for both the incident wave force (i.e., Froude-Kylov force) and the force resulting from the diffraction of the incident wave due to the presence of the structure.

The hydrodynamic interaction of structural members is to be taken into account. For structures composed of surface piercing caissons or for installation sites where the ratio of water depth to wave length is less than 0.25, nonlinear effects of wave action are to be taken into account. This may be done by modifying linear diffraction theory to account for nonlinear effects or by performance of model tests.

3.3 Wind Loads

Wind loads and local wind pressures are to be determined on the basis of analytical methods or wind tunnel tests on a representative model of the structure.

In general, the wind load on the overall structure to be combined with other design environmental loads is to be determined using a one-minute sustained wind speed. For installations with negligible dynamic response to wind, a one-hour sustained wind speed may be used to calculate the wind loads on the overall structure. Wind loads on broad, essentially flat structures such as living quarters, walls, enclosures, etc. are to be determined using a fifteen second gust wind speed. Wind pressures on individual structural members, equipment on open decks, etc. are to be determined using a three second gust wind speed.

For wind loads normal to flat surfaces or normal to the axis of members not having flat surfaces, the following relation may be used:

$$F_{wind} = 6.11\ C_s\ V_y^{\ 2}\ A \times 10^{-4} \qquad (kN)$$

Where:

C_s = the shape coefficient (dimensionless), see Table 3-2

V_y = wind speed at altitude y (m/sec)

A = projected area of member on a plane normal to the direction of the considered force (m^2)

For any direction of wind approach to the structure, the wind force on flat surfaces should be considered to act normal to the surface. The wind force on cylindrical objects should be assumed to act in the direction of the wind.

Table 3-2: Values of C_s

Shape	C_s
Cylindrical shape	0.50
Major flat surfaces and overall projected area of platform	1.00
Isolated structural shapes (cranes, angles, beams, channels, etc.)	1.50
Under-deck areas (exposed beams and girders)	1.30
Derricks or truss cranes (each face)	1.25
Sides of Buildings	1.50

The area of open trussworks commonly used for derricks and crane booms may be approximated by taking 30% of the projected area of both the windward and leeward sides with the shape coefficient taken in accordance with Table 3-2.

Where one structural member shields another from direct exposure to the wind, shielding may be taken into account. Generally, the two structural components are to be separated by not more than seven times the width of the windward component for a reduction to be taken in the wind load on the leeward member.

Where appropriate, dynamic effects due to the cyclic nature of gust wind and cyclic loads due to vortex induced vibration are to be investigated. Both drag and lift components of load due to vortex induced vibration are to be taken into account. The effects of wind loading on structural members or components that would not normally be exposed to wind loads after platform installation are to be considered. This would especially apply to fabrication or transportation phases.

3.4 Current Loads

Current induced loads on immersed structural members are to be determined on the basis of analytical methods, model test data or full-scale measurements. When currents and waves are superimposed, the current velocity is to be added vectorially to the wave induced particle velocity prior to computation of the total force. Current profiles used in design are to be representative of the expected conditions at the installation site. Where appropriate, flutter and dynamic amplification due to vortex shedding are to be taken into account.
For calculation of current loads in the absence of waves, the lift force normal to flow direction, and the drag force may be determined as follows:

$$F_L = \frac{1}{2}\rho C_L V^2 A_l \qquad (kN/m)$$

$$F_D = \frac{1}{2}\rho C_D V^2 A_l \qquad (kN/m)$$

where:

$\rho = 1.025\ tonnes/m^3$, Sea Water Density

F_L ≡ Total Lift Force per unit length (kN/m)

C_L ≡ Lift Coefficient (dimensionless)

V ≡ Local Current Velocity (m/sec)

A_l ≡ Projected Area per unit length in a plane normal to the direction of the force (m^2 / m)

F_D ≡ Total Drag Force per unit length (kN/m)

C_D ≡ Drag Coefficient (dimensionless)

In general, lift force may become significant for long cylindrical members with large length-diameter ratios and should be checked in design under these conditions. The source of C_L values employed is to be documented.

3.5 Ice and Snow Loads

At locations where structures are subject to ice and snow accumulation the following effects are to be accounted for, as appropriate to the local conditions:

- Weight and change in effective area of structural members due to accumulated ice and snow
- Incident pressures due to pack ice, pressure ridgesand ice island fragments impinging on the structure

For the design of structures that are to be installed in service in extreme cold weather such as arctic regions, reference is to be made to API 2N: "Planning, Designing, and Constructing Fixed Offshore Platforms in Ice Environments."

3.6 Earthquake Loads

For structures located in seismically active areas strength level and ductility level earthquake induced ground motions (see 3-1-1/3.1) are to be determined on the basis of seismic data applicable to the installation site. Earthquake ground motions are to be described by either applicable ground motion records or response spectra consistent with the recurrence period appropriate to the design life of the structure. Available standardized spectra applicable to the region of the installation site are acceptable provided such spectra reflect site-specific conditions affecting frequency content, energy distribution, and duration.

These conditions include: the type of active faults in the region, the proximity of the site to the potential source faults, the attenuation or amplification of ground motion between the faults and the site, and the soil conditions at the site.

The ground motion description used in design is to consist of three components corresponding to two orthogonal horizontal directions and the vertical direction. All three components are to be applied to the structure simultaneously.

When a standardized response spectrum, such as given in the American Petroleum Institute (API) RP 2A, is used for structural analysis, input values of ground motion (spectral acceleration representation) to be used are not to be less severe than the following:

100% in both orthogonal horizontal directions
50% in the vertical direction

When three-dimensional, site-specific ground motion spectra are developed, the actual directional accelerations are to be used. If single site-specific spectra are developed, accelerations for the remaining two orthogonal directions should be applied in accordance with the factors given above.

If time history method is used for structural analysis, at least three sets of ground motion time histories are to be employed. The manner in which the time histories are used is to account for the potential sensitivity of the structure's response to variations in the phasing of the ground motion records.

Structural appurtenances, equipment, modules, and piping are to be designed to resist earthquake induced accelerations at their foundations.

As appropriate, effects of soil liquefaction, shear failure of soft muds and loads due to acceleration of the hydrodynamic added mass by the earthquake, submarine slide, tsunamis and earthquake generated acoustic shock waves are to be taken into account.

3.7 Marine Growth

The following effects of anticipated marine growth are to be accounted for in design. Increase in hydrodynamic diameter Increase in surface roughness in connection with the determination of hydrodynamic coefficients (e.g., lift, drag and inertia coefficients) Increase in dead load and inertial mass The amount of accumulation assumed for design is to reflect the extent of and interval between cleaning of submerged structural parts.

3.8 Sea Ice

The global forces exerted by sea ice on the structure as a whole and local concentrated loads on structural elements are to be considered. The effects of rubble piles on the development of larger areas, and their forces on the structure, need to be considered.

The impact effect of a sea ice feature must consider mass and hydrodynamic added mass of the ice, its velocity, direction and shape relative to the structure, the mass and size of the structure, the added mass of water and soil accelerating with the structure, the compliance of the structure-soil interaction and the failure mode of the ice-structure interaction. The dynamic response of structure to ice may be important in flexible structures. As appropriate, liquefaction of the underlying soils due to repetitive compressive failures of the ice against the structure is to be taken into account.

3.9 Subsidence

The effects of subsidence should be considered in the overall foundation and structural design. This would be especially applicable to facilities where unique geotechnical conditions exist such that significant sea floor subsidence could be expected to occur as a result of depiction of the subsurface reservoir.

Chapter 3 General Design Requirements

SECTION 1 General

1 General

This Chapter of the Rules outlines general concepts and considerations which may be incorporated in design. In addition, considerations for particular types of offshore structures are enumerated.
Subsequent Chapters of these Rules dealing specifically with steel, concrete and foundation design are to be viewed in light of the requirements given in this Chapter. Wherever references are made in the Rules to API-RP2A, if applicable, other industry standards such as ISO documents may also be used.

The design assessment of service life extension and reuse of existing platforms is to be based on the condition and usage of the platform is to be in accordance with those described in Part 5 of these Rules.

SECTION 2 Analytical Approaches

1 Format of Design Specifications

The design requirements of these Rules are generally specified in terms of a working stress format for steel structures and an ultimate strength format for concrete structures. In addition, the Rules require that consideration be given to the serviceability of structure relative to excessive deflection, vibration, and, in the case of concrete, cracking.

ACS will give special consideration to the use of alternative specification formats, such as those based on probabilistic or semi-probabilistic limit state design concepts.

2 Loading Formats

With reference to 3-1 and 3-2, either a deterministic or spectral format may be employed to describe various load components. When a static approach is used, it is to be demonstrated, where relevant, that consideration has been given to the general effects of dynamic amplification. The influence of waves other than the highest waves is to be investigated for their potential to produce maximum peak stresses due to resonance with the structure.

When considering an earthquake in seismically active areas (see 3-2), a dynamic analysis is to be performed. A dynamic analysis is also to be considered to assess the effects of environmental or other types of loads where dynamic amplification is expected. When a fatigue analysis is performed, a long-term distribution of the stress range, with proper consideration of dynamic effects, is to be obtained for relevant loadings anticipated during the design life of the structure (see 3-4-7 and 3-5-3/4).

If the modal method is employed in dynamic analysis, it should be recognized that the number of modes to be considered is dependent on the characteristics of the structure and the conditions being considered.

For earthquake analysis, a minimum number of modes is to be considered to provide approximately 90% of the total energy of all modes. Normally, at least six modes with the highest energy content are to be considered. The correlation between the individual modal responses in determining the total response is to be investigated. The complete quadratic combination (CQC) method may be used for combining modal responses. If the correlation between the individual modal responses is small, the total response may be calculated as the square root of the sum of the squares of the individual modal responses.

For extreme wave and fatigue analyses, dynamic response is to be considered for structural modes having periods greater than 3.0 seconds. For significant modes with periods of 3.0 seconds or less, the dynamic effect need not be considered provided the full static effect (including flexure of individual members due to localized wave forces) is considered.

3 Combination of Loading Components

Loads imposed during and after installation are to be taken into account. In consideration of the various loads described in 3-2, loads to be considered for design are to be combined consistent with their probability of simultaneous occurrence. However, earthquake loadings may be applied without consideration of other environmental effects unless conditions at the site necessitate their inclusion. If site-specific directional data is not obtained, the direction of applied environmental loads is to be such as to produce the highest possible influence on the structure.

Loading combinations corresponding to conditions after installation are to reflect both operating and design environmental loadings (see 3-1-1/3). Reference is to be made to 3-4, 3-5 and 3-6 regarding the minimum load combinations to be considered.

The Operator is to specify the operating environmental conditions and the maximum tolerable environmental loads during installation.

SECTION 3 Overall Design Considerations

1 Design Life

The design life of the structure is to be specified by the Operator. Continuance of classification beyond the Design Life will be subject to a special survey and engineering analysis as indicated in Part 5 of these Rules.

2 Air Gap

An air gap of at least 1.5 m is to be provided between the maximum wave crest elevation and the lowest protuberance of the superstructure for which wave forces have not been included in the design.

After accounting for the initial and expected long-term settlements of the structure, due to consolidation and subsidence in a hydrocarbon or other reservoir area, the design wave crest elevation is to be superimposed on the still water level (see 3-1-1/4.4) and consideration is to be given to wave run-up, tilting of the structure and, where appropriate, tsunamis.

