

Rules for Building and Classing

Offshore Installations



January 2024



RULES FOR BUILDING AND CLASSING

OFFSHORE INSTALLATIONS
JANUARY 2024

**American Bureau of Shipping
Incorporated by Act of Legislature of
the State of New York 1862**

**© 2024 American Bureau of Shipping. All rights reserved.
ABS Plaza
1701 City Plaza Drive
Spring, TX 77389 USA**



RULES FOR BUILDING AND CLASSING

OFFSHORE INSTALLATIONS

CONTENTS

PART 1	Conditions of Classification.....	1
	CHAPTER 1 Scope and Conditions of Classification.....	1
PART 2	Materials and Welding.....	9
	CHAPTER 1 Materials.....	10
	CHAPTER 2 Welding and Fabrication.....	24
PART 3	Design.....	29
	CHAPTER 1 General.....	30
	CHAPTER 2 Structural Design.....	46
PART 4	Extension of Use and Reuse.....	97
	CHAPTER 1 Extension of Use.....	98
	CHAPTER 2 Reuse.....	103
PART 5	Testing and Surveys.....	105
	CHAPTER 1 Surveys During Construction and Installation.....	106
	CHAPTER 2 Surveys After Construction.....	116



PART 1

Conditions of Classification

CONTENTS

CHAPTER 1	Scope and Conditions of Classification.....	1
	Section 1 Classification (<i>1 January 2008</i>).....	2
	Section 2 Classification Symbols and Notations (<i>1 January 2008</i>).....	3
	Section 3 Rules for Classification (<i>1 January 2008</i>)	6
	Section 4 Plans and Design Data to be Submitted	7

This Page Intentionally Left Blank



PART 1

CHAPTER 1

Scope and Conditions of Classification

CONTENTS

SECTION	1	Classification (1 January 2008)	2
SECTION	2	Classification Symbols and Notations (1 January 2008)	3
	1	Offshore Installations Built Under Survey.....	3
	3	Offshore Installations Not Built Under Survey	3
	5	Classification Data.....	4
	7	Additional Class Notations	4
	7.1	Strength Criteria for Site-specific Conditions (S).....	4
	7.3	Design Fatigue Life.....	4
	7.5	Self-Elevating Units Operating as Offshore Installations.....	5
SECTION	3	Rules for Classification (1 January 2008)	6
	1	Application of Rules	6
SECTION	4	Plans and Design Data to be Submitted	7
	1	Submission of Site Condition Reports.....	7
	3	Submission of Design Data and Calculations	7
	5	Submission of Plans and Specifications	7
	7	Information Memorandum	8



PART 1

CHAPTER 1

Scope and Conditions of Classification

SECTION 1

Classification (*1 January 2008*)

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

Additional requirements specific to offshore installations are contained in the following Sections of this Chapter.

Classification Symbols and Notations (1 January 2008)

A listing of Classification Symbols and Notations available to the Owners of vessels, offshore drilling and production units and other marine structures and systems, “List of ABS Notations and Symbols” is available from the ABS website “<http://www.eagle.org>”.

1 Offshore Installations Built Under Survey

Offshore Installations which have been built under the supervision of the ABS 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**.

Offshore Installations which have been built to the satisfaction of the ABS Surveyors, to the requirements as contained in the *ABS Rules for Building and Classing Facilities on Offshore Installations* and/or *ABS Guide for Building and Classing Subsea Pipeline Systems* and/or *ABS Guide for Building and Classing Subsea Riser Systems*, and which are approved by the Committee will be classed and distinguished in the *Record* by the symbols **⊠ A1 Offshore Installation** followed by the appropriate notation:

- ⊠ A1 Offshore Installation – Hydrocarbon Processing**
- ⊠ A1 Offshore Installation – Hydrocarbon Production**
- ⊠ A1 Offshore Installation – Electric Generating Plant (electric generating plant – export load)**
- ⊠ A1 Offshore Installation – Undersea Pipeline**
- ⊠ A1 Offshore Installation – Chemical Processing**
- ⊠ A1 Offshore Installation – Metals/Ore Processing**

3 Offshore Installations Not Built Under Survey

Offshore Installations which have not been built under the supervision of the ABS 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* in the manner as described as in 1-1-2/1, but the mark “**⊠**” signifying the survey during construction will be omitted.

5 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.

7 Additional Class Notations (1 July 2021)

7.1 Strength Criteria for Site-specific Conditions (S) (1 July 2022)

Offshore installations designed and built to the requirements for pre-service conditions and strength criteria for in-service site-specific conditions in accordance with these Rules and maintained in accordance with the applicable ABS requirements and site-specific environmental data for in-service conditions will be indicated by the **(S)** qualifier following the basic notation of 1-1-2/1 and 1-1-2/3 as described in the following Subparagraphs.

The **(S)** qualifier followed by the definition of the site is mandatory to be assigned and published in the ABS *Record*.

7.1.1 New Construction or Conversion

The qualifier **(S)** will be followed by definition of the site. For example:

⊗ A1 Offshore Installation (S) Gulf of Mexico

A1 Offshore Installation (S) Gulf of Mexico

7.1.2 Life Extension of Offshore Installation (1 July 2022)

For life extension of an existing offshore installation remaining at the same site, the intended period of operation is extended. The strength of the offshore installation is to be reassessed to demonstrate that it remains in compliance with applicable requirements.

If the environmental criteria for the site or operating area have been revised since the original approval due to new environmental data or changing environmental conditions, the coastal state may require the use of new environmental criteria for the life extension.

Refer to Part 4 and Part 5, Chapter 2 of these Rules for detailed Engineering and Survey requirements relating to life extension of existing offshore installations at the same site.

After the life extension is completed in accordance with these Rules, the qualifier **(S)** notation can be retained for the site.

7.1.3 Relocation of Offshore Installation (1 July 2022)

When an existing offshore installation is proposed to relocate to a new site, the strength of the offshore installation is to be reassessed to confirm that it remains in compliance with the applicable requirements.

Refer to Part 4 and Part 5, Chapter 2 of these Rules for detailed Engineering and Survey requirements relating to relocation of existing offshore installations.

After the relocation is completed in accordance with these Rules, the qualifier **(S)** notation can be updated for the new site.

7.3 Design Fatigue Life

7.3.1 New Construction or Conversion (1 July 2022)

The design fatigue life value notation is to be assigned and published in the *Record*. The “design fatigue life” refers to the target value set by the owner or designer, not the value calculated in the analysis. The design fatigue life is to be verified to be in compliance with the fatigue criteria in

these Rules. The class notation **FL(number of years), Year** will be assigned to identify the design fatigue life in years and the year of maturation of fatigue life in the defined site. For example, **FL(20), 2040** for an offshore installation built in 2020 if the minimum design fatigue life specified is 20 years.

For an existing Self-Elevating Unit (SEU) converted to operate as an offshore installation, the expected minimum remaining fatigue life of the structure is to be assessed for compliance with these Rules and the *ABS Guide for the Fatigue Assessment of Offshore Structures*, based on the service history provided by the Owner or Operator. The class notation **RFL(number of years), Year** will be assigned to identify the remaining fatigue life in years and the year of maturation of fatigue life in the defined site. For example, **RFL(10), 2030** for a SEU converted to offshore installation in 2020 if the remaining design fatigue life specified is 10 years.

The class notation **FL(number of years), Year** or **RFL(number of years), Year**, as applicable, is mandatory to be assigned and published in the *ABS Record*.

7.3.2 Life Extension of Offshore Installation (1 July 2022)

When the operating life of an existing offshore installation exceeds the design fatigue life specified in the **FL (number of years), Year** notation for which it was classed, an evaluation is to be made and appropriate actions are to be taken to extend the use of the offshore installation for the new operating life under the site-specific conditions.

If the environmental criteria for the site or operating area have been revised since the original approval due to new environmental data or changing environmental conditions, the coastal state may require the use of new environmental criteria for the life extension.

Refer to Part 4 and Part 5, Chapter 2 of these Rules for detailed requirements relating to life extension of existing offshore installations at the same site.

After the life extension is completed in accordance with this Rules, the existing **FL** or **RFL** (for SEU converted to offshore installation) notation with total number of years of fatigue life and year of maturation is to be updated accordingly.

7.3.3 Relocation of Offshore Installation (1 July 2022)

When an existing offshore installation is proposed to relocate to a new site, the fatigue life of the offshore installation is to be reassessed to demonstrate it has sufficient remaining fatigue life for the new operating conditions to comply with the Rule requirements.

Refer to Part 4 and Part 5, Chapter 2 of these Rules for detailed Engineering and Survey requirements relating to relocation of existing offshore installations.

After the relocation is completed in accordance with these Rules, the existing **FL** or **RFL** (for SEU converted to offshore installation) notation can be updated for the new site.