3 Long-Term and Secondary Effects

Consideration is to be given to the following effects, as appropriate to the planned structure:

- Local vibration due to machinery, equipment and vortex shedding
- Stress concentrations at critical joints
- Secondary stresses induced by large deflection ($P-\delta$ effects)
- Cumulative fatigue
- Corrosion
- Abrasion due to ice
- Freeze-thaw action on concrete and coatings

4 Reference Marking

For large or complex structures, consideration should be given to installing permanent reference markings during construction to facilitate future surveys.

Where employed, such markings may consist of weld beads, metal or plastic tags, or other permanent markings. In the case of a concrete structure, markings may be provided using suitable coatings or permanent lines molded into the concrete.

5 Zones of Exposure

Measures taken to mitigate the effects of corrosion as required by 3-4-1/3 and 3-5-1/1.3 are to be specified and described in terms of the following definitions for corrosion protection zones:

Submerged Zone: That part of the installation below the splash zone.

Splash Zone: The part of the installation containing the areas above and below the still water level (see 3-1-1/4.4) which are regularly subjected to wetting due to wave action. Characteristically, the splash zone is not easily accessible for field painting, nor protected by cathodic protection.

Atmospheric Zone: That part of the installation above the splash zone.

Additionally, for structures located in areas subject to floating or submerged ice, that portion of the structure which may reasonably be expected to come into contact with floating or submerged ice is to be designed with consideration for such contact.

SECTION 4 Considerations for Particular Types of Structures

1 General

In this subsection are listed specific design considerations which are to be taken into account for particular types of structures. They constitute additional pertinent factors which affect the safety and performance of the structure and are not intended to supplant or modify other criteria contained in these Rules.

Where required, the interactive effects between the platform and conductor or riser pipes due to platform motions are to be investigated. For compliant structures which exhibit significant wave induced motions, determination of such interactive effects may be of critical importance.

2 Pile-Supported Steel Platforms

2.1 Factors to be considered

Factors to be considered in the structural analysis are to include the soil-pile interaction and the loads imposed on the tower or jacket during towing and launching.

2.2 Installation Procedures

Carefully controlled installation procedures are to be developed so that the bearing loads of the tower or jacket on the soil are kept within acceptable limits until the piles are driven.

2.3 Special Procedures

Special procedures may have to be used to handle long, heavy piles until they are self-supporting in the soil. Pile driving delays are to be minimized to avoid set-up of the pile sections.

2.4 Dynamic Analysis

For structures likely to be sensitive to dynamic response, the natural period of the structure should be checked to insure that it is not in resonance with waves having significant energy content.

2.5 Instability

Instability of structural members due to submersion is to be considered, with due account for second-order effects produced by factors such as geometrical imperfections.

3 Concrete or Steel Gravity Platforms

3.1 Positioning

The procedure for transporting and positioning the structure and the accuracy of measuring devices used during these procedures are to be documented.

3.2 Repeated Loadings

Effects of repeated loadings on soil properties, such as pore pressure, water content, shear strength and stress strain behavior, are to be investigated.

3.3 Soil Reactions

Soil reactions against the base of the structure during installation are to be investigated. Consideration should be given to the occurrence of point loading caused by sea bottom irregularities. Suitable grouting between base slab and sea floor can be employed to reduce concentration of loads.

3.4 Maintenance

The strength and durability of construction materials are to be maintained. Where sulphate attack is anticipated, as from stored oil, appropriate cements are to be chosen, pozzolans incorporated in the mix, or the surfaces given suitable coatings.

3.5 Reinforcement Corrosion

Means are to be provided to minimize reinforcing steel corrosion.

3.6 Instability

Instability of structural members due to submersion is to be considered, with due account for second-order effects produced by factors such as geometrical imperfections.

3.7 Horizontal Sliding

Where necessary, protection against horizontal sliding along the sea floor is to be provided by means of skirts, shear keys or equivalent means.

3.8 Dynamic Analysis

A dynamic analysis, including simulation of wave-structure response and soil-structure interaction, should be considered for structures with natural periods greater than approximately 3 seconds.

3.9 Long Term Resistance

The long term resistance to abrasion, cavitation, freeze-thaw durability and strength retention of the concrete are to be considered.

3.10 Negative Buoyancy

Provision is to be made to maintain adequate negative buoyancy at all times to resist the uplift forces from waves, currents, and overturning moments. Where this is achieved by ballasting oil storage tanks with sea water, continuously operating control devices should be used to maintain the necessary level of the oil-water interface in the tanks.

4 Concrete-Steel Hybrid Structures

4.1 Horizontal Loading

Where necessary, the underside of the concrete base is to be provided with skirts or shear keys to resist horizontal loading; steel or concrete keys or equivalent means may be used.

4.2 Steel and Concrete Interfaces

Special attention is to be paid to the design of the connections between steel and concrete components.

4.3 Other Factors

Pertinent design factors for the concrete base listed in 3-3-1/4.3 are also to be taken into account.

5 Guyed Compliant Towers

5.1 Clump Weights

Where necessary, clump weights (with or without buoyancy units) between the tower and anchors on the sea floor are to be provided to minimize the uplift forces on the anchors, to hold the guylines taut, and to restrict the lateral movement of the tower.

5.2 Lifting Clump Weights

As required by the design, clump weights should have provisions for being lifted off the sea floor during a storm. Lifting of the clump weights will decrease the stiffness of the mooring system, and allow the tower to displace more with the large waves.

5.3 Swiveling Fairleads

Consideration should be given to locating the swiveling fairleads on the tower as close as possible to the center of pressure of the design wind, wave and current loads in order to minimize horizontal forces at the bottom of the tower.

5.4 Foundations

Foundations supporting the base are to be embedded in the sea floor to a depth sufficient to attain the desired load-carrying capacity.

6 Tension Leg Platform (TLP)

6.1 Factors to be Considered

In determining the design environmental criteria, the design events that will produce the worst response to each component of the structure are to be considered. The largest responses of different components of the structure are not necessarily produced by the highest wave condition.

6.2 Tendons

The pretension is to be selected to result in positive tension at the foundation tendon connection for all design and operating load conditions.

6.3 Analysis

Frequency domain or time domain analysis may be performed to determine the responses of the structure such as extreme offset and yaw, minimum and maximum tendon tension, and deck clearance.

6.4 Damaged Condition Analysis

In addition to intact operating and design environmental conditions, damaged conditions such as accidental flooding of a buoyant compartment and/or a missing or flooded tendon are to be considered in the design.

6.5 Foundation

Foundations used to anchor the tendon leg system to the sea floor are to be sufficient to attain the required load-carrying capacity.

6.6 Transportation and Installation Procedures

Transportation and installation procedures are to be developed which minimize the stresses of the structural components. For the design of TLP, reference is to be made to API RP2T: "Recommended Practice for Planning, Designing, and Constructing Tension Leg Platforms".

7 Minimum Structures

7.1 Design Considerations

These Rules are to be applied in design of minimum structures wherever applicable. Minimum structures generally have less structural redundancy and more prominent dynamic responses due to the flexible nature of the structural configuration. The dynamic effects on the structure are to be considered in the structural analysis when the structure has a natural period greater than 3 seconds. The pertinent design factors listed in 3-3-1/4.2 are to be taken into account.

7.2 Mechanical Connections

Connections other than welded joints are commonly used in minimum structures. For these mechanical connections such as clamps, connectors and bolts, joining diagonal braces to the column or piles to the minimum structure, the strength and fatigue resistance are to be assessed by analytical methods or testing.

8 Site Specific Self-Elevating Mobile Offshore Units

8.1 Design Considerations

Self-Elevating Mobile Offshore Units converted to site dependent platform structures are to be designed in accordance with these Rules along with the ACS "Rules for Building and Classing Mobile Offshore Drilling Units", wherever applicable.

8.2 Foundation

When selecting a unit for a particular site, due consideration should be given to soil conditions at the installation site. The bearing capacity and sliding resistance of the foundation are to be investigated. The foundation design is to be in accordance with 3-6-5. As applicable, the foot prints left by Jack-up rigs and scour are to be considered in the foundation design.

8.3 Structural Analysis

In the structural analysis, the leg to hull connections and soil/structure interaction are to be properly considered. The upper and lower guide flexibility, stiffness of the elevating/ holding system, and any special details regarding its interaction with the leg should be taken into consideration. For units with spud cans, the legs may be assumed pinned at the reaction point. For mat supported units, the soil structure interaction may be modelled using springs.

8.4 Holding Capacity

While used as a site dependent platform structure, the calculated loads are to demonstrate that the maximum holding capacity of the jacking system will not be exceeded.

8.5 Preload

Units with spud cans are to be preloaded on installation in order to minimize the possibility of significant settlement under severe storm conditions.

Chapter 4 Steel Structures

SECTION 1 General

1 General

The requirements of this Chapter are to be applied in the design and analysis of the principal components of steel structures intended for offshore applications. Items to be considered in the design of welded connections are specified in 2-2.

2 Materials

The requirements of this section are intended for structures constructed of steel manufactured and having properties as specified in 2-1. Where it is intended to use steel or other materials having properties differing from those specified in 2-1, their applicability will be considered subject to a review of the specifications for the alternative materials and the proposed methods of fabrication.

3 Corrosion Protection

Materials are to be protected from the effects of corrosion by the use of a corrosion protection system including the use of coatings. The system is to be effective from the time the structure is initially placed on site. Where the sea environment contains unusual contaminants, any special corrosive effects of such contaminants are also to be considered. For the design of protection systems, reference is to be made to the National Association of Corrosion Engineers (NACE) publication NACE SP0176-2007, or other appropriate references.

4 Access for Inspection

In the design of the structure, consideration should be given to providing access for inspection during construction and, to the extent practicable, for survey after construction.

5 Steel-Concrete Hybrid Structures

The steel portions of a steel-concrete hybrid structure are to be designed in accordance with the requirements of this section, and the concrete portions are to be designed as specified in 3-5. Any effects of the hybrid structure interacting on itself in areas such as corrosion protection should be considered.

SECTION 2 General Design Criteria

1 General

Steel structures are to be designed and analyzed for the loads to which they are likely to be exposed during construction, installation and in-service operations. To this end, the effects on the structure of a minimum set of loading conditions, as indicated in 3-4-3, are to be determined, and the resulting structural responses are not to exceed the safety and serviceability criteria given below.

The use of design methods and associated safety and serviceability criteria, other than those specifically covered in this section, is permitted where it can be demonstrated that the use of such alternative methods will result in a structure possessing a level of safety equivalent to that provided by the direct application of these requirements.

The contents of 3-2 and 3-3 are to be consulted regarding definitions and requirements pertinent to the determination of loads and general design requirements.

SECTION 3 Loading Conditions

1 General

Loadings which produce the most unfavorable effects on the structure during and after construction and installation are to be considered. Loadings to be investigated for conditions after installation are to include at least those relating to both the realistic operating and design environmental conditions combined with other pertinent loads in the following manner:

- Operating environmental loading combined with dead and maximum live loads appropriate to the function and operations of the structure;
- Design environmental loading combined with dead and live loads appropriate to the function and operations of the structure during the design environmental condition.

For structures located in seismically active areas, earthquake loads (see 3-2-1/3.6 and 3-3-2/3) are to be combined with dead and live loads appropriate to the operation and function of the structure which may be occurring at the onset of an earthquake.

SECTION 4 Structural Analysis

1 General

1.1

The nature of loads and loading combinations as well as the local environmental conditions are to be taken into consideration in the selection of design methods. Methods of analysis and their associated assumptions are to be compatible with the overall design principles. Linear, elastic methods (working stress methods) can be employed in design and analysis provided proper measures are taken to prevent general and local buckling failure, and the interaction between soil and structure is adequately treated. When assessing structural instability as a possible mode of failure, the effects of initial stresses and geometric imperfections are to be taken into account.
Construction tolerances are to be consistent with those used in the structural stability assessment.