7.5 Self-Elevating Units Operating as Offshore Installations

For the designation (**Self-Installing Unit**) to be added to the basic notation of 1-1-2/1 and 1-1-2/3, the machinery and systems are to be included within the scope of classification by applying criteria contained in the *ABS Rules for Building and Classing Mobile Offshore Units (MOU Rules)*. The designation (**Self-Installing Unit**) following the basic notation of 1-1-2/1 and 1-1-2/3 will be assigned and published in the *ABS Record*. For example:

⊗ A1 Offshore Installation (Self-Installing Unit)

A1 Offshore Installation (Self-Installing Unit)



PART 1

CHAPTER 1

Scope and Conditions of Classification

SECTION 3

Rules for Classification (*1 January 2008*)

1 Application of Rules

These Rules are applicable to offshore installations as defined in 3-1-1/1.13 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 a guidance to the designer, builder, owner, et al.

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:

- i)* Environmental conditions of waves, winds, currents, tides, water depth, air and sea temperature and ice;
- ii)* Seabed topography, stability, and pertinent geotechnical data; Seismic conditions;
- iii)* 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 ABS.

3 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 are to 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.

5 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 ABS. This schedule, which ABS 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.

7 Information Memorandum

An information memorandum on the offshore installation is to be prepared and submitted to ABS. ABS will review the contents of the memorandum to establish consistency with other data submitted for the purpose of obtaining classification. ABS 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:

- i)* Site plan indicating the general features at the site and the exact location of the installation
- ii)* Environmental design criteria, including the recurrence interval used to assess environmental phenomena (see 3-1-2/5.1)
- iii)* Plans showing the general arrangement of the offshore installation
- iv)* Description of the safety and protective systems provided
- v)* The number of personnel to be normally stationed at the installation
- vi)* Listing of governmental authorities having cognizance over the installation
- vii)* Listing of any novel features
- viii)* Brief description of any monitoring proposed for use on the installation
- ix)* Description of transportation and installation procedures



PART 2

Materials and Welding

CONTENTS

CHAPTER 1	Materials	10
	Section 1 Structural Steels.....	12
	Section 2 Materials for Concrete Construction	19
CHAPTER 2	Welding and Fabrication	24
	Section 1 Welding.....	25

CONTENTS

SECTION	1	Structural Steels.....	12
	1	General.....	12
	1.1	Scope.....	12
	1.3	Material Selection.....	12
	1.5	Corrosion Control.....	12
	1.7	Toughness.....	12
	1.9	Through Thickness Stress.....	12
	3	Steel Properties.....	13
	3.1	General.....	13
	3.3	Tensile Properties.....	13
	3.5	Toughness.....	13
	3.7	Bolts and Nuts.....	13
	5	Toughness Criteria for Steel Selection.....	13
	5.1	General.....	13
	5.3	Steel Classification.....	13
	5.5	Toughness Characteristics.....	16
	7	Minimum Service Temperature.....	18
	7.1	Material below the Splash Zone.....	18
	7.3	Material within or above the Splash Zone.....	18
	7.5	Special Conditions.....	18
	TABLE 1	Steel Tensile Properties.....	13
	TABLE 2	Structural Steel Plates and Shapes.....	14
	TABLE 3	Structural Steel Pipes.....	16
	TABLE 4	Charpy Toughness Specification for Steels.....	17
SECTION	2	Materials for Concrete Construction	19
	1	General.....	19
	1.1	Scope.....	19
	1.3	Zones.....	19
	3	Cement.....	19

	3.1	Type.....	19
	3.3	Tricalcium Aluminate.....	20
	3.5	Oil Storage.....	20
5		Water.....	20
	5.1	Cleanliness.....	20
	5.2	Nonpotable Water.....	20
7		Chloride or Sulfide Content.....	20
9		Aggregates.....	20
	9.1	General.....	20
	9.3	Washing.....	20
	9.5	Size.....	20
11		Admixtures.....	21
	11.1	General.....	21
	11.3	Recognized Standards.....	21
	11.5	Pozzolan Content.....	21
13		Steel Reinforcement.....	21
	13.1	Reinforcement for Non-Prestressed Concrete.....	21
	13.3	Welded Reinforcement.....	21
	13.5	Steel Reinforcement for Prestressed Concrete.....	21
	13.7	Other Materials.....	21
15		Concrete.....	22
17		Water-Cement Ratios.....	22
19		Other Durability Requirements.....	22
	19.1	Cement Content.....	22
	19.3	Freeze-Thaw Durability.....	22
	19.5	Scouring.....	22
21		Grout for Bonded Tendons.....	22
	21.1	General.....	22
	21.3	Chlorides and Sulfates.....	22
	21.5	Contents.....	22
	21.7	Sand.....	23
	21.9	Preparation.....	23
	21.11	Temperature.....	23
		TABLE 1 W/C Ratios and Compressive Strengths.....	22

1 General

1.1 Scope

This Section 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 Section 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.

1.3 Material Selection

Materials used are required to exhibit satisfactory formability and weldability characteristics. As required, documentation is to be submitted to substantiate the applicability of a proposed steel. Reference can be made to 2-1-1/Tables 2 and 3 for ASTM and API steel grades and to Section 3-1-3 for guidance on the selection of ABS grades of steel.

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.

1.5 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 are also to be considered. Appropriate coatings are to be used to achieve satisfactory corrosion protection for miscellaneous parts such as bolts and nuts.

1.7 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.

1.9 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.

3 Steel Properties

3.1 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.

3.3 Tensile Properties

In 2-1-1/5.3 TABLE 1, the designation Group I, II or III is used to categorize tensile properties.

3.5 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 2-1-1/5.

3.7 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.

5 Toughness Criteria for Steel Selection

5.1 General

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

5.3 Steel Classification

Steels are to be classified as Groups I, II or III according to their tensile properties as listed in 2-1-1/5.3 TABLE 1. The yield strengths given in 2-1-1/5.3 TABLE 1 are provided only as a means of categorizing steels.

TABLE 1
Steel Tensile Properties

<i>Yield Strength f_y</i>		
<i>Group</i>	<i>ksi</i>	<i>MPa</i>
I	$f_y < 40$	$f_y < 275$
II	$40 \leq f_y \leq 60$	$275 \leq f_y \leq 415$
III	$60 \leq f_y \leq 100$	$415 \leq f_y \leq 690$

Some of the typical ASTM and API steels belonging to the groups of 2-1-1/5.3 TABLE 1 are shown in 2-1-1/Tables 2 and 3. Steels other than those mentioned therein may be used, provided that their chemical composition, mechanical properties and weldability are similar to those listed.

TABLE 2
Structural Steel Plates and Shapes

<i>Group</i>	<i>Specification and Grade</i>	<i>Yield Strength</i>		<i>Tensile Strength</i>	
		<i>ksi</i>	<i>MPa</i>	<i>ksi</i>	<i>MPa</i>
I	ASTM A36-94 (to 2 in. thick)	36	250	58-80	400-550
	ASTM A131-94 Grade A (to ½ in. thick) (ABS Grade A)	34	235	58-75	400-515
	ASTM A285-90 Grade C (to C\w in. thick)	30	205	55-75	380-515
	ASTM A131-94 Grades B, D (ABS Grades B, D)	34	235	58-75	400-515
	ASTM A516-90 Grade 65	35	240	65-85	450-585
	ASTM A573-93a Grade 65	35	240	65-77	450-530
	ASTM A709-93a Grade 36T2	36	250	58-80	400-550
	ASTM A131-94 Grade E (ABS Grade E) (ABS Grades CS, E)	34	235	58-75	400-515