1.2

Dynamic effects are to be accounted for if the wave energy in the frequency range of the structural natural frequencies is of sufficient magnitude to produce significant dynamic response in the structure. In assessing the need for dynamic analyses of deep water or unique structures, information regarding the natural frequencies of the structure in its intended position is to be obtained. The determination of dynamic effects is to be accomplished either by computing the dynamic amplification effects in conjunction with a deterministic analysis or by a random dynamic analysis based on a probabilistic formulation. In the latter case, the analysis is to be accompanied by a statistical description and evaluation of the relevant input parameters.

1.3

For static loads, plastic methods of design and analysis can be employed only when the properties of the steel and the connections are such that they exclude the possibility of brittle fracture, allow for formation of plastic hinges with sufficient plastic rotational capability, and provide adequate fatigue resistance.

1.4

In a plastic analysis, it is to be demonstrated that the collapse mode (mechanism) which corresponds to the smallest loading intensities has been used for the determination of the ultimate strength of the structure. Buckling and other destabilizing nonlinear effects are to be taken into account in the plastic analysis. Whenever non-monotonic or repeating loads are present, it is to be demonstrated that the structure will not fail by incremental collapse or fatigue.

1.5

Under dynamic loads, when plastic strains may occur, the considerations specified in c are to be satisfied and any buckling and destabilizing nonlinear effects are to be taken into account.

SECTION 5 Allowable Stresses and Load Factors

1 Working Stress Approach

When a design is based on a working stress method (see 3-4-4/1.1 and 3-3-2), the safety criteria are to be expressed in terms of appropriate basic allowable stresses in accordance with requirements specified below.

1.1

Structural members and loadings are to be in accordance with the discretion of ACS.

1.2

Where stresses in members described in a are shown to be due to forces imposed by the design environmental condition acting alone or in combination with dead and live loads, the basic allowable stresses cited in a may be increased by one-third provided the resulting structural member sizes are not less than those required for the operating environment loading combined with dead and live loads without the one-third increase in allowable stresses.

1.3

When considering loading combinations which include earthquake loads (see 3-4-3) on individual members or on the overall structure, the allowable stress may be set equal to 1.7 times the basic allowable stress of the member.

1.4

The allowable stresses specified in 3-4-5/1.2 are to be regarded as the limits for stresses in all structural parts for the marine operations covered in 3-7, except for lifting, where the one third increase in the basic allowable stress is not permitted. The lifting analysis should adequately account for equipment and fabrication weight increase.

1.5

For any two- or three-dimensional stress field within the scope of the working stress formulation, the equivalent stress (e.g., the von Mises stress intensity) is to be limited by an appropriate allowable stress less than yield stress, with the exception of those stresses of a highly localized nature. In the latter case, local yielding of the structure may be accepted provided it can be demonstrated that such yielding does not lead to progressive collapse of the overall structure and that the general structural stability is maintained.

1.6

Whenever elastic instability, overall or local, may occur before the stresses reach their basic allowable levels, appropriate allowable buckling stresses govern.

2 Plastic Design Approach

2.1

Whenever the ultimate strength of the structure is used as the basis for the design of its members, the safety factors or the factored loads are to be formulated in accordance with the requirements of ACS or an equivalent code.

2.2

The capability of the principle structural members to develop their predicted ultimate load capacity is to be demonstrated.

2.3

For safety against brittle fracture, special attention is to be given to details of high stress concentration and to improved material quality.

SECTION 6 Structural Response to Earthquake Loads

1 General

Structures located in seismically active areas are to be designed to possess adequate strength and stiffness to withstand the effects of strength level earthquake, as well as sufficient ductility to remain stable during rare motions of greater severity associated with ductility level earthquake. The sufficiency of the structural strength and ductility is to be demonstrated by strength and, as required, ductility analyses.

For strength level earthquake, the strength analysis is to demonstrate that the structure is adequately sized for strength and stiffness to maintain all nominal stresses within their yield or buckling limits.

In the ductility analysis, it is to be demonstrated that the structure has the capability of absorbing the energy associated with the ductility level earthquake without reaching a state of incremental collapse.

The design criteria for earthquake are to be in accordance with the discretion of ACS.

SECTION 7 Fatigue Assessment

1 General

For structural members and joints where fatigue is a probable mode of failure, or for which past experience is insufficient to assure safety from possible cumulative fatigue damage, an assessment of fatigue life is to be carried out. Emphasis is to be given to joints and members in the splash zone, those that are difficult to inspect and repair once the structure is in service, and those susceptible to corrosion-accelerated fatigue.

For structural members and joints which require a detailed assessment of cumulative fatigue damage, the results of the assessment are to indicate a minimum expected fatigue life of twice the design life of the structure where sufficient structural redundancy exists to prevent catastrophic failure of the structure of the member or joint under consideration. Where such redundancy does not exist or where the desirable degree of redundancy is significantly reduced as a result of fatigue damage, the result of a fatigue assessment is to indicate a minimum expected fatigue life of three or more times the design life of the structure.

A spectral fatigue analysis technique is recommended to calculate the fatigue life of the structure.
Other rational analysis methods are also acceptable if the forces and member stresses can be properly represented. The dynamic effects should be taken into consideration if they are significant to the structural response.

SECTION 8 Stresses in Connections

1 General

Connections of structural members are to be developed to insure effective load transmission between joined members, to minimize stress concentration and to prevent excessive punching shear.

Connection details are also to be designed to minimize undue constraints against overall ductile behavior and to minimize the effects of postweld shrinkage. Undue concentration of welding is to be avoided.

The design of tubular joints may be in accordance with the API RP 2A.

SECTION 9 Structure-Pile Connections

1 General

The attachment of the structure to its foundation is to be accomplished by positive, controlled means such as welding or grouting, with or without the use of mechanical shear keys or other mechanical connectors.

Details of mechanical connectors are to be submitted for review. Such attachments are to be capable of withstanding the static and long-term cyclic loadings to which they will be subjected.

General references may be made to the API RP 2A where the ratio of the diameter to thickness of either the pile or the sleeve is less than or equal to 80. Where a ratio exceeds 80, special consideration is to be given to the effects of reduced confinement on allowable bond stress. Particulars of grouting mixtures are to be submitted for review.

The allowable stresses or load factors to be employed in the design of foundation structure for steel gravity bases or piles are to be in accordance with 3-4-5, and with regard to laterally loaded piles in accordance with 3-6-4/5.

SECTION 10 Structure Response to Hydrostatic Loads

1 General

Analyses of the structural stability are to be performed to demonstrate the ability of structural parts to withstand hydrostatic collapse at the water depths at which they will be located.

SECTION 11 Deflections

1 General

The platform deflections which may affect the design of piles, conductors, risers and other structures in way of the platform are to be considered. Where appropriate, the associated geometric nonlinearity is to be accounted for in analysis.

SECTION 12 Local Structure

1 General

Structures which do not directly contribute to the overall strength of the fixed offshore structure, i.e., their loss or damage would not impair the structural integrity of the offshore structure, are considered to be local structure.

Local structures are to be adequate for the nature and magnitude of applied loads. Allowable stresses specified in 3-4-5 are to be used as stress limits except for those structural parts whose primary function is to absorb energy, in which case sufficient ductility is to be demonstrated.

Chapter 5 Concrete Structures

SECTION 1 General

1 General

1.1

The requirements of this Chapter are to be applied to offshore installations of reinforced and prestressed concrete construction.

1.2 Materials

Unless otherwise specified, the requirements of this section are intended for structures constructed of materials manufactured and having properties as specified in Section 2-1. Where it is intended to use materials having properties differing from those specified in Section 2-1, the use of such materials will be specially considered. Specifications for alternative materials, details of the proposed methods of manufacture and, where available, evidence of satisfactory previous performance, are to be submitted for approval.

1.3 Durability

Materials, concrete mix proportions, construction procedures and quality control are to be chosen to produce satisfactory durability for structures located in a marine environment. Problems to be specifically addressed include chemical deterioration of concrete, corrosion of the reinforcement and hardware, abrasion of the concrete, freeze-thaw durability, and fire hazards as they pertain to the zones of exposure defined in 3-3-3/5.

Test mixes should be prepared and tested early in the design phase to ensure that proper values of strength, creep, alkali resistance, etc. will be achieved.

1.4 Access for Inspection

The components of the structure are to be designed to enable their inspection during construction and, to the extent practicable, periodic survey after installation.

1.5 Steel-Concrete Hybrid Structures

The concrete portions of a hybrid structure are to be designed in accordance with the requirements of this Chapter, and the steel portions in accordance with the requirements of 3-4.

SECTION 2 General Design Criteria

1 Design Method

1.1 General

The requirements of this section relate to the ultimate strength method of design.

1.2 Load Magnitude

The magnitude of a design load for a given type of loading k is obtained by multiplying the load, F_k, by the appropriate load factor, c_k, i.e., design load = $c_k F_k$.

1.3 Design Strength

In the analysis of sections, the design, strength of a given material is obtained by multiplying the material strength, f, by the appropriate strength reduction factor, φ, i.e., design strength = φf. The material strength, f, for concrete is the specified compression strength of concrete after 28 days and for steel is the minimum specified yield strength.

2 Load Definition

2.1 Load Categories

The load categories referred to in this section, i.e., dead loads, live loads, deformation loads, and environmental loads, are defined in 3-2-1/2.

2.2 Combination Loads

Loads taken in combination for the Operating Environmental Conditions and the Design Environmental Condition are indicated in 3-5-3/2.

2.3 Earthquake and Other Loads

Earthquake loads and loads due to environmental phenomena of rare occurrence need not be combined with other environmental loads unless site-specific conditions indicate that such combination is appropriate.

3 Design Reference

Design considerations for concrete structures not directly addressed in these Rules are to be in accordance with discretion of ACS (e.g. American Concrete Institute (ACI) 318 and ACI 357, or an equivalent recognized standard.)

SECTION 3 Design Requirements

1 General

The strength of the structure is to be such that adequate safety exists against failure of the structure or its components. Among the modes of possible failure to be considered are the following:

- Loss of overall equilibrium
- Failure of critical sections
- Instability resulting from large deformations
- Excessive plastic or creep deformation

The serviceability of the structure is to be assessed. The following items are to be considered in relation to their potential influences on the serviceability of the structure:

- Cracking and spalling
- Deformations
- Corrosion of reinforcement or deterioration of concrete
- Vibrations
- Leakage

2 Required Strength (Load Combinations)

The required strength (U) of the structure and each member is to be equal to, or greater than, the maximum of the following:

$$U = 1.2(D+T) + 1.6L_{\max} + 1.3E_O$$
$$U = 1.2(D+T) + 1.2L_{\max} + c_E E_{\max}$$
$$U = 0.9(D+T) + 0.9L_{\min} + c_E E_{\max}$$

in which c_E assumes the following values:

c_E = 1.3 for wave, current, wind, or ice load

c_E = 1.4 for earthquake loads

In the preceding relations, the symbols D, T, and L represent dead load, deformation load, and live load, respectively (see 3-5-2/2). The symbol E_O represents operating environmental loads, while $E_{\max}$ represents design environmental loads. The symbol $L_{\min}$ represents minimum expected live loads, while $L_{\max}$ represents maximum expected live loads.

For loads of type D, the load factor 1.2 is to be replaced by 1.0 if it leads to a more unfavorable load combination. For loads of type E_O the load factor 1.3 may be reduced if a more unfavorable load combination results. For strength evaluation the effects of deformation load may be ignored provided adequate ductility is demonstrated.