Group	Specification and Grade	Yield Strength		Tensile Strength	
		ksi	MPa	ksi	MPa
II	ASTM A572-94b Grade 42 (to 2 in. thick)	42	290	60 min.	415 min.
	ASTM A572-94b Grade 50 (to ½ in. thick*)	50	345	65 min.	450 min.
	ASTM A588-94 (to 2 in. thick)	50	345	70 min.	485 min.
	ASTM A709-93a Grades 50T2, 50T3	50	345	65 min.	450 min.
	ASTM A131-94 Grade AH32 (ABS Grade AH32)	46	315	68-85	470-585
	ASTM A131-94 Grade AH36 (ABS Grade AH36)	51	350	71-90	490-620
	API Spec 2H-Grade 42	42	290	62-80	425-550
	API Spec 2H-Grade 50 (to 2½ in. thick)	50	345	70-90	485-620
	(over 2½ in. thick)	47	325	70-90	485-620
	API Spec 2W-Grade 42 (to 1 in. thick)	42-67	290-460	62 min.	425 min.
	(over 1 in. thick)	42-62	290-430	62 min.	425 min.
	Grade 50 (to 1 in. thick)	50-75	345-515	65 min.	450 min.
	(over 1 in. thick)	50-70	345-485	65 min.	450 min.
	Grade 50T (to 1 in. thick)	50-80	345-550	70 min.	485 min.
	(over 1 in. thick)	50-75	345-515	70 min.	485 min.
	API Spec 2Y-Grade 42 (to 1 in. thick)	42-67	290-460	62 min.	425 min.
	(over 1 in. thick)	42-62	290-430	62 min.	425 min.
	Grade 50 (to 1 in. thick)	50-75	345-515	65 min.	450 min.
	(over 1 in. thick)	50-70	345-485	65 min.	450 min.
	Grade 50T (to 1 in. thick)	50-80	345-550	70 min.	485 min.
	(over 1 in. thick)	50-75	345-515	70 min.	485 min.
	ASTM A131-94 Grades DH32, EH32 (ABS Grades DH32, EH32)	46	315	68-85	470-585
	Grades DH36, EH36 (ABS Grades DH36, EH36)	51	350	71-90	490-620
	ASTM A537-91 Class 1 (to 2½ in. thick)	50	345	70-90	485-620
	ASTM A633-94a Grade A	42	290	63-83	435-570
	Grades C, D	50	345	70-90	480-620
ASTM A678-94a (80) Grade A	50	345	70-90	485-620	

Group	Specification and Grade	Yield Strength		Tensile Strength	
		ksi	MPa	ksi	MPa
III	ASTM A537-91 Class 2	60	415	80-100	550-690
	ASTM A633-94a Grade E	60	415	80-100	550-690
	ASTM A678-94a (80) Grade B	60	415	80-100	550-690
	API Spec 2W-Grade 60 (to 1 in. thick)	60-90	415-620	75 min.	515 min.
	(over 1 in. thick)	60-85	415-585	75 min.	515 min.
	API Spec 2Y-Grade 60 (to 1 in. thick)	60-90	415-620	75 min.	515 min.
	(over 1 in. thick)	60-85	415-585	75 min.	515 min.
	ASTM A710-Grade A Class 3 (to 2 in. thick)	75	515	85 min.	585 min.
		65	450	75 min.	515 min.
	60	415	70 min.	485 min.	

* To 2 in. Thick for Type 1, Fully Killed, Fine Grain Practice.

TABLE 3
Structural Steel Pipes

Group	Specification and Grade	Yield Strength		Tensile Strength	
		ksi	MPa	ksi	MPa
I	API 5L-Grade B	35	240	60 min.	415 min.
	ASTM A53-93a Grade B	35	240	60 min.	415 min.
	ASTM A135-93 Grade B	35	240	60 min.	415 min.
	ASTM A139-93a Grade B	35	240	60 min.	415 min.
	ASTM A381-93 Grade Y35	35	240	60 min.	415 min.
	ASTM A500-93 Grade A	33-39	230-270	45 min.	310 min.
	ASTM A501-93	36	250	58 min.	400 min.
	ASTM A106-94 Grade B	35	240	60 min.	415 min.
	ASTM A524-93 (strength varies with thickness)	30-35	205-240	55-85	380-585
II	API 5L95 Grade X42 (2% max. cold expansion)	42	290	60 min.	415 min.
	API 5L95 Grade X52 (2% max. cold expansion)	52	360	66 min.	455 min.
	ASTM A500-93 Grade B	42-46	290-320	58 min.	400 min.
	ASTM A618-93 Grade Ia, Ib & II (to C/v in. thick)	50	345	70 min.	485 min.
	API 5L95 Grade X52 (with SR5, SR6, or SR8)	52	360	66 min.	455 min.

5.5 Toughness Characteristics

Satisfactory toughness characteristics can be demonstrated by any one of the following.

- i) Demonstration of past successful application, under comparable conditions, of a steel, produced to a recognized standard (such as those of the ASTM, API or other recognized standard)

- ii) Demonstration that a steel manufactured by a particular producer using a specific manufacturing process has minimum toughness levels representative of those listed herein
- iii) Charpy impact testing in accordance with 2-1-1/5.5 TABLE 4

TABLE 4
Charpy Toughness Specification for Steels

Group	Section Size	Energy Absorption (Longitudinal)	
		Joules	ft-lb
I	6 mm < t < 19 mm (0.25 in. < t < 0.75 in.)	20	15
	t > 19 mm (0.75 in.)	27	20
II, III	t > 6 mm (0.25 in.)	34	25

The following notes apply to 2-1-1/5.5 TABLE 4:

- 1 Test Temperatures – The following applies for service temperatures down to –30°C (–22°F); for lower service temperatures, test requirements are to be specially considered.
 - a. For structural members and joints whose performance is vital to the overall integrity of the structure and which experience an unusually severe combination of stress concentration, rapid loading, cold working, and restraint, the impact test guidelines of 2-1-1/5.5 TABLE 4 are to be met at test temperatures as given below:

Group	Test Temperature	Minimum Service Temperature (As determined by 2-1-1/7)
I, II	30°C (54°F) below Minimum Service Temperature	
III	–40°C (–40°F)	0°C (32°F)
	–50°C (–58°F)	–10°C (14°F)
	–50°C (–58°F)	–20°C (–4°F)
	–60°C (–76°F)	–30°C (–22°F)

- b. For structural members and joints which sustain significant tensile stress and whose fracture may pose a threat to the survival of the structure, the impact test guidelines of 2-1-1/5.5 TABLE 4 are to be met at test temperatures as given below:

Group	Test Temperature	Minimum Service Temperature (As determined by 2-1-1/7)
I, II	10°C (18°F) below Minimum Service Temperature	
III	–30°C (–22°F)	0°C (32°F)
	–40°C (–40°F)	–10°C (14°F)
	–40°C (–40°F)	–20°C (–4°F)
	–50°C (–58°F)	–30°C (–22°F)

- c. For primary structural members subjected to significant tensile stresses and whose usage warrants impact toughness testing, the impact test guidelines of 2-1-1/5.5 TABLE 4 are to be met at the following test temperatures:

<i>Group</i>	<i>Test Temperature</i>	<i>Minimum Service Temperature (As determined by 2-1-1/7)</i>
I, II	At Minimum Service Temperature	
III	Same as note 1b)	

- d. For structural members which have sufficient structural redundancy so that their fracture would not pose a threat to the survivability of the structure, the toughness criteria specified for c) above may be relaxed provided the materials used in such cases are appropriate for the loading conditions, loading rates, and temperatures encountered in service.
- 2 Impact tests are not necessary for section sizes below 6 mm (0.25 in.) in thickness.
- 3 Energy values in 2-1-1/5.5 TABLE 4 are minimum average values for full-size longitudinal specimens. Alternative toughness criteria which may be applied are:
- *Under-sized Longitudinal Specimens:* Proportional reduction in 2-1-1/5.5 TABLE 4 energy values in accordance with ASTM A20 or equivalent
 - *Transverse Specimens:* $\frac{2}{3}$ of the energy values shown in 2-1-1/5.5 TABLE 4 but in no case less than 20 Joules (15 ft-lb)
 - *Longitudinal or Transverse Specimens:* Lateral expansion is not to be less than 0.5 mm (0.02 in.), or 0.38 mm (0.015 in.), respectively
 - Nil-ductility temperature (NDT) as determined by drop weight tests is to be 5°C (10°F) below the test temperature indicated in item 1 above
 - Other fracture toughness tests as appropriate.
- 4 The minimum number of specimens to be tested per heat is three. However, this number is to be increased in accordance with usage of the material (see ASTM A673 or equivalent).

7 Minimum Service Temperature

Minimum service temperature refers to the temperature of the material and is generally to be established in accordance with 2-1-1/7.1, 2-1-1/7.3, and 2-1-1/7.5 below. This temperature is to be based on meteorological data taken over a period of not less than 10 years for the lowest average daily temperature.

7.1 Material below the Splash Zone

For material below the splash zone (see 3-2-2/5.9), the service temperature is defined as 0°C (32°F). A higher service temperature may be used if adequate supporting data can be presented relative to the lowest average daily water temperature applicable to the depths involved.

7.3 Material within or above the Splash Zone

For material within or above the splash zone, the service temperature is the same as the lowest average daily atmospheric temperature. A higher service temperature may be used if the material above the waterline is warmed by adjacent sea water temperature or by auxiliary heating.

7.5 Special Conditions

In all cases where material temperature is reduced by localized cryogenic storage or other cooling conditions, such factors are to be taken into account in establishing minimum service temperature.

1 General

1.1 Scope

This Section 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 Section may be considered for approval upon presentation of sufficient evidence of satisfactory performance.

1.3 Zones

Particular attention is to be given in each of the following zones (see 3-2-2/5.9) to the considerations indicated:

- i) Submerged Zone.* Chemical deterioration of the concrete, corrosion of the reinforcement and hardware, and abrasion of the concrete
- ii) Splash Zone.* Freeze-thaw durability, corrosion of the reinforcement and hardware, chemical deterioration of the concrete, and fire hazards
- iii) Ice Zone.* Freeze-thaw durability, corrosion of the reinforcement and hardware, chemical deterioration of the concrete, fire hazards, and abrasion of the concrete
- iv) Atmospheric Zone.* Freeze-thaw durability, corrosion of reinforcement and hardware, and fire hazards

3 Cement

3.1 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.

3.3 Tricalcium Aluminate

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

3.5 Oil Storage

For environments which contain detrimental sulfur bearing materials (such as where oil storage is planned and the oil is expected to contain sulfur 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.

5 Water

5.1 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.

5.2 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 are to include 7-day and 28-day strength data on mortars prepared and tested in accordance with recognized standards such as ASTM C109.

7 Chloride or Sulfide Content

Water for structural concrete or grout is not to contain more than 0.07% chlorides as Cl by weight of cement, nor more than 0.09% sulfates as SO₄ when tested by ASTM D512. Chlorides in mix water for prestressed concrete or grout are to be limited to 0.04% by weight of cement.

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

9 Aggregates

9.1 General

Aggregates are to conform to the requirements of ASTM C330 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.

9.3 Washing

Marine aggregates are to be washed with fresh water before use to remove chlorides and sulfates so that the total chloride and sulfate content of the concrete mix does not exceed the limits defined in 2-1-2/7.

9.5 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 not be larger than the smallest of the following:

- i)* One-fifth of the narrowest dimension between sides of forms
- ii)* One-third of the depth of slabs
- iii)* Three-fourths of the minimum clear spacing between individual reinforcing bars, bundles of bars, prestressing tendons, or post-tensioning ducts

11 Admixtures

11.1 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.

11.3 Recognized Standards

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

11.5 Pozzolan Content

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

13 Steel Reinforcement

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

13.1 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

13.3 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) D1.1, or is to be proven to produce connections of satisfactory quality.

13.5 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

13.7 Other Materials

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

15 Concrete

The concrete is to be designed to provide sufficient strength and durability. A satisfactory method for quality control of concrete is to be used which is equivalent to ACI 318. Mixing, placing, and curing of concrete are to conform to recognized standards.

17 Water-Cement Ratios

Unless otherwise approved, water-cement ratios and 28-day compressive strengths of concrete for the three exposure zones are to be in accordance with 2-1-2/17 TABLE 1.

TABLE 1
W/C Ratios and Compressive Strengths

<i>Zone</i>	<i>Maximum W/C Ratio</i>	<i>Minimum 28-day Cylinder Compressive Strength</i>
Submerged	0.45	35 MPa (5000 psi)
Splash and Atmospheric	0.40 to 0.45*	35 MPa (5000 psi)

* Depending upon severity of exposure

19 Other Durability Requirements

19.1 Cement Content

Minimum cement content is to provide an adequate amount of paste for reinforcement protection and generally be not less than 355 kg/m³ (600 lb/yd³).

19.3 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 (0.01 in.).

19.5 Scouring

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

21 Grout for Bonded Tendons

21.1 General

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

21.3 Chlorides and Sulfates

Grout is not to contain chlorides or sulfates in amounts which are detrimental to the structure. Limitations are included in 2-1-2/7.

21.5 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, sulfates or any other material which has been shown to be detrimental to the steel or grout.

21.7 Sand

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

21.9 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 is to 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.

21.11 Temperature

Temperature of members at the time of grouting is to be above 10°C (50°F) and is to be maintained at this temperature for at least 48 hours.



PART 2

CHAPTER 2 Welding and Fabrication

CONTENTS

SECTION	1	Welding.....	25
	1	Requirements.....	25
	3	Inspection of Welds.....	25
	3.1	General.....	25
	3.3	Extent of Inspection of Welds.....	26
	3.5	Acceptance Criteria.....	28

1 Requirements

The requirements for welding and fabrication are contained in Chapter 4 of the separate, generic ABS *Rules for Materials and Welding (Part 2)*.

Additional welding requirements specific to offshore installations are contained in the following Sections of this Chapter. Requirements for the design of fillet welds are given in Section 3-2-7.

3 Inspection of Welds

3.1 General

Inspection of welded joints in important locations is to be carried out preferably by established nondestructive test methods such as radiographic, ultrasonic, magnetic-particle or dye-penetrant inspection. An approved acceptance criterion or the ABS *Guide for Nondestructive Inspection* is to be used in evaluating radiographs and ultrasonic indications (see also 2-2-1/3.5).

Radiographic or ultrasonic inspections, or both, are to be used when the overall soundness of the weld cross section is to be evaluated.

Magnetic-particle or dye-penetrant inspection may be used when investigating the outer surface of welds, as a check of intermediate weld passes such as root passes, and to check back chipped, ground or gouged joints prior to depositing subsequent passes. Surface inspection of important tee or corner joints in critical locations, using an approved magnetic-particle or dye-penetrant method, is to be conducted to the satisfaction of the Surveyor.

Some steels, especially higher-strength steels, may be susceptible to delayed cracking. When welding these materials, the final nondestructive testing is to be delayed for a suitable period to permit detection of such defects.

Weld run-on or run-off tabs may be used where practicable and these may be sectioned for examination.

The practice of taking weld plugs or samples by machining or cutting from the welded structure is not recommended and is to be used only in the absence of other suitable inspection methods. When such weld plugs or samples are removed from the welded structure, the holes or cavities thus formed are to be properly prepared and welded, using a suitable welding procedure as established for the original joint.

3.3 Extent of Inspection of Welds

3.3.1 General

The minimum extent of nondestructive testing to be conducted is indicated in 2-2-1/3.3.4 or 2-2-1/3.3.5 below. The distribution of inspected welds is to be based on the classification of application of the welds, as mentioned in 2-2-1/3.3.3, and the variety of weld sizes used in the structure.

Nondestructive testing is generally to be carried out after all forming and postweld heat treatment, and procedures are to be adequate to detect delayed cracking.

Welds which are inaccessible or difficult to inspect in service are to be subjected to increased levels of nondestructive inspection.

Nondestructive examination of full penetration butt welds is generally to be carried out by radiographic or ultrasonic methods. Where a method (such as radiography or ultrasonics) is selected as the primary nondestructive method of inspection, the acceptance standards of such a method govern.

Where inspection by any method indicates the presence of defects that could jeopardize the integrity of the structure, removal and repair of such defects are to be carried out to the satisfaction of the attending Surveyor.

If the ultrasonic method be used as the primary inspection method, such testing is to be supplemented by a reasonable amount of radiographic inspection to determine that adequate quality control is being achieved.

To assess the extent of surface imperfections in welds made in Group III steels used in critical structural locations, representative inspection by the magnetic-particle or dye-penetrant method is also to be accomplished.

3.3.2 Plans

A plan for nondestructive testing of the structure is to be submitted. This plan is to include, but not be restricted to, visual inspection of all welds, representative magnetic-particle or dye-penetrant inspection of tee and fillet welds not subjected to ultrasonic inspection, and the inspection of all field welds by appropriate means. The extent and method of inspection are to be indicated on the plan, and the extent of inspection is to be based on the function of the structure and the accessibility of the welds after the structure is in service. For automated welds for which quality assurance techniques indicate consistent satisfactory performance, a lesser degree of inspection may be permitted.

3.3.3 Classification of Application

Welds are to be designated as being either special, primary or secondary depending on the function and severity of service of the structure in which the welds are located. Special welds are those occurring in structural locations of critical importance to the integrity of the structure or its safe operation. Secondary welds are those occurring in locations of least importance to the overall integrity of the structure. Primary welds are those occurring in locations whose importance is intermediate between the special and secondary classifications. Reference can be made to 3-1-3/5 TABLE 1 for examples of applications following this classification system.

3.3.4 Extent of Nondestructive Inspection – Steel Jacket and Other TKY Joint Structures

In general, the number of penetration type welds (i.e., butt, T, K, and Y joints) to be inspected in each classification is to be based on the percentages stated below. Alternatively, the extent of radiographic and ultrasonic inspection may be based on other methods, provided the alternative will not result in a lesser degree of inspection. Where the extent of welds to be inspected is stated

as a percentage, such as 20% of primary welds, this means that complete inspection of 20% of the total number of welds considered to be primary is required.