While the critical design loadings will be identified from the load combinations given above, the other simultaneously occurring load combinations during construction and installation phases are to be considered if they can cause critical load effects.

3 Strength Reduction Factors

The strength of a member or a cross section is to be calculated in accordance with the provisions of 3-5-4 and it is to be multiplied by the following strength reduction factor, φ:

(I) For bending with or without axial tension, $\varphi = 0.9$

(II) For axial compression or axial compression combined with bending:

- (a) Reinforced members with spiral reinforcement, $\varphi = 0.75$
- (b) Other reinforced members (excluding slabs and shells), $\varphi = 0.70$
- (c) The values given above may be increased linearly to 0.9 as P_u decreases from $0.1 f_c' A_g$ or P_b, whichever is smaller, to zero.

f_c' = specified compression strength of concrete

A_g = gross area of section

P_u = axial design load in compression member

P_b = axial load capacity assuming simultaneous occurrence of the ultimate strain of concrete and yielding of tension steel

- (d) Slabs and shells, $\varphi = 0.70$

(III) For shear and torsion, $\varphi = 0.85$

(IV) For bearing on concrete, $\varphi = 0.70$

Alternatively, the expected strength of concrete members can be determined by using idealized stress-strain curves and material factors (c_M) given in ACI 357R. The material factors applied to the stress-strain curves limit the maximum stress to achieve the desired reliability similar to using the strength reduction factors given above. The strength reduction factors (φ) and the material factors (c_M) are not to be used simultaneously.

4 Fatigue

The fatigue strength of the structure will be considered satisfactory if under the unfactored operating loads the following conditions are satisfied:

- The stress range in reinforcing or prestressing steel does not exceed 138 MPa, or where reinforcement is bent, welded or spliced, 69 MPa;
- There is no membrane tensile stress in concrete and not more than 1.4 MPa flexural tensile stress in concrete;
- The stress range in compression in concrete does not exceed $0.5 f_c'$ where f_c' is the specified compressive strength of concrete;
- Where maximum shear exceeds the allowable shear of the concrete alone, and where the cyclic range is more than half the maximum allowable shear in the concrete alone, all shear is taken by reinforcement. In determining the allowable shear of the concrete alone, the influence of permanent compressive stress may be taken into account;
- In situations where fatigue stress ranges allow greater latitude than those under the serviceability requirements given in Table 3-3, the latter condition shall assume precedence;
- Bond stress does not exceed 50% of that permitted for static loads.

Where the above nominal values are exceeded, an in-depth fatigue analysis is to be performed. In such an analysis the possible reduction of material strength is to be taken into account on the basis of appropriate data (S-N curves) corresponding to the 95th percentile of specimen survival. In this regard, consideration is to be given not only to the effects of fatigue induced by normal stress, but also to fatigue effects due to shear and bond stress. Particular attention is to be given to submerged areas subjected to the low-cycle, high-stress components of the loading history. Where an analysis of the fatigue life is performed, the expected fatigue life of the structure is to be at least twice the design life.

In order to estimate the cumulative fatigue damage under variable amplitude stresses, a recognized cumulative rule is to be used. Miner's rule is an acceptable method for the cumulative fatigue damage analysis.

5 Serviceability Requirements

5.1 Serviceability

The serviceability of the structure is to be checked by the use of stress-strain diagrams (Figures 3-1 and 3-2) with strength reduction factor, $\varphi = 1.0$, and the unfactored load combination:

$$U = D + T + L + E_O$$

where L is the most unfavorable live load and all other terms are as previously defined.

Using this method the reinforcing stresses are to be limited in compliance with Table 3-3.

Additionally for hollow structural cross sections, the maximum permissible membrane strain across the walls should not cause cracking under any combination of D, L, T and $E_{\max}$ using load factors taken as 1.0. For structures prestressed in one direction only, tensile stresses in reinforcement transverse to the prestressing steel shall be limited so that the strains at the plane of the prestressing steel do not exceed $\Delta P_s / E_s$. Where ΔP_s is as defined in Table 3-3 and E_s is the modulus of elasticity of reinforcement (see 3-5-4/2.7).

Alternative criteria such as those which directly limit crack width will also be considered.

5.2 Liquid-Containing Structures

The following criteria are to be satisfied for liquid-containing structures to ensure adequate design against leakage:

- The reinforcing steel stresses are to be in accordance with 3-5-3/5.1;
- The compression zone is to extend over 25% of the wall thickness or 205 mm, whichever is less;
- There is to be no membrane tensile stress unless other construction arrangements are made, such as the use of special barriers to prevent leakage

Table 3-3: Allowable Tensile Stresses for Prestress and Reinforcing Steel to Control Cracking

Stage	Loading	Allowable Stress (MPa)	
		Reinforcing Steel, f_s	Prestressing Tendons, ΔP_s
Construction: where cracking during construction would be detrimental to the completed structure	All loads on the structure during construction	160	130
Construction: where cracking during construction is not detrimental to the completed structure	All loads on the structure during construction	210 or $0.6 f_y$ whichever is less	130
Transportation and installation	All loads on the structure during transportation and installation	160	130
At offshore site	Dead and live plus operating environmental loads	120	75
At offshore site	Dead and live loads plus design environmental loads	$0.8 f_y$	

Notes:

f_y = yield stress of the reinforcing steel

f_s = allowable stress in the reinforcing steel

ΔP_s = increase in tensile stress in prestressing steel with reference to the stress at zero strain in the concrete

SECTION 4 Analysis and Design

1 General

Generally, the analysis of structures may be performed under the assumptions of linearly elastic materials and linearly elastic structural behavior, following the requirements of ACI 318 and the additional requirements of this Section.
The material properties to be used in analysis are to conform to 3-5-4/2. However, the inelastic behavior of concrete based on the true variation of the modulus of elasticity with stress and the geometric nonlinearities, including the effects of initial deviation of the structure from the design geometry, are to be taken into account whenever their effects reduce the strength of the structure.
The beneficial effects of the concrete's nonlinear behavior may be accounted for in the analysis and design of the structure to resist dynamic loadings.
When required, the dynamic behavior of concrete structures may be investigated using a linear structural model, but soil-structural impedances are to be taken into account.
The analysis of the structure under earthquake conditions may be performed under the assumption of elasto-plastic behavior due to yielding, provided that the requirements of 3-5-4/7 are satisfied.

2 Material Properties for Structural Analysis

2.1 Specified Compressive Strength

The specified compressive strength of concrete, f_c', is to be based on 28-day tests performed in accordance with specifications ASTM C172, ASTM C31 and ASTM C39.

2.2 Early Loadings

For structures which are subjected to loadings before the end of the 28-day hardening period of concrete, the compressive strength of concrete is to be taken at the actual age of concrete at the time of loading.

2.3 Early-Strength Concrete

For early-strength concrete, the age for the tests for f_c' may be determined on the basis of the cement manufacturer's certificate.

2.4 Modulus of Elasticity-Concrete

For the purposes of structural analyses and deflection checks, the modulus of elasticity of normal weight concrete may be assumed as equal to $4733\sqrt{f_c'}$ MPa or determined from stress-strain curves developed by tests (see Figure 3-1) the latter method is used, the modulus of elasticity is to be determined using the secant modulus for the stress equal to $0.5 f_c'$.

2.5 Uniaxial Compression-Concrete

In lieu of tests, the stress-strain relation shown in Figure 3-1 may be used for uniaxial compression of concrete.

2.6 Poisson Ratio

The Poisson ratio of concrete may be taken equal to 0.17.

2.7 Modulus of Elasticity-Reinforcement

The modulus of elasticity, E_s of non-prestressed steel reinforcement is to be taken as 200×10^3 MPa. The modulus of elasticity of prestressing tendons is to be determined by tests.

2.8 Uniaxial Tension-Reinforcement

The stress-strain relation of non-prestressed steel reinforcement in uniaxial tension is to be assumed as shown in Figure 3-2. The stress-strain relation of prestressing tendons is to be determined by tests, or taken from the manufacturers certificate.

2.9 Yield Strength-Reinforcement

If the specified yield strength, f_y , of non-prestressed reinforcement exceeds 420 MPa , the value of f_y used in the analysis is to be taken as the stress corresponding to a strain of 0.35%.

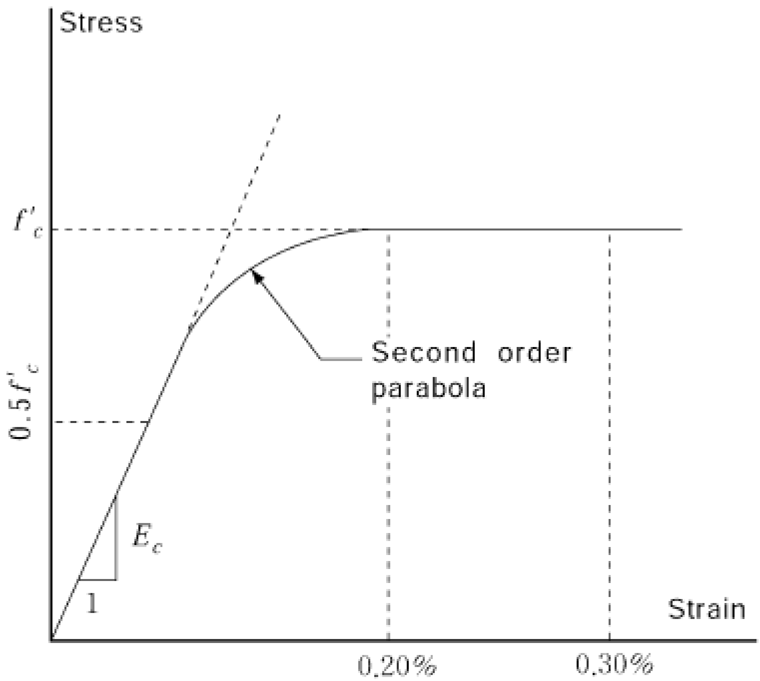

Figure 3-1 : Stress-Strain Relation for Concrete in Uniaxial Compression

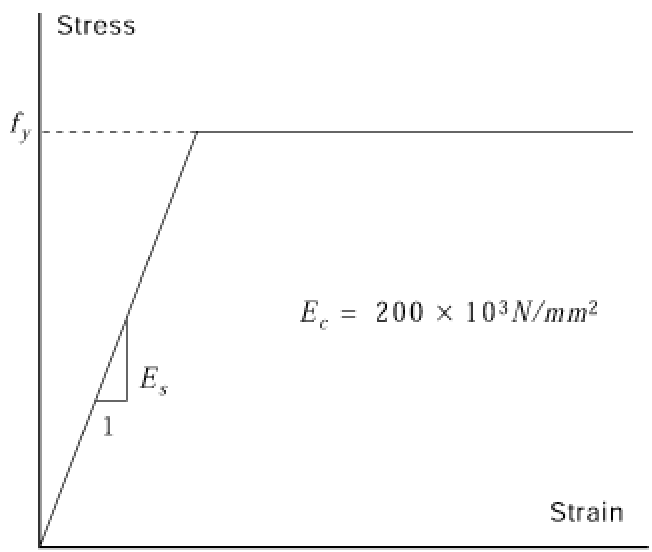

Figure 3-2 : Stress-Strain Relation for Non-Prestressed Steel in Uniaxial Tension

3 Analysis of Plates, Shells, and Folded Plates

In all analyses of shell structures, the theory employed in analysis is not to be based solely on membrane or direct stress approaches. The buckling strength of plate and shell structures is to be checked by an analysis which takes into account the geometrical imperfections of the structure, the inelastic behavior of concrete and the creep deformations of concrete under sustained loading. Special attention is to be devoted to structures subjected to external pressure and the possibility of their collapse (implosion) by failure of concrete in compression.