All welds considered special are to be inspected 100% by the ultrasonic or radiographic method. Twenty percent of all welds considered primary are to be inspected by the ultrasonic or radiographic method. Welds considered to be secondary are to be inspected on a random basis using an appropriate method. In locations where ultrasonic test results are not considered reliable, the use of magnetic-particle or dye-penetrant inspection as a supplement to ultrasonic inspection is to be conducted. For T, K, or Y joints, approval may be given to substituting magnetic-particle or dye-penetrant inspection for ultrasonic inspection when this will achieve a sufficient inspection quality.

Magnetic-particle or dye-penetrant inspection of fillet welds is to be accomplished for all permanent fillet welds used in jacket construction, all jacket-to-pile shim connections, and all fillet welds in special application areas of the deck structure. The random inspection of other deck fillet welds is to be carried out at the discretion of the Surveyor.

3.3.5 Extent of Nondestructive Inspection Steel Plate or Shell Type Structures

The minimum extent of the ultrasonic or radiographic inspection of plate or shell type structures is to be equivalent to, or in general agreement with, the number of check points obtained by the following equations. As practicable, the length of each check point is to be at least 750 mm (30 in.).

For structures which are rectangular in shape:

$$n = L(B + D)/46.5 \quad \text{Metric Units}$$

$$n = L(B + D)/500 \quad \text{U.S. Units}$$

where

- n = number of check points (2 is minimum number)
- L = length of greatest dimension of structure, in m (ft)
- B = greatest breadth, in m (ft)
- D = greatest depth at the center, in m (ft)

For structures which are other than rectangular a proportional number of check points is to be supplied.

For structures which are circular in shape:

$$n = Ld/46.5 \quad \text{Metric Units}$$

$$n = Ld/500 \quad \text{U.S. Units}$$

where

- n = number of check points (2 is minimum number)
- L = length of the circular structure, in m (ft)
- d = diameter of the circular structure, in m (ft)

3.3.6 Additional Inspection – Special Conditions

Additional inspection may be required depending on the type and use of the structure, the material and welding procedures involved, and the quality control procedures employed.

3.3.7 Additional Inspection – Production Experience

If the proportion of unacceptable welds becomes abnormally high, the frequency of inspection is to be increased.

3.3.8 High Through Thickness (Z-Direction) Stresses

At important intersections, welds which impose high stresses perpendicular to the member thicknesses (Z-direction loading) are to be ultrasonically inspected to verify freedom from lamellar tearing after welding.

3.5 Acceptance Criteria

As stated in 2-2-1/3.1, recognized acceptance criteria such as those issued by the AWS are to be employed.

When employing the *ABS Guide for Nondestructive Inspection*, Class A and Class B criteria are to be applied as follows:

- i) Class A acceptance criteria are to be used for special application structure and critical locations within primary application structure such as circumferential welds of cylindrical and built up columns or legs, weld intersections of external plating in platforms, etc.
- ii) Class B acceptance criteria are to be used for primary application structure where Class A acceptance does not apply.
- iii) Twice Class B acceptance criteria are to be used for secondary application structure.

When radiographic or ultrasonic inspection is specified for other types of connections, such as partial penetration and groove type tee or corner welds, modified procedures and acceptance criteria are to be specified which adequately reflect the application.

CONTENTS

CHAPTER 1	General.....	30
	Section 1	Definitions and Design Documentation32
	Section 2	Environmental Conditions.....37
	Section 3	Section 03 Material Selection 43
CHAPTER 2	Structural Design.....	46
	Section 1	Loads..... 51
	Section 2	General Design Requirements..... 59
	Section 3	Steel Structures..... 65
	Section 4	Concrete Structures.....70
	Section 5	Foundations..... 84
	Section 6	Marine Operations..... 92
	Section 7	Weld Design 95

CONTENTS

SECTION	1	Definitions and Design Documentation	32
	1	Definitions	32
	1.1	Recurrence Period	32
	1.3	Owner	32
	1.5	Operator	32
	1.7	Constructor	32
	1.9	Consultant	32
	1.11	Surveyor	32
	1.13	Offshore Installations	32
	1.15	Platform Structures	33
	1.17	Extension of Use	33
	1.19	Reuse	34
	1.21	Watertight	34
	1.23	Weathertight	34
	3	Design Documentation	34
	3.1	Reports	34
	3.3	Calculations	35
	3.5	Plans and Other Data (2011)	36
SECTION	2	Environmental Conditions	37
	1	General	37
	3	Environmental Factors to be Considered	37
	5	Environmental Design Criteria	38
	5.1	Design Environmental Condition	38
	5.3	Operating Environmental Conditions	39
	7	Specific Environmental Condition	39
	7.1	Waves	39
	7.3	Wind	39
	7.5	Currents	40
	7.7	Tides	41
	7.9	Temperature	41

	7.11	Ice and Snow.....	41
	7.13	Marine Growth.....	41
	7.15	Seismicity and Earthquake Related Phenomena.....	42
	7.17	Sea Ice.....	42
	TABLE 1	Wind Speed for Time-Averaging Periodt.....	40
SECTION	3	Section 03 Material Selection	43
	1	General	43
	3	Classification of Applications	43
	3.1	Examples of Applications.....	43
	5	Steel Selection Criteria.....	44
	TABLE 1	Material Selection Guidelines for ABS Grades of Structural Steel*	44

1 Definitions**1.1 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.

1.3 Owner

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

1.5 Operator

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

1.7 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.

1.9 Consultant

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

1.11 Surveyor

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

1.13 Offshore Installations

An *Offshore Installation* is a buoyant or non-buoyant 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 ABS 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 and manned submersibles, which are treated in Rules separately issued by ABS. Where doubt exists concerning the applicability of these Rules, clarification is to be obtained from ABS.

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

1.15 Platform Structures

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

1.15.1 Pile Supported Platform

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

1.15.2 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.

1.15.3 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 1B-1-3/1 of the Offshore Installations Rules Supplement to the ABS *Rules for Conditions of Classification – Offshore Units and Structures (Part 1B)*) 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 the ABS *Rules for Building and Classing Mobile Offshore Units (MOU Rules)*, and other requirements which ABS, in consultation with the Owner, deems appropriate.

1.15.4 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.

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 (See 1B-1-4/11 of the ABS *Rules for Conditions of Classification – Offshore Units and Structures (Part 1B)*).

1.17 Extension of Use

Extension of Use refers to an existing platform to be used at the same location for a specified period of time beyond its original design life. See Part 4, Chapter 1.

1.19 Reuse

Reuse refers to an existing platform to be moved to a new location to continue its operation for a specified period of time. See Part 4, Chapter 2.

1.21 Watertight (2024)

Watertight means capable of preventing the passage of water through the structure under a head of water for which the surrounding structure is designed.

1.23 Weathertight (2024)

Weathertight means that in any sea condition, water will not penetrate into the offshore installation.

3 Design Documentation

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 is to 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.

3.1 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.

3.1.1 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 are to 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 Section 3-1-2; 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 3-1-2/5.1.

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.

3.1.2 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 3-2-5/3. 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 if pile installation procedures significantly deviate from those anticipated.

3.1.3 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, Chapters 1 and 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 Part 2, Chapter 1 of these Rules, a report is to be provided indicating the standards actually to be employed and their relative adequacy with respect to the corresponding ASTM standards.

3.3 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 3-1-1/3.1.

3.3.1 Loadings

Calculations for loadings are to be submitted in accordance with Section 3-2-1.

3.3.2 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 Section 3-2-6), 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.

3.3.3 Marine Operations

As applicable, calculations are to be submitted in compliance with Section 3-2-6.

3.3.4 Other Calculations

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

3.5 Plans and Other Data (2011)

Structural plans and other data should generally be submitted electronically to ABS. However, hard copies will also be accepted. These plans are to include the following, where applicable:

- i)* Arrangement plans, elevations, and plan views clearly showing in sufficient detail the overall configuration, dimensions and layout of the structure, its facilities and foundation
- ii)* 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
- iii)* 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
- iv)* Pile plans indicating arrangements, nominal sizes, thicknesses and penetration
- v)* Welding details and procedures, and schedule of nondestructive testing
- vi)* Corrosion control systems
- vii)* 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
- viii)* 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.

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 Section 3-1-1. 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.

3 Environmental Factors to be Considered

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

- i)* Waves
- ii)* Wind
- iii)* Currents
- iv)* Tides and storm surges
- v)* Air and sea temperatures
- vi)* Ice and snow

- vii) Marine growth
- viii) Seismicity
- ix) 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 Section 3-2-5.

5 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.

5.1 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:

- i) 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
- ii) The extreme air and sea temperatures
- iii) The maximum and minimum water level due to tide and storm surge

However, depending upon site-specific conditions, consideration is to be given to the combinations of events contained in item *i*) above. The recurrence period chosen for events *i*), *ii*), and *iii*) 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 *i*), *ii*), and *iii*) above. However, the recurrence interval is not to be less than 50 years.

For installation sites located in seismically active areas (see 3-1-2/7.15), 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.

5.3 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.

7 Specific Environmental Condition

7.1 Waves

7.1.1 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.

7.1.2 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.

7.1.3 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:

- i) Provision for air gap
- ii) Maximum mud line shear force and overturning moment
- iii) Dynamic response of the structure
- iv) Maximum stress
- v) Fatigue
- vi) 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.

7.3 Wind

7.3.1 General Statistical Wind Data

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.

7.3.2 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 is to 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.

TABLE 1
Wind Speed for Time-Averaging Period t

Relative to the 1-Hour Wind Speed at 10 m (33 ft) above SWL (see 3-1-2/7.7)

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

7.3.3 Vertical Profiles of Horizontal Wind

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

$$V_y = V_H(y/h)^{1/n}$$

where

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

V_H = wind speed at reference height H , usually 10 m (33 ft) above a reference water depth, in m/s (ft/s)

$1/n$ = exponent dependent upon the time-averaging period of the measured wind speed V_H

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.

7.3.4 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 3-1-2/7.3.2 TABLE 1.

Linear interpolation is to be used with 3-1-2/7.3.2 TABLE 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 mile of wind”, V_f , the corresponding time-averaging period, t , in seconds is given by:

$$t = 3600/V_f$$

where V_f is the fastest mile of wind at a reference height of 10 m (33 ft), in miles per hour.

7.5 Currents

7.5.1 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.

7.5.2 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.

7.7 Tides

7.7.1 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 nearsurface 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) is to 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.

7.7.2 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.

7.9 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.

7.11 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 is to be derived from actual field measurements, laboratory data, or data from analogous areas.

7.13 Marine Growth

Marine growth is to be considered in the design of an offshore installation. Estimates of the rate and extent of marine growth are to 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 is to be given to the types of fouling likely to occur and their possible effects on corrosion protection coatings.

7.15 Seismicity and Earthquake Related Phenomena

7.15.1 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:

- i)* Magnitudes and recurrence intervals of seismic events
- ii)* Proximity to active faults
- iii)* Type of faulting
- iv)* Attenuation of ground motion between the faults and the site
- v)* Subsurface soil conditions
- vi)* Records from past seismic events at the site where available, or from analogous sites

7.15.2 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 are to be taken into account.

- i)* Liquefaction of subsurface soils
- ii)* Submarine slides
- iii)* Tsunamis
- iv)* Acoustic overpressure shock waves

7.17 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 is to 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 is to 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.

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 3-1-3/3.

3 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:

- i) 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.
- ii) Primary Application* refers to primary load carrying members of a structure where the occurrence of a fracture could induce a major structural failure.
- iii) 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.

3.1 Examples of Applications

The following are typical examples of application categories.

3.1.1 Secondary Application Structure (Least Critical)

- i)* Internal structure including bulkheads and girders in legs or columns
- ii)* Deck plating not essential for overall structural integrity
- iii)* Low-stressed deck beams in parallel and bracing, except where structure is considered primary or special application
- iv)* Plating of certain columns with low slenderness ratios, except at intersections

3.1.2 Primary Application Structure (Intermediate)

- i)* Plating of lattice legs
- ii)* External shell plating of caissons

- iii) Deck plating and structure which is not considered special or secondary
- iv) Main braces, jacket legs and deck legs, except where considered special
- v) 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
- vi) 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

3.1.3 Special Application Structure (Most Critical)

- i) External shell or deck structure in way of intersections of vertical columns
- ii) Portions of deck plating, heavy flanges, and deep webs at major load supporting members within the deck, which form box or I-type supporting structure, and which receive major concentrated loads
- iii) Intersection of major bracing members and critical joint nodes
- iv) Members which receive immediate concentrated loads at intersections of major structural members

5 Steel Selection Criteria (2023)

3-1-3/5 TABLE 1 shows selection criteria for each structural element category for ABS grades of ordinary and higher strength structural steel.

Selection of steel grades and thicknesses other than those shown in 3-1-3/5 TABLE 1 is to be based on the fundamental principles specified in 2-1-1/5.

TABLE 1
Material Selection Guidelines for ABS Grades of Structural Steel*

Numbers in table are maximum thickness in mm (in.). Blank areas indicate no application.

	Application Areas																	
	Secondary Applications						Primary Applications						Special Applications					
Service Temp.																		
°C	0	-10	-20	-30	-40	-50	0	-10	-20	-30	-40	-50	0	-10	-20	-30	-40	-50
(°F)	(32)	(14)	(-4)	(-22)	(-40)	(-58)	(32)	(14)	(-4)	(-22)	(-40)	(-58)	(32)	(14)	(-4)	(-22)	(-40)	(-58)
Grade																		
A	30	20	10				20	10										
	(1.18)	(0.79)	(0.39)				(0.79)	(0.39)										
B	40	30	20	10			25	20	10				15					
	(1.57)	(1.18)	(0.79)	(0.39)			(1.00)	(0.79)	(0.39)				(0.59)					
D	50	50	45	35	25	15	45	40	30	20	10		30	20	10			
	(2.00)	(2.00)	(1.77)	(1.38)	(1.00)	(0.59)	(1.77)	(1.57)	(1.18)	(0.79)	(0.39)		(1.18)	(0.79)	(0.39)			
E	50	50	50	50	45	35	50	50	50	40	30	20	50	45	35	25	15	
	(2.00)	(2.00)	(2.00)	(2.00)	(1.77)	(1.38)	(2.00)	(2.00)	(2.00)	(1.57)	(1.18)	(0.79)	(2.00)	(1.77)	(1.38)	(1.00)	(0.59)	
AH	40	30	20	10			25	20	10				15					
	(1.57)	(1.18)	(0.79)	(0.39)			(1.00)	(0.79)	(0.39)				(0.59)					
DH	50	50	45	35	25	15	45	40	30	20	10		30	20	10			
	(2.00)	(2.00)	(1.77)	(1.38)	(1.00)	(0.59)	(1.77)	(1.57)	(1.18)	(0.79)	(0.39)		(1.18)	(0.79)	(0.39)			
EH	50	50	50	50	45	35	50	50	50	40	30	20	50	45	35	25	15	
	(2.00)	(2.00)	(2.00)	(2.00)	(1.77)	(1.38)	(2.00)	(2.00)	(2.00)	(1.57)	(1.18)	(0.79)	(2.00)	(1.77)	(1.38)	(1.00)	(0.59)	
FH	50	50	50	50	50	50	50	50	50	50	50	40	50	50	50	50	40	30
	(2.00)	(2.00)	(2.00)	(2.00)	(2.00)	(2.00)	(2.00)	(2.00)	(2.00)	(2.00)	(2.00)	(1.57)	(2.00)	(2.00)	(2.00)	(2.00)	(1.57)	(1.18)
AQ	40	25	10				20											
	(1.57)	(1.00)	(0.39)				(0.79)											
DQ	50	45	35	25	15		45	35	25	15			25	15				
	(2.00)	(1.77)	(1.38)	(1.00)	(0.59)		(1.77)	(1.38)	(1.00)	(0.59)			(1.00)	(0.59)				
EQ	50	50	50	45	35	25	50	50	45	35	25	15	50	40	30	20	10	
	(2.00)	(2.00)	(2.00)	(1.77)	(1.38)	(1.00)	(2.00)	(2.00)	(1.77)	(1.38)	(1.00)	(0.59)	(2.00)	(1.57)	(1.18)	(0.79)	(0.39)	
FQ	50	50	50	50	50	45	50	50	50	50	45	35	50	50	50	40	30	20
	(2.00)	(2.00)	(2.00)	(2.00)	(2.00)	(1.77)	(2.00)	(2.00)	(2.00)	(2.00)	(1.77)	(1.38)	(2.00)	(2.00)	(2.00)	(1.57)	(1.18)	(0.79)

* See the ABS Rules for Materials and Welding (Part 2) for description of ABS Grades of Structural Steel.

When tensile stresses through the thickness (Z direction) exceed approximately 50% of the minimum specified yield stress (as defined in the applicable ABS Rules), consideration is to be given to applying Z grade steel (refer to 2-1-1/17 of the ABS Rules for Materials and Welding (Part 2)). Alternatives to applying Z grade may be proposed provided it is demonstrated by ultrasonic testing before and after welding that no through thickness tearing has occurred, and/or the welding preparation, weld size and bead sequence is such that damaging through thickness loads induced by weld shrinkage are avoided.