4 Deflection Analysis

Immediate deflections may be determined by the methods of linear structural analysis. For the purposes of deflection analysis, the member stiffnesses are to be computed using the material properties specified in the design and are to take into account the effect of cracks in tension zones of concrete. The effect of creep strain in concrete is to be taken into account in the computations of deflections under sustained loadings.

5 Analysis and Design for Shear and Torsion

The applicable requirements of ACI 318 or their equivalent are to be complied with in the analysis and design of members subject to shear or torsion or to combined shear and torsion.

6 Analysis and Design for Bending and Axial Loads

6.1 Assumed Conditions

The analysis and design of members subjected to bending and axial loads are to be based on the following assumptions:

- The strains in steel and concrete are proportional to the distance from the neutral axis;

- Tensile strength of the concrete is to be neglected, except in prestressed concrete members under unfactored loads, where the requirements in 3-5-3/5 apply;

- The stress in steel is to be taken as equal to ES times the steel strain, but not larger than f_y ;

- The stresses in the compression zone of concrete are to be assumed to vary with strain according to the curve given in Figure 3-1 or any other conservative rule. Rectangular distribution of compressive stresses in concrete specified by ACI 318 may be used;

- The maximum strain in concrete at the ultimate state is not to be larger than 0.30%

6.2 Failure

The members in bending are to be designed in such a way that any section yielding of steel occurs prior to compressive failure of concrete.

7 Seismic Analysis

7.1 Dynamic Analysis

For structures to be located at sites known to be seismically active (see 3-5-4/8), dynamic analysis is to be performed to determine the response of the structure to design earthquake loading. The structure is to be designed to withstand this loading without damage. In addition, a ductility check is also to be performed to ensure that the structure has sufficient ductility to experience deflections more severe than those resulting from the design earthquake loading without the collapse of the platform structure, its foundation or any major structural component.

7.2 Design Conditions

The dynamic analysis for earthquake loadings is to be performed taking into account:

- The interaction of all components of the structure;

- The compliance of the soil and the dynamic soil-structure interaction;

- The dynamic effects of the ambient and contained fluids.

7.3 Method of Analysis

The dynamic analysis for earthquake loadings may be performed by any recognized method, such as determination of time histories of the response by direct integration of the equations of motion, or the response spectra method.

7.4 Ductility Check

In the ductility check, distortions at least twice as severe as those resulting from the design earthquake are to be assumed. If the ductility check is performed with the assumption of elasto-plastic behavior of the structure, the selected method of analysis is to be capable of taking into account the nonlinearities of the structural model. The possibility of dynamic instability (dynamic buckling) of individual members and of the whole structure should be considered.

8 Seismic Design

8.1 Compressive Strain

The compressive strain in concrete at it critical sections (including plastic hinge locations) is to be limited to 0.3%, except when greater strain may be accommodated by confining steel.

8.2 Flexural Bending or Load Reversals

For structural members or sections subjected to flexural bending or to load reversals, where the percentage of tensile reinforcement exceeds 70% of the reinforcement at which yield stress in the steel is reached simultaneously with compression failure in the concrete, special confining reinforcement and/or compressive reinforcement are to be provided to prevent brittle failure in the compressive zone of concrete.

8.3 Web Reinforcement

Web reinforcement (stirrups) of flexural members is to be designed for shear forces which develop at full plastic bending capacity of end sections. In addition:

- The diameter of rods used as stirrups is not to be less than 10 mm;
- Only closed stirrups (stirrup ties) are to be used;
- The spacing of stirrups is not to exceed d/2, where d is the distance from the extreme compression fiber to the centroid of tensile reinforcement. Tails of stirrups are to be anchored within a confined zone, i.e., turned inward.

8.4 Splices

No splices are allowed within a distance d from a plastic hinge. Lap splices are to be at least 460 mm.

SECTION 5 Design Details

1 Concrete Cover

1.1 General

The following minimum concrete cover for reinforcing bars is required:

- Atmospheric zone not subjected to salt spray: 50 mm;
- Splash and atmospheric zones subjected to salt spray and exposed to soil: 65 mm;
- Submerged zone: 50 mm;
- Areas not exposed to weather or soil: 40 mm;
- Cover of stirrups may be 13 mm (0.5 in.) less than covers listed above.

1.2 Tendons and Ducts

The concrete cover of prestressing tendons and post-tensioning ducts is to be increased 25 mm above the values listed in 3-5-5/1.1.

1.3 Sections Less Than 500 mm Thick

In sections less than 500 mm thick, the concrete cover of reinforcing bars and stirrups may be reduced below the values listed in 3-5-5/1.1; however, the cover is not to be less than the following:

- 1.5 times the nominal aggregate size;
- 1.5 times the maximum diameter of reinforcement, or 19 mm;
- Tendons and post-tensioning duct covers are to have 12.5 mm added to the above.

2 Minimum Reinforcement

For loadings during all phases of construction, transportation, and operation (including design environmental loading) where tensile stresses occur on a face of the structure, the following minimum reinforcement on the face is required:

$$A_S = \left(\frac{f_t}{f_y}\right) b\, d_e$$

A_S = total cross-section area of reinforcement

f_t = mean tensile strength of concrete

f_y = yield stress of the reinforcing steel

b = width of structural element

d_e = effective tension zone, to be taken as $1.5c + 10d_b$

c = cover of reinforcement

d_b = diameter of reinforcement bar

d_e should be at least 0.2 times the depth of the section but not greater than $0.5(h - x)$, where x is the depth of the compression zone prior to cracking and h is the section thickness.

At intersections between structural elements, where transfer of shear forces is essential to the integrity of the structure, adequate transverse reinforcement is to be provided.

3 Reinforcement Details

Generally, lapped joints should be avoided in structural members subjected to significant fatigue loading. If lapped splices are used in members subject to fatigue, the development length of reinforcing bars is to be twice that required by ACI 318, and lapped bars are to be tied with tie wire. Reinforcing steel is to comply with the chemical composition specifications of ACI 359 if welded splices are used.

For anchorage of shear reinforcement as well as for anchorage of main reinforcement, mechanically headed bars (T-headed bars) may be used if their effectiveness has been verified by static and dynamic testing.

4 Post Tensioning Ducts

Ducting for post-tensioning ducts may be rigid steel or plastic, (polyethylene or polystyrene). Steel tubing shall have a minimum wall thickness of 1 mm. Plastic tubing shall have a minimum wall thickness of 2 mm. Ducts may also be semi-rigid steel, spirally wrapped, of minimum thickness of 0.75 mm, and shall be grout-tight. All splices in steel tubes and semi-rigid duct shall be sleeved and the joints sealed with heat-shrink tape. Joints in plastic duct shall be fused or sleeved and sealed.

The inside diameter of ducts shall be at least 6 mm larger than the diameter of the post-tensioning tendon in order to facilitate grout injection.

5 Post-Tensioning Anchorages and Couplers

Anchorages for unbonded tendons and couplers are to develop the specified ultimate capacity of the tendons without exceeding anticipated set. Anchorages for bonded tendons are to develop at least 90% of the specified ultimate capacity of the tendons, when tested in an unbonded condition without exceeding anticipated set. However, 100% of the specified ultimate capacity of the tendons is to be developed after the tendons are bonded in the member.

Anchorage and end fittings are to be permanently protected against corrosion. Post-tensioning anchorages shall preferably be recessed in a pocket which is then filled with concrete. The fill should be mechanically-tied to the structure by reinforcements as well as bonded by epoxy or polymer.

Anchor fittings for unbonded tendons are to be capable of transferring to the concrete a load equal to the capacity of the tendon under both static and cyclic loading conditions.

SECTION 6 Construction

1 General

Construction methods and workmanship are to follow accepted practices as described in ACI 318, ACI 357, API RP 2A, and the specifications referred to by these codes. Additional requirements relevant to concrete offshore structures are included below.

2 Mixing, Placing, and Curing of Concrete

2.1 Mixing

Mixing of concrete is to conform with the requirements of ACI 318 and ASTM C94.

2.2 Cold Weather

In cold weather, concreting in air temperatures below 2°C should be carried out only if special precautions are taken to protect the fresh concrete from damage by frost. The temperature of the concrete at the time of placing is to be at least 4°C and the concrete is to be maintained at this or a higher temperature until it has reached a strength of at least 5 MPa.

Protection and insulation are to be provided to the concrete where necessary. The aggregates and water used in the mix are to be free from snow, ice and frost. The temperature of the fresh concrete may be raised by heating the mixing water or the aggregates or both. Cement should never be heated nor should it be allowed to come into contact with water at a temperature greater than 60°C.

2.3 Hot Weather

During hot weather, proper attention is to be given to ingredients, production methods, handling, placing, protection and curing to prevent excessive concrete temperatures or water evaporation which will impair the required strength or serviceability of the member or structure. The temperature of concrete as placed is not to exceed 30°C and the maximum temperature due to heat of hydration is not to exceed 65°C.

2.4 Curing

Special attention is to be paid to the curing of concrete in order to ensure maximum durability and to minimize cracking. Concrete should be cured with fresh water, whenever possible, to ensure that the concrete surface is kept wet during hardening. Care should be taken to avoid the rapid lowering of concrete temperatures (thermal shock) caused by applying cold water to hot concrete surfaces.

2.5 Sea Water

Sea water is not to be used for curing reinforced or prestressed concrete, although, if demanded by the construction program, “young” concrete may be submerged in sea water provided it has gained sufficient strength to withstand physical damage. When there is doubt about the ability to keep concrete surfaces permanently wet for the whole of the curing period, a heavy duty membrane curing compound should be used.

2.6 Temperature Rise

The rise of temperature in the concrete, caused by the heat of hydration of the cement, is to be controlled to prevent steep temperature stress gradients which could cause cracking of the concrete. Since the heat of hydration may cause significant expansion, members must be free to contract, so as not to induce excessive cracking. In general, when sections thicker than 610 mm are concreted, the temperature gradients between internal concrete and external ambient conditions are to be kept below 20°C.

2.7 Joints

Construction joints are to be made and located in such a way as not to impair the strength and crack resistance of the structure. Where a joint is to be made, the surface of the concrete is to be thoroughly cleaned and all laitance and standing water removed. Vertical joints are to be thoroughly wetted and coated with neat cement grout or equivalent enriched cement paste or epoxy coating immediately before placing of new concrete.

2.8 Watertight Joints

Whenever watertight construction joints are required, in addition to the above provisions, the heavy aggregate of the existing concrete is to be exposed and an epoxide-resin bonding compound is to be sprayed on just before concreting. In this case, the neat cement grout can be omitted.

3 Reinforcement

The reinforcement is to be free from loose rust, grease, oil, deposits of salt or any other material likely to affect the durability or bond of the reinforcement. The specified cover to the reinforcement is to be maintained accurately. Special care is to be taken to correctly position and rigidly hold the reinforcement so as to prevent displacement during concreting.

4 Prestressing Tendons, Ducts and Grouting

4.1 General

Further guidance on prestressing steels, sheathing, grouts and procedures to be used when storing, making up, positioning, tensioning and grouting tendons will be found in the relevant sections of ACI 318, Prestressed Concrete Institute (PCI) publications, Federation Internationale de la Precontrainte (FIP) Recommended Practices, and the specialist literature.

4.2 Cleanliness

All steel for prestressing tendons is to be clean and free from grease, insoluble oil, deposits of salt or any other material likely to affect the durability or bond of the tendons.

4.3 Storage

During storage, prestressing tendons are to be kept clear of the ground and protected from weather, moisture from the ground, sea spray and mist. No welding, flame cutting or similar operations are to be carried out on or adjacent to prestressing tendons under any circumstances where the temperature of the tendons could be raised or weld splash could reach them.