PART 3

CHAPTER 2 Structural Design

CONTENTS

SECTION	1	Loads.....	51
	1	General.....	51
	3	Types of Loads.....	51
	3.1	Dead Loads.....	51
	3.3	Live Loads.....	51
	3.5	Deformation Loads.....	52
	3.7	Environmental Loads.....	52
	5	Determination of Environmental Loads.....	52
	5.1	General.....	52
	5.3	Wave Loads.....	53
	5.5	Wind Loads.....	54
	5.7	Current Loads.....	56
	5.9	Ice and Snow Loads.....	56
	5.11	Earthquake Loads.....	56
	5.13	Marine Growth.....	57
	5.15	Sea Ice.....	57
	5.17	Subsidence.....	58
		TABLE 1 Values of C_s	55
SECTION	2	General Design Requirements.....	59
	1	General.....	59
	3	Analytical Approaches.....	59
	3.1	Format of Design Specifications.....	59
	3.3	Loading Formats.....	59
	3.5	Combination of Loading Components.....	60
	5	Overall Design Considerations.....	60
	5.1	Design Life.....	60
	5.3	Air Gap.....	60
	5.5	Long-Term and Secondary Effects.....	60
	5.7	Reference Marking.....	61

	5.9	Zones of Exposure.....	61
7		Considerations for Particular Types of Structures	61
	7.1	General.....	61
	7.3	Pile-Supported Steel Platforms.....	61
	7.5	Concrete or Steel Gravity Platforms.....	62
	7.7	Concrete-Steel Hybrid Structures.....	63
	7.9	Guyed Compliant Towers.....	63
	7.11	Minimum Structures.....	63
	7.13	Site Specific Self-Elevating Offshore Units.....	63
SECTION	3	Steel Structures.....	65
	1	General.....	65
	1.1	Materials.....	65
	1.3	Corrosion Protection.....	65
	1.5	Access for Inspection.....	65
	1.7	Steel-Concrete Hybrid Structures.....	65
	3	General Design Criteria.....	66
	5	Loading Conditions.....	66
	7	Structural Analysis.....	66
	7.1	General.....	66
	7.3	Dynamic Effects.....	66
	7.5	Static Loads.....	67
	7.7	Plastic Analysis.....	67
	7.9	Dynamic Loads.....	67
	9	Allowable Stresses and Load Factors	67
	9.1	Working Stress Approach.....	67
	9.3	Plastic Design Approach.....	68
	11	Structural Response to Earthquake Loads	68
	13	Fatigue Assessment.....	68
	15	Stresses in Connections	69
	17	Structure-Pile Connections	69
	19	Structural Response to Hydrostatic Loads	69
	21	Deflections	69
	23	Local Structure	69
	TABLE 1	Fatigue Life.....	69
SECTION	4	Concrete Structures.....	70
	1	General.....	70
	1.1	Materials.....	70
	1.3	Durability.....	70
	1.5	Access for Inspection.....	70
	1.7	Steel-Concrete Hybrid Structures.....	70

3	General Design Criteria.....	71
3.1	Design Method.....	71
3.3	Load Definition.....	71
3.5	Design Reference.....	71
5	Design Requirements.....	71
5.1	General.....	71
5.3	Required Strength (Load Combinations).....	72
5.5	Strength Reduction Factors.....	72
5.7	Fatigue.....	73
5.9	Serviceability Requirements.....	74
7	Analysis and Design.....	75
7.1	General.....	75
7.3	Material Properties for Structural Analysis.....	75
7.5	Analysis of Plates, Shells, and Folded Plates.....	76
7.7	Deflection Analysis.....	76
7.9	Analysis and Design for Shear and Torsion.....	76
7.11	Analysis and Design for Bending and Axial Loads.....	76
7.13	Seismic Analysis.....	77
7.15	Seismic Design.....	77
9	Design Details	78
9.1	Concrete Cover.....	78
9.3	Minimum Reinforcement.....	78
9.5	Reinforcement Details.....	79
9.7	Post-tensioning Ducts.....	79
9.9	Post-Tensioning Anchorages and Couplers.....	79
11	Construction	79
11.1	General.....	79
11.3	Mixing, Placing, and Curing of Concrete.....	80
11.5	Reinforcement.....	81
11.7	Prestressing Tendons, Ducts and Grouting.....	81

TABLE 1	Allowable Tensile Stresses for Prestress and Reinforcing Steel to Control Cracking	74
---------	--	----

FIGURE 1	Stress-Strain Relation for Concrete in Uniaxial Compression	82
----------	---	----

FIGURE 2	Stress-Strain Relation for Non-Prestressed Steel in Uniaxial Tension	83
----------	--	----

SECTION 5	Foundations.....	84
1	General.....	84
3	Site Investigation.....	84
3.1	General.....	84
3.3	Sea Floor Survey.....	85

	3.5	Geological Survey.....	85
	3.7	Subsurface Investigation and Testing.....	85
	3.9	Documentation.....	86
5		Foundation Design Requirements.....	87
	5.1	General.....	87
	5.3	Cyclic Loading Effects.....	87
	5.5	Scour.....	87
	5.7	Deflections and Rotations.....	87
	5.9	Soil Strength.....	87
	5.11	Dynamic and Impact Considerations.....	88
	5.13	Loading Conditions.....	88
	5.15	Anchoring System.....	88
	5.17	Loads and Soil Conditions Due to Temporarily Situated Structures.....	88
7		Pile Foundations.....	89
	7.1	General.....	89
	7.3	Axial Piles.....	89
	7.5	Factors of Safety for Axial Piles.....	89
	7.7	Laterally Loaded Piles.....	89
	7.9	Anchor Piles.....	90
	7.11	Pile Groups.....	90
	7.13	Connections Between Piles and Structure.....	90
9		Gravity Structures.....	90
	9.1	General.....	90
	9.3	Stability.....	91
	9.5	Soil Reaction on the Structure.....	91
SECTION	6	Marine Operations.....	92
	1	General.....	92
	3	Documentation.....	92
	5	Analysis.....	93
	5.1	Loads.....	93
	5.3	Stress.....	93
	5.5	Stability.....	93
	7	Fitness to Tow Certificate.....	94
SECTION	7	Weld Design	95
	1	Fillet Welds.....	95
	1.1	General.....	95
	1.3	Tee Connections.....	95
	1.5	Lapped Joints.....	96
	1.7	Overlapped End Connections.....	96
	1.9	Overlapped Seams.....	96

	1.11	Plug Welds or Slot Welds.....	96
3		Full Penetration Corner or Tee Joints	96

1 General

This Section 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 3-2-1/3 are to be accounted for in design.

3 Types of Loads

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

3.1 Dead Loads

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

- i)* 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
- ii)* Weight of permanent ballast and the weight of permanent machinery
- iii)* External hydrostatic pressure and buoyancy calculated on the basis of the still water level
- iv)* Static earth pressure

3.3 Live Loads

Live loads associated with the normal operation and uses 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 3-2-1/3.7) Live loads acting after construction and installation include the following:

- i)* The weight of drilling or production equipment which can be removed, such as derrick, draw works, mud pumps, mud tanks, rotating equipment, etc.
- ii)* The weight of crew and consumable supplies, such as mud, chemicals, water, fuel, pipe, cable, stores, drill stem, casing, etc.
- iii)* Liquid in the vessels and pipes during operation
- iv)* Liquid in the vessels and pipes during testing
- v)* The weight of liquids in storage and ballast tanks

- vi) The forces exerted on the structure due to operations (e.g., maximum derrick reaction)
- vii) The forces exerted on the structure during the operation of cranes and vehicles
- viii) 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
- ix) 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 i) through vii) 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 Section 3-2-6).

3.5 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.

3.7 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 Section 3-1-2. Operating Environmental Loads are those loads derived from the parameters characterizing Operating Environmental Conditions (see 3-1-2/5.3). Design Environmental Loads are those loads derived from the parameters characterizing the Design Environmental Condition (see 3-1-2/5.1).

The combination and severity of Design Environmental Loads are to be in accordance with 2-1-2/5.1.

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.

5 Determination of Environmental Loads

5.1 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 Section 3-1-2. 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.

5.3 Wave Loads

5.3.1 Range of Wave Parameters

A sufficient range of realistic wave periods and wave crest positions relative to the structure are to be investigated to provide an accurate determination of the maximum wave loads on the structure. Consideration is to 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.

5.3.2 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.