4.4 Protective Coatings

Where protective wrappings or coatings are used on prestressing tendons, they are to be chemically neutral so as not to produce chemical or electrochemical corrosive attack on the tendons.

4.5 Entry of Water

All ducts are to be watertight and all splices carefully taped to prevent the ingress of water, grout or concrete. During construction, the ends of ducts are to be capped and sealed to prevent the entry of sea water. Ducts may be protected from excessive rust by the use of chemically neutral protective agents such as vapor phase inhibitor powder.

4.4 Grouting

Where ducts are to be grouted, all oil or similar material used for internal protection of the sheathing is to be removed before grouting. However, water-soluble oil used internally in the ducts or on the tendons may be left on, to be removed by the initial portion of the grout.

4.5 Air Vents

Air vents are to be provided at all crests in the duct profile. Threaded grout entries, which permit the use of a screwed connector from the grout pump, may be used with advantage.

4.6 Procedures

For long vertical tendons, the grout mixes, admixtures and grouting procedures are to be checked to ensure that no water is trapped at the upper end of the tendon due to excessive bleeding or other causes. Suitable admixtures known to have no injurious effects on the metal or concrete may be used for grouting to increase workability and to reduce bleeding and shrinkage. Temperature of members must be maintained above 10°C for at least 48 hours after grouting. General guidance on grouting will be found in the specialist literature. Holes left by unused ducts or by climbing rods of slipforms are to be grouted in the same manner as described above.

Chapter 6 Foundations

SECTION 1 General

1 Application

1.1

Soil investigations, design considerations for the supporting soil and the influence of the soil on the foundation structure are covered in this Chapter.

1.2

The degree of design conservatism should reflect prior experience under similar conditions, the manner and extent of data collection, the scatter of design data, and the consequences of failure. For cases where the limits of applicability of any method of calculation employed are not well defined, or where the soil characteristics are quite variable, more than one method of calculation or a parametric study of the sensitivity of the relevant design data is to be used.

SECTION 2 Site Investigation

1 General

The actual extent, depth and degree of precision applied to the site investigation program are to reflect the type, size and intended use of the structure, familiarity with the area based on previous site studies or platform installations, and the consequences which may arise from a failure of the foundation.

For major structures, the site investigation program is to consist of the following three phases:
(i) Sea Floor Survey (see 3-6-2/2) to obtain relevant geophysical data
(ii) Geological Survey (see 3-6-2/3) to obtain data of a regional nature concerning the site
(iii) Subsurface Investigation and Testing (see 3-6-2/4) to obtain the necessary geotechnical data

The results of these investigations are to be the bases for the additional site related studies which are listed in 3-6-2/5.

A complete site investigation program is to be accomplished for each offshore structure. However, use of the complete or partial results of a previously completed site investigation as the design basis for another similarly designed and adjacent offshore structure is permitted when the adequacy of the previous site's investigation for the new location is satisfactorily demonstrated.

When deciding the area to be investigated, due allowance is to be given to the accuracy of positioning devices used on the vessel employed in the site investigation to ensure that the data obtained are pertinent to the actual location of the structure.

2 Sea Floor Survey

Geophysical data for the conditions existing at and near the surface of the sea floor are to be obtained. The following information is to be obtained where applicable to the planned structure:
- Soundings or contours of the sea bed;
- Position of bottom shapes which might affect scour;
- The presence of boulders, obstructions, and small craters;
- Gas seeps;
- Shallow faults;
- Slump blocks;
- Ice scour of sea floor sediments;
- Subsea permafrost or ice bonded soils;

3 Geological Survey

Data of the regional geological characteristics which can affect the design and siting of the structure are to be considered in planning the subsurface investigation, and they are also to be used to assure that the findings of the subsurface investigation are consistent with known geological conditions.

Where necessary, an assessment of the seismic activity at the site is to be made. Particular emphasis is to be placed on the identification of fault zones, the extent and geometry of faulting and attenuation effects due to conditions in the region of the site.

For structures located in a producing area, the possibility of sea floor subsidence due to a drop in reservoir pressure is to be considered.

4 Subsurface Investigation and Testing

The subsurface investigation and testing program is to obtain reliable geotechnical data concerning the stratigraphy and engineering properties of the soil. These data are to be used to assess whether the desired level of structural safety and performance can be obtained and to assess the feasibility of the proposed method of installation.

Consistent with the stated objective, the soil testing program is to consist of an adequate number of in-situ tests, borings and samplings to examine all important soil and rock strata. The testing program is to reveal the necessary strength, classification and deformation properties of the soil. Further tests are to be performed as needed, to describe the dynamic characteristics of the soil and the static and cyclic soil-structure interaction.

For pile-supported structures, the minimum depth of at least one bore hole, for either individual or clustered piles, is to be the anticipated length of piles plus a zone of influence. The zone of influence is to be at least 15.2 m or 1.5 times the diameter of the cluster, whichever is greater, unless it can be shown by analytical methods that a lesser depth is justified. Additional bore holes of lesser depth are required if discontinuities in the soil are likely to exist within the area of the structure.

For a gravity-type foundation, the required depth of at least one boring is to be at least equal to the largest horizontal dimension of the base. In-situ tests are to be carried out, where possible, to a depth that will include the anticipated shearing failure zone.

A reasonably continuous profile is to be obtained during recovery of the boring samples. The desired extent of sample recovery and field testing is to be as follows:

- The recovery of the materials to a depth of 12 m below the mudline is to be as complete as possible. Thereafter, samples at significant changes in strata are to be obtained, at approximately 3 m intervals to 61 m and approximately 8 m intervals below 61 m.

- At least one undrained strength test (vane, drop cone, unconfined compression, etc.) on selected recovered cohesive samples is to be performed in the field.

- Where practicable, a standard penetration test or equivalent on each significant sand stratum is to be performed, recovering samples where possible.

- Field samples for laboratory work are to be retained and carefully packaged to minimize changes in moisture content and disturbance.

Samples from the field are to be sent to a recognized laboratory for further testing. They are to be accurately labeled and the results of visual inspection recorded. The testing in the laboratory is to include at least the following:

- Perform unconfined compression tests on clay strata where needed to supplement field data;
- Determine water content and Atterberg limits on selected cohesive samples;
- Determine density of selected samples;
- As necessary, develop appropriate constitutive parameters or stress-strain relationships from either unconfined compression tests, unconsolidated undrained triaxial compression tests, or consolidated undrained triaxial compression tests;
- Perform grain size sieve analysis, complete with percentage passing 200 sieve, on each significant sand or silt stratum;
- For pile-supported structures, consideration is to be given to the need for additional tests to adequately describe the dynamic characteristics of the soil and the static and cyclic lateral soil-pile;
- For gravity structures, laboratory tests are also to include, where necessary, the following:
  (a) Shear strength tests with pore pressure measurements. The shear strength parameters and pore water pressures are to be measured for the relevant stress conditions
  (b) Cyclic loading tests with deformation and pore pressure measurements to determine the soil behavior during alternating stress;
  (c) Permeability and consolidation tests performed as required.

5 Documentation

The foundation design documentation mentioned in Chapter 2 of Part 1 is to be submitted for review. As applicable, the results of studies to assess the following effects are also to be submitted:

- Scouring potential of the sea floor
- Hydraulic instability and the occurrence of sand waves
- Instability of slopes in the area where the structure is to be placed
- Liquefaction and other soil instabilities
- For Arctic areas, possible degradation of subsea permafrost layers as a result of the production of hot oil
- Soils conditions in the vicinity of footprints left by temporarily situated drilling units or other service units
- Effects of volcanic sands, organic matter, carbonate soil, calcareous sands and other substances which degrade the strength of the soil foundation

In these studies, the structure is to be considered present.

SECTION 3 Foundation Design Requirements

1 General

The loadings used in the analysis of the safety of the foundation are to include those defined in 3-6-3/7 and those experienced by the foundation during installation. Foundation displacements are to be evaluated to the extent necessary to assure that they are within limits which do not impair the intended function and safety of the structure.

The soil and the structure are to be considered as an interactive system, and the results of analyses, as required in subsequent paragraphs, are to be evaluated from this point of view.

2 Cyclic Loading Effects

The influence of cyclic loading on soil properties is to be considered. For gravity structures in particular, possible reduction of soil strength is to be investigated and employed in design. In particular the following conditions are to be considered:

- Design storm during the initial consolidation phase
- Short-term effects of the design storm
- Long-term cumulative effects of several storms, including the design storm

Reduced soil strength characteristics resulting from these conditions are to be employed in design. In seismically active zones, similar deteriorating effects due to repeated loadings are to be considered.
Other possible cyclic load effects, such as changes in load-deflection characteristics, liquefaction potential and slope stability are also to be considered, and these effects should be accounted for when they will affect the design.

3 Scour

Where scour is expected to occur, either effective protection is to be furnished soon after the installation of the structure, or the depth and lateral extent of scouring, as evaluated in the site investigation program, is to be accounted for in design.

4 Deflections and Rotations

Tolerable limits of deflections and rotations are to be established based on the type and function of the platform, and the effects of those movements on risers, piles and other structures which interact with the platform. Maximum allowable values of platform movements, as limited by these structural considerations or overall platform stability, are to be considered in the design.

5 Soil Strength

The ultimate strength or stability of soil is to be determined using test results which are compatible with the method selected. In a total stress approach the total shear strength of the soil obtained from simple tests is used. A total stress approach largely ignores changes in the soil's pore water pressure under varying loads and the drainage conditions at the site.
When an effective stress approach is used effective soil strength parameters and pore water pressures are determined from tests which attempt to predict in-situ total stresses and pore pressures.

6 Dynamic and Impact Considerations

For dynamic and impact loading conditions, a realistic and compatible treatment is to be given to the interactive effects between the soil and structure. When analysis is required it may be accomplished by lumped parameter, foundation impedance functions, or by continuum approaches including the use of finite element methods. Such models are to include consideration of the internal and radiational damping provided by the soil and the effects of soil layering.

Studies of the dynamic response of the structure are to include, where applicable, consideration of the nonlinear and inelastic characteristics of the soil, the possibilities of deteriorating strength and increased or decreased damping due to cyclic soil loading, and the added mass of soil subject to acceleration. Where applicable, the influence of nearby structures is to be included in the analysis.

7 Loading Conditions

Those loadings which produce the worst effects on the foundation during and after installation are to be taken into account. Post installation loadings to be checked are to include at least those relating to both the operating and design environmental conditions, combined in the following manner:

(i) Operating environmental loading combined with dead and maximum live loads appropriate to the function and operations of the structure;

(ii) Design environmental loading combined with dead and live loads appropriate to the function and operations of the structure during the design environmental condition;

(iii) Design environmental loading combined with dead load and minimum live loads appropriate to the function and operations of the structure during the design environmental conditions.

For areas with potential seismic activity, the foundation is to be designed for sufficient strength to sustain seismic loads.

8 Anchoring System

Where the anchoring utilizes piles, the requirements in these Rules applicable to piles are to be used. The loads at the mooring line attachments are to be calculated and the pile's local strength is to be checked. Where the anchoring utilizes gravity anchors, the requirements in these Rules applicable to gravity based structures are to be used.

Where platforms such as guyed towers and compliant towers are permanently and partially supported by a mooring system, the analysis of the platform's foundation is to include the interactive effects of the mooring system.

Other types of anchoring will be specially considered.

9 Loads and Soil Conditions Due to Temporarily Situated Structures

Changes in soil conditions due to temporarily situated platforms such as self-elevating drilling units, workover rigs or tender rigs placed near the structure are to be assessed and investigated. These changes and their influence on the structure are to be incorporated in the foundation design to ensure that structure's function and safety are not impaired.

SECTION 4 Pile Foundations

1 General

The effects of axial, bending and lateral loads are to be accounted for in the design of individual and group piles. The design of a pile is to reflect the interactive behavior between the soil and the pile and between the pile and the structure.

Methods of pile installation are to be consistent with the type of soil at the site, and with the installation equipment available. Pile driving is to be carried out and supervised by qualified and experienced personnel, and driving records are to be obtained and submitted for review.

Should unexpectedly high or low driving resistance or other conditions be encountered which lead to a failure of the pile to reach its desired penetration, a reevaluation of the pile's capacity is to be carried out considering the parameters resulting from the actual installation.

Where necessary, the effects of bottom instability in the vicinity of the structure are to be assessed.

2 Axial Piles

For piles in compression, the axial capacity is to be considered to consist of the skin friction, Q_f developed along the length of the pile, and the end bearing, Q_p at the tip of the pile. The axial capacity of a pile subjected to tension is to be equal to or less than the skin friction alone. Predictions of the various parameters needed to evaluate Q_f and Q_p are to be accomplished using a recognized analytical method, such as that found in the API RP 2A, or another method shown to be more appropriate to the conditions at the site. When required, the acceptability of any method used to predict the components of pile resistance is to be demonstrated by showing satisfactory performance of the method under conditions similar to those existing at the actual site. The results of dynamic pile driving analysis alone are not to be used to predict the axial load capacity of a pile.

3 Factors of Safety for Axial Piles

When the pile is subjected to the three loading cases described in 3-6-3/7 and the ultimate capacities are evaluated using the above cited API method, the allowable values of axial pile bearing and pullout loads are to able values of axial pile bearing and pullout loads are to be determined by dividing the ultimate capacities obtained above by a factor of safety tabulated below:

Loading Condition	Factor of Safety
3-6-3/7 (i)	2.0
3-6-3/7 (ii) , (iii)	1.5

For the Design Earthquake, the factor of safety will be specially considered.

4 Laterally Loaded Piles

In the evaluation of the pile's behavior under lateral loadings, the combined-load-deflection characteristics of the soil and pile, and the pile and the structure are to be taken into account. The representation of the soil's lateral deflection when it is subjected to lateral loads is to adequately reflect the deterioration of the lateral bearing capacity when the soil is subjected to cyclic loading.

The description of the lateral load versus deflection characteristics for the various soil strata is to be based on constitutive data obtained from suitable soil tests. Reference is to be made to the API RP 2A for a procedure to evaluate the load-deflection characteristics of laterally loaded piles. However, the use of alternative methods is permitted when they are more appropriate for conditions at the site.

Where applicable, the rapidly deteriorating cyclic bearing capacity of stiff clays, especially those exhibiting the presence of a secondary structure, is to be accounted for in the design.

5 Anchor Piles

When lateral loads are directly applied to a pile such as in the case when it is used to anchor a mooring line suitable load factors greater than 1.0 are to be used to increase the magnitudes of the lateral load effects resulting from the load conditions of 3-6-3/7.
Calculation of the soil capacity and the pile stresses is to be based on consideration of the modified loads.

6 Pile Groups

Where applicable, the effects of close spacing on the load and deflection characteristics of pile groups are to be determined. The allowable load for a group, both axial and lateral, is not to exceed the sum of the apparent individual pile allowable loads reduced by a suitable factor.

7 Connections between Piles and Structure

The loads acting on the platform may be transferred to the piles by connecting the jacket legs or pile sleeves to the piles by welding, grouting the annulus between the jacket leg or pile sleeve and the pile, or by use of mechanical devices such as pile grippers.

The design of the grouted pile to structure connection should consider the use of mechanical shear connectors as their presence increase the strength of the connection, and eliminates any effect of long term grouting shrinkage. Adequate clearance between the pile and the jacket leg should be provided for proper placement of the grout. Reliable means for the introduction of the grout to the annulus should be provided to ensure complete filling of the annulus and to minimize the possibility of dilution of the grout and the formation of voids in the grout. Wipers or similar devices should be used to minimize intrusion of mud into the annulus during installation. For the design of the grouted connections, reference is to be made to API RP2A or other appropriate references.

If mechanical devices are used their strength and fatigue characteristics are to be adequately demonstrated by analysis, testing or experience.

SECTION 5 Gravity Structures

1 General

The stability of the foundation with regard to bearing and sliding failure modes is to be investigated employing the soil shear strengths determined in accordance with 3-6-2/4 and 3-6-3/2. The effects of adjacent structures and the variation of soil properties in the horizontal direction are to be considered where relevant.

Where leveling of the site is not carried out, the predicted tilt of the overall structure is to be based on the average bottom slope of the sea floor and the tolerance of the elevation measuring device used in the site investigation program. Differential settlement is also to be calculated and the tilting of the structure caused by this settlement is to be combined with the predicted structural tilt. Any increased loading effects caused by the tilting of the structure are to be considered in the foundation stability requirements of 3-6-5/2.

When an underpressure or overpressure is experienced by the sea floor under the structure, provision is to be made to prevent piping which could impair the integrity of the foundation. The influence of hydraulic and slope instability, if any, is to be determined for the structural loading cases (ii) and (iii) of 3-6-3/7.

Initial consolidation and secondary settlements, as well as permanent horizontal displacements, are to be calculated.

2 Stability

The bearing capacity and lateral resistance are to be calculated under the most unfavorable combination of loads. Possible long-term redistribution of bearing pressures under the base slab are to be considered in order to ensure that the maximum edge pressures are used in the design of the perimeter of the base.

The lateral resistance of the platform is to be investigated with respect to various potential shearing planes. Special consideration is to be given to any layers of soft soil.

Calculations for overturning moment and vertical forces induced by the passage of a wave are to include the vertical pressure distribution across the top of the foundation and along the sea floor.

The capacity of the foundation to resist a deep-seated bearing failure is to be analyzed. In lieu of a more rigorous analysis, where uniform soil conditions are present or where conservatively chosen soil properties are used to approximate a non-uniform soil condition, and where a trapezoidal distribution of soil pressure is a reasonable expectation, the capacity of the foundation to resist a deep-seated bearing failure can be calculated by standard bearing capacity formulas applicable to eccentrically loaded shallow foundations. Alternatively, slip-surface methods, covering a range of kinematically possible deep rupture surfaces can be employed in the bearing capacity calculations.

The maximum allowable shear strength of the soil is to be determined by dividing the ultimate shear strength of the soil by the minimum safety factors given below.

When the ultimate soil strength is determined by an effective stress method, the safety factor is to be applied to both the cohesive and frictional terms. If a total stress method is used, the safety factor is to be applied to the undrained shear strength. The minimum safety factors to be obtained, when employing a standard bearing capacity formulation and various trial sliding failure planes with the loading conditions of 3-6-3/7, are 2.0 for loading case (i), and 1.5 for loading cases (ii) and (iii). The safety factors to be obtained when considering the Design Earthquake will be specially considered.

Where present, the additional effects of penetrating walls or skirts which transfer vertical and lateral loads to the soil are to be investigated as to their contribution to bearing capacity and lateral resistance.

3 Soil Reaction on the Structure

For conditions during and after installation, the reaction of the soil against all structural members seated on or penetrating into the sea floor is to be determined and accounted for in the design of these members. The distribution of soil reactions is to be based on the results obtained in 3-6-2/4. Calculations of soil reactions are to account for any deviation from a plane surface, the load-deflection characteristics of the soil and the geometry of the base of the structure.

Where applicable, effects of local soil stiffening, nonhomogeneous soil properties, as well as the presence of boulders and other obstructions, are to be accounted for in design. During installation, consideration is to be given to the possibility of local contact pressures due to irregular contact between the base and the sea floor; these pressures are additive to the hydrostatic pressure.

An analysis of the penetration resistance of structural elements projecting into the sea floor below the foundation structure is to be performed. The design of the ballasting system is to reflect uncertainties associated with achieving the required penetration of the structure. Since the achievement of the required penetration of the platform and its skirts is of critical importance, the highest expected values of soil strength are to be used in the calculation of penetration.

Chapter 7 Marine Operations

SECTION 1 General

1 General

The effects which may be induced in the structure during the marine operations required for the transportation and installation of the structure and equipment are to be accounted for. The emphasis of this Chapter is on the influence which these operations may have on the safety and integrity of the structure. However, the adequacy of the tie-down and barge strength should also be evaluated.

2 Application

In these Rules, marine operations will generally include the following activities as appropriate to the planned installation:

- Lifting and mooring operations
- Load-out
- Construction afloat
- Towing
- Launching and uprighting
- Submergence
- Mating
- Pile installation
- Final field erection
- Removal operations

For all marine operations except towing, the Surveyor is to be satisfied that skilled supervision is being provided and that the operations are being executed satisfactorily. During a tow, the towage master is to assure that proper procedures are followed. The Operator may also optionally request that a Surveyor be present during a tow.

SECTION 2 Documentation

1 General

The extent of documentation and analysis (3-7-3) of marine operations is to be commensurate with the size and type of structure involved, the particular operation being considered, the extent of past experience with similar operations, and the severity of the expected environmental conditions.

2 Report

A report on the marine operations planned to transport and install the structure is to be developed and submitted for use in association with the review of the analyses required in 3-7-3. For structures requiring a significant amount of construction while afloat (e.g., large concrete gravity structures), documentation of the operations involved is to be included in this report. The purpose of this report is to demonstrate that the strength and integrity of the structure are not reduced or otherwise jeopardized by the marine operations.

Generally, this report is to contain the following information:

- Description of the marine operations to be performed and the procedures to be employed;

- For operations which do not govern design of the structure, a description of the engineering logic, experience or preliminary calculations supporting this conclusion;

- For operations which govern design of the structure, the assumptions, calculations and results of the analyses required in 3-7-3;

- For structures to be uprighted or submerged by selective ballasting, a detailed description of the mechanical, electrical and control systems to be employed, the ballasting schedule and supporting calculations.

SECTION 3 Analysis

1 Loads

Analyses are to be performed to determine the type and magnitude of the loads and load combinations to which the structure will be exposed during the performance of marine operations. Particular attention is to be given to inertial, impact, and local loads which are likely to occur during marine operations. Where significant fatigue damage occurs during marine operations, it shall be included in calculating the total fatigue lives.

2 Stress

Where temporary attachments or appurtenances (tiedowns, skid beams, etc.) are utilized, analyses are to be performed to ensure that these items and their supporting structure have sufficient strength to withstand the type and magnitude of loads with the appropriate factor of safety. The strength criteria of Chapters 4 and 5 of Part 3 for steel structures and concrete structures, respectively, are to be employed in this determination.

3 Stability

Analyses are to be performed to ensure that the structure, or its means of support where such exist, has sufficient hydrostatic stability and reserve buoyancy to allow for successful execution of all phases of marine operations.

For large or unusual structures, an experimental determination of the center of gravity of the structure and its means of support, where such exist, is to be performed.

SECTION 4 Fitness to Tow Certificate

1 General

Upon request by the Operator and where authorized to do so, ACS will undertake the services required for the issuance of a fitness to tow certificate.

The adequacy of the towlines, attachments and towing vessels will not be reviewed by ACS. Review by ACS solely for the purposes of classification is not to be considered a replacement for the review commonly required for the issuance of a towage certificate.

PART

4

Machinery Installations

Chapter 1 General

SECTION 1 General

1 Application

The requirements in this Part apply to the machinery installations of the offshore installation. Equipments and systems of the drilling and production systems are not covered by these requirements.

The machinery installations of units, except where specially required in this Part, are to comply with the relevant requirements in ACS MODU Rules.

Piping system design, fabrication and testing are to comply with the requirements in this Part and standards recognized by ACS, such as ASME B31, "Code for Pressure Piping", latest edition.

2 Plans and Documents to be submitted

The following plans and documents are to be submitted to ACS:

- General arrangement of machinery spaces;
- Plans and documents of boilers and pressure vessels, engines and other equipments specified in ACS Rules for Classification of Vessels;
- An arrangement plan clearly indicating the hazardous areas as outlined in 4-1-1/3;
- Complete particulars of the ventilating system including capacities of fans, number of complete air changes per minute, air flow, area subject to positive and negative pressure, and location of self-closing doors;
- A description of the ventilating system for all hazardous areas;
- Piping and instrumentation diagram.

3 Hazardous Space

Hazardous space means space to be classified on the basis of the latest edition of API RP 505, "Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1 and Zone 2", or an equivalent recognized standard.

Chapter 2 Engines, Boilers, and Pressure Vessels

SECTION 1 General

1 General

Exhaust gasses of internal combustion engines and boilers are to be discharged outside of all hazardous areas and exhaust outlets of internal combustion engines are to be fitted with suitable spark arresting devices.

Air intakes for internal combustion engines and boilers are to be located not less than 3 meters away from hazardous space.

SECTION 2 Installations in Hazardous Areas

1 General

Internal combustion engines are not to be installed in Zone 0 hazardous areas, as defined by API RP 505.

When internal combustion engines are installed in Zone 1 and Zone 2, such installation will be subject to special consideration. Fired boilers are not to be installed in hazardous areas.

SECTION 3 Fire Detection of Machinery Spaces

1 General

Spaces having boilers, fired heaters or engines are to be fitted with an automatic fire detection system that will secure the fuel to the space. Additionally, on manned platforms, the system is to sound an alarm.

SECTION 4 Boilers and Pressure Vessels

1 General

Boilers and pressure vessels are to be designed, constructed and tested in accordance with the *American Society of Mechanical Engineers'* "Boiler and Pressure Vessel Code", latest edition.

For boilers and fired heaters, firing arrangements are to be arranged so that fuel is automatically cut off on loss of flame.

When boilers and fired heaters using gas as fuel are located in an enclosed space, the space is to be adequately ventilated and it is to be fitted with an effective gas detection system; a fuel valve is to automatically close upon detection of gas.

Arrangements for using crude oil as fuel will require special consideration.

SECTION 5 Diesels and Gas Turbine Engines

1 General

Engines will be accepted on the basis of the manufacturer's guarantee, subject to the carrying out of a satisfactory performance test witnessed by the Surveyor after installation. Engines and their installation are to be to the satisfaction of ACS.

SECTION 6 Ventilation of Machinery Spaces

1 General

Attention is to be given to ventilation inlet and outlet locations and air flow in order to minimize the possibility of cross contamination. Ventilation inlets are to be located in non-hazardous areas.

Ventilation for hazardous areas is to be completely separated from that for non-hazardous areas.

Chapter 3 Auxiliaries and Piping Arrangement

SECTION 1 Vent Pipes

1 General

The structural arrangement of all tanks is to be such as to permit the free passage of air and gases from all parts of the tanks to the vent pipes. Vent pipes are to be arranged to provide adequate drainage under normal conditions.

1 Size

The diameter of each vent pipe is not to be less than 38 mm inside diameter for fresh water tanks and 63 mm inside diameter for oil tanks unless specially approved otherwise.

Where tanks are to be filled by pump pressure, the aggregate area of the vents in the tank is to be at least 125 % of the effective area of the filling line. However, the vents need not exceed the above minimum sizes when overflows of which the area is to be at least 125 % of the effective area of the filling line are fitted. Notwithstanding the above, the pump capacity and pressure head are to be considered in the sizing of vents and overflows.

SECTION 2 Sounding Pipes

1 General

Tanks are to be fitted with sounding pipes not less than 38 mm inside diameter and where a sounding pipe exceeds 20 m in length, the minimum internal diameter is to be at least 50 mm.

They are to be led as straight as possible from the lowest part of the tank to a position which is always accessible.

2 Gauge Glasses

Tanks may be fitted with suitable gauge glasses in lieu of sounding pipes, provided they are fitted with a valve at each end of the gauge and adequately protected from mechanical damage.

Gauge glasses on tanks containing combustible liquids are to be of flat shape and of heat resisting quality, and to have approved self-closing valves at each end.

SECTION 3 Fuel Oil Systems

1 General

Fuel oil pumping arrangements are to be distinct from the other pumping systems as far as practicable, and means are to be provided for preventing dangerous interconnection.

2 Pipes in Fuel Oil Tanks

Oil pipes and other pipes, where passing through fuel oil tanks, are to be of steel, except that other materials may be considered where it is demonstrated that the material is suitable for the intended service.

All packing is to be of a composition not affected by oil.

3 Drip Pans

Pumps, strainers, etc., requiring occasional examination are to have drip pans.

4 Valves on Fuel Oil Tanks

Where pipe lines emanate from oil tanks at such a level that they will be subjected to a static head of oil from the tank, they are to be fitted with positive closing valves located at the tank or where the pipe line enters the machinery space. Arrangements are to be provided for closing them from a readily accessible and safe location outside of the compartment in which the valve is located.

Where independent filling lines are fitted, they are to enter at or near the top of the tank; but if this be impracticable, they are to be fitted with non-return valves at the tank.

5 Remote Shutdown of Pumps

Fuel oil transfer pumps, fuel oil unit pumps and other similar fuel pumps are to be fitted with remote controls situated outside the space concerned so that they may be stopped in the event of a fire arising in the space in which they are located.

6 Fuel Oil Tanks and Drains

The fuel oil overflows, drains from fuel and lubricating oil tanks and from drip pans of oil pumps and tanks are to be led to a drain tank fitted with air and sounding pipes and an independent suction from the fuel oil transfer pumps.

Non-return valves are to be fitted in drain lines entering the drain tanks where backflow would present a hazard. Suitable means are to be provided for pumping out these drain tanks.

Tanks not forming part of the platform structure are to have suitable drip pans.

Service tanks are to be located at a sufficient height to permit gravity flow to the service pump section.

SECTION 4 Fuel Oil Storage for Helicopter Facilities

1 General

Areas where fuel oil storage tanks for helicopters are located and fueling operations conducted are to be suitably isolated from areas which contain a source of vapor ignition.

Fuel oil storage tanks are to be provided with vents in accordance with 4-3-1. The vents are to extend to at least 2.4 m above the deck.

Fuel oil storage tanks are to be of approved metallic construction. Special attention is to be given to the design, mounting and securing arrangements and electrical bonding of the tank and fuel oil transfer system.

The storage and handling area is to be permanently marked.

Coamings or other similar arrangements are to be provided at each fuel oil storage tank and are to be sufficient in height to retain the contents of the storage tank plus fire-extinguishing agents where provided.

PART

5

Electrical Installations, Safety Features and Fire Protection

Chapter 1 Electrical Installations

SECTION 1 General

1 Application

The requirements in this Part apply to the electrical installations of the offshore installation. Components of the drilling and production systems are not covered by these requirements.

Electrical installations are to comply with the requirements of standards recognized by ACS.

2 Plans and documents to be submitted

The following plans and documents are to be submitted in triplicate to ACS:

- Generators and motors:
  Complete rating, class of insulation and rated ambient temperature, rated temperature rise and standard to which manufactured

- Switchgear and switchboards:
  Arrangements and details, front view, installation arrangements and wiring diagram including a schematic diagram

- Motor-control equipment:
  Terminal arrangements, degree of enclosure and wiring diagram

- Wiring:
  Plans of all wiring, complete feeder list, giving for each feeder and branch circuit the load, wire size, type of wire or cable, rating or setting of circuit breakers, rating of fuses and switches, interrupting capacity of circuit breakers and fuses

- Short-circuit data:
  Data are to be submitted giving the maximum calculated short-circuit current at each point in the distribution system.

- Hazardous areas:
  A plan showing the electrical equipment installed in hazardous areas

- Cathodic protection:
  Details of Impressed-Current-Cathodic protection system

- Other plans and documents deemed necessary by ACS

SECTION 2 Electrical Installations

1 General Considerations

- Watertight or weatherproof equipment:
  Electrical equipment exposed to the weather or located where it would be exposed to other severe moisture conditions is to be weatherproof or watertight.

- Corrosion-resistant parts:
  Enclosures, working and other parts of electrical equipment which would be damaged or rendered ineffective by corrosion are to be made of corrosion-resistant materials or of material rendered corrosion-resistant.

- Grounding arrangements:
  (i) Where not obtained through normal construction, arrangements are to be provided to effectively ground all machinery, metal structures of derricks, masts and helicopter platforms.
  (ii) Grounding arrangements are to be provided for tending vessels.

- Standards:
  Standards recognized by ACS are to be complied with in the manufacture and testing of motors, generators, cables and wiring, and also in the provision of overload, over-current and short-circuit protection.

2 Installations in Hazardous Areas

Installations in hazardous areas are to comply with ACS Rules for Classification of Vessels.
In general, equipment in hazardous areas is to be explosion-proof, intrinsically safe, or purged and pressurized.
Explosion-proof and intrinsically safe equipment is to be of an approved type. Purged and pressurized equipment is to comply with a recognized standard.

3 Auxiliary power supply

An auxiliary power supply is to be provided. The auxiliary power supply is to have a capacity sufficient to power all electrical equipment required to maintain safety of operations in the event of failure in the primary electrical power supply.

4 Emergency source of power for manned platforms

4.1 General

A self-contained emergency source of power is to be installed in a non-hazardous space. Its location and arrangement are to be such as to insure that a fire or other failure in a space containing the main source, the auxiliary source, or in any space containing internal combustion machinery, any oil-fired boiler or oil fuel unit will not interfere with the supply or distribution of emergency power.

4.2 Power Supply

The power available is to be sufficient to supply for at least 18 hours all services necessary for safety in an emergency, particular attention being given to the following:

- Navigation and special purpose lights and warning systems including helicopter landing lights;
- Emergency lighting for machinery spaces, control stations, alleyways, stairways and exits;
- General alarm and communications system;
- Fire detection and alarm system;
- Fire extinguishing systems;
- Permanently installed lifting gear for diving bell if dependent on the platform's electrical power;
- Abandonment systems dependent on electric power including lighting for embarkation stations;
- The capability of closing the blow-out prevention control system;

4.3 Testing

Means are to be provided for periodic testing of the emergency source of power and are to include the testing of automatic arrangements.

4.4 Emergency shutdown facilities

Arrangements are to be provided for the selective disconnection or shutdown of the following from an emergency control station:

- Ventilating system
- Non-essential electrical equipment
- Essential electrical equipment
- Emergency equipment except battery-supplied lighting and radio
- Generator prime movers

Chapter 2 Safety Features and Fire Protection

SECTION 1 General

1 Application

The requirements in this Part apply to the safety features and fire protection of the offshore installation.

Consideration will be given to the published safety and fire protection requirements of the governmental authority of the country in which the platform is to be located.

Where published regulations are not available and where a governmental authority permits, the applicable requirements from ACS MODU Rules are to be applied. For manned platforms, unless there are regulations issued by the appropriate governmental authority, it is to be to the satisfaction of ACS.

For safety features and fire protection of the platform, where deemed appropriate by ACS, national standards, internationally recognized standards (e.g. NFPA Standards, API RP 14G and etc.) or standards considered as equivalent for those may be applied.