5.3.3 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:

$$F = F_D + F_I$$

where

F = hydrodynamic force vector per unit length along the member, acting normal to the axis of the member

F_D = drag force vector per unit length

F_I = inertia force vector per unit length

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

$$F_D = (c/2g)DC_D u_n |u_n|$$

where

c = weight density of water, in N/m³ (lb/ft³)

g = gravitational acceleration, in m/s² (ft/s²)

D = 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), in m (ft)

C_D = drag coefficient (dimensionless)

u_n = component of the fluid velocity vector normal to the axis of the member, in m/s (ft/s)

$|u_n|$ = absolute value of u_n , in m/s (ft/s)

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

$$F_I = (c/g)(pD^2/4)C_M a_n$$

where

- C_M = inertia coefficient based on the displaced mass of fluid per unit length (dimensionless)
- a_n = component of the fluid acceleration vector normal to the axis of the member, in m/s² (ft/s²)

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:

$$F = F_D + F_I(c/2g)DC_D(u_n - u'_n)|u_n - u'_n| + (c/g)(pD^2/4)a_n + (c/g)(pD^2/4)C_m(a_n - a'_n)$$

where

- u'_n = component of the velocity vector of the structural member normal to its axis, in m/s (ft/s)
- C_m = added mass coefficient, i.e., $C_m = C_M - 1$
- a'_n = component of the acceleration vector of the structural member normal to its axis, in m/s² (ft/s²)

For structural shapes other than circular cylinders, the term $pD^2/4$ 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_M range between 1.5 and 2.0.

5.3.4 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., FroudeKrylov 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.

5.5 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:

$$F_w = (c_a/2g)C_sV_y^2A \quad \text{N(lb)}$$

where

F_w = wind load, in N (lb)

g = gravitational acceleration, in m/s² (ft/s²)

c_a = weight density of air, in N/m³ (lb/ft³)

C_s = shape coefficient (dimensionless)

V_y = wind speed at altitude y , in m/s (ft/s)

A = projected area of member on a plane normal to the direction of the considered force, in m² (ft²)

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

In the absence of experimental data, values for the shape coefficient (C_s) may be assumed as follows:

TABLE 1
Values of C_s

<i>Shape</i>	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 truss works 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 3-2-1/5.5 TABLE 1.

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.

5.7 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:

$$F_L = C_L(c/2g)V^2A_\ell \quad \text{N/m(lb/ft)}$$

$$F_D = C_D(c/2g)V^2A_\ell \quad \text{N/m(lb/ft)}$$

where

F_L = total lift force per unit length, in N/m (lb/ft)

C_L = lift coefficient (dimensionless)

c = weight density of water, in N/m³ (lb/ft³)

V = local current velocity, in m/s (ft/s) (see 3-1-2/7.5)

A_ℓ = projected area per unit length in a plane normal to the direction of the force, in m²/m (ft²/ft)

F_D = total drag force per unit length, in N/m (lb/ft)

C_D = drag coefficient (see 3-2-1/5.3.3)

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

5.9 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 ridges and 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 Bulletin 2N: "Planning, Designing, and Constructing Fixed Offshore Platforms in Ice Environments."

5.11 Earthquake Loads

For structures located in seismically active areas, strength level and ductility level earthquake induced ground motions (see 3-1-2/5.1) 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 sitespecific 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
- 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 are to 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.

5.13 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.

5.15 Sea Ice

The global forces exerted by sea ice on the structure as 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.

5.17 Subsidence

The effects of subsidence are to 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 depletion of the subsurface reservoir.

1 General

This Section 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 sections of these Rules dealing specifically with steel, concrete and foundation design are to be viewed in light of the requirements given in this section. 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 4 of these Rules.

3 Analytical Approaches

3.1 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.

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

3.3 Loading Formats

With reference to Sections 3-1-2 and 3-2-1, 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 Section 3-2-1), 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 3-2-3/13 and 3-2-4/5.7).

If the modal method is employed in dynamic analysis, it is to 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 are 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.

3.5 Combination of Loading Components

Loads imposed during and after installation are to be taken into account. In consideration of the various loads described in Section 3-2-1, 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 Section 3-2-5). Reference is to be made to Sections 3-2-3 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.

5 Overall Design Considerations

5.1 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 4 of these Rules.

5.3 Air Gap

An air gap of at least 1.5 m (5 ft) 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 3-1-2/7.7) and consideration is to be given to wave run-up, tilting of the structure and, where appropriate, tsunamis.

5.5 Long-Term and Secondary Effects

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

- i)* Local vibration due to machinery, equipment and vortex shedding
- ii)* Stress concentrations at critical joints
- iii)* Secondary stresses induced by large deflection (P δ effects)
- iv)* Cumulative fatigue
- v)* Corrosion
- vi)* Abrasion due to ice

vii) Freeze-thaw action on concrete and coatings

5.7 Reference Marking

For large or complex structures, consideration is to 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.

5.9 Zones of Exposure

Measures taken to mitigate the effects of corrosion as required by 3-2-3/1.3 and 3-2-4/1.3 are to be specified and described in terms of the following definitions for corrosion protection zones.

5.9.1 Submerged Zone

The *Submerged Zone* is that part of the installation below the splash zone.

5.9.2 Splash Zone

The *Splash Zone* is the part of the installation containing the areas above and below the still water level (see 3-1-2/7.7) 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.

5.9.3 Atmospheric Zone

The *Atmospheric Zone* is 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.

7 Considerations for Particular Types of Structures

7.1 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.

7.3 Pile-Supported Steel Platforms

7.3.1 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.

7.3.2 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.

7.3.3 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.

7.3.4 Dynamic Analysis

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

7.3.5 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.

7.5 Concrete or Steel Gravity Platforms

7.5.1 Positioning

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

7.5.2 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.

7.5.3 Soil Reactions

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

7.5.4 Maintenance

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

7.5.5 Reinforcement Corrosion

Means are to be provided to minimize reinforcing steel corrosion.

7.5.6 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.

7.5.7 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.

7.5.8 Dynamic Analysis

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

7.5.9 Long Term Resistance

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

7.5.10 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 are to be used to maintain the necessary level of the oil-water interface in the tanks.

7.7 Concrete-Steel Hybrid Structures

7.7.1 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.

7.7.2 Steel and Concrete Interfaces

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

7.7.3 Other Factors

Pertinent design factors for the concrete base listed in 3-2-2/7.5 are also to be taken into account.

7.9 Guyed Compliant Towers

7.9.1 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.

7.9.2 Lifting Clump Weights

As required by the design, clump weights are to 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.

7.9.3 Swiveling Fairleads

Consideration is to 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.

7.9.4 Foundations

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

7.11 Minimum Structures

7.11.1 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 3-2-2/7.3 are to be taken into account.

7.11.2 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.

7.13 Site Specific Self-Elevating Offshore Units (1 July 2021)

7.13.1 Design Considerations (1 July 2021)

Self-Elevating Mobile Offshore Units converted or newly built to operate as site dependent platform structures are to be designed in accordance with these Rules along with the *MOU Rules*, wherever applicable. Reference should also be made to the *ABS Requirements for Building and Classing Self-Elevating Units Intended to Operate as Offshore Installations*.

7.13.2 Foundation (2018)

When selecting a unit for a particular site, due consideration is to 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 3-2-5/9.

For individual leg footing (spudcan) foundation, alternatively, reference can be made to ISO 19905-1 for the design environmental conditions. For normal operating with reduced metocean conditions, if the operations manual allows increase in, or redistribution of the variable loads, the foundation is to be assessed using the same criteria for the design environmental condition.

As applicable, the footprints left by jack-up rigs and scour are to be considered in the foundation design.

7.13.3 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 are to 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.

7.13.4 Fatigue Assessment (1 July 2021)

Fatigue strength is to be assessed using the criteria in the *ABS Guide for the Fatigue Assessment of Offshore Structures (Offshore Fatigue Guide)* with safety factors in accordance with 3-2-3/13. For existing Self-Elevating Units converted to Offshore Installation, the assessment of the remaining fatigue life is to consider the service history, which is to be provided by the Owner or Operator. For areas that will become inaccessible for inspection, such as leg to spud can or leg to mat connections, a fatigue design factor of 5 for non-critical structural members and joints or 10 for critical structural members and joints is to be applied. A reduced fatigue design factor may be allowed if the area is made accessible for inspection.

7.13.5 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.

7.13.6 Preload

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

PART 3

CHAPTER 2 Structural Design

SECTION 3 Steel Structures

1 General

The requirements of this Section 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 Section 2-2-1 of these Rules and Chapter 4 of the *ABS Rules for Materials and Welding (Part 2)*.

1.1 Materials

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

1.3 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 RP 0176-94, or other appropriate references.

1.5 Access for Inspection

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

1.7 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 Section 3-2-4. Any effects of the hybrid structure interacting on itself in areas such as corrosion protection is to be considered.

3 General Design Criteria

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 3-2-3/5, 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 Sections 3-2-1 and 3-2-2 are to be consulted regarding definitions and requirements pertinent to the determination of loads and general design requirements.

5 Loading Conditions

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:

- 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

For structures located in seismically active areas, earthquake loads (see 3-2-2/3.5) 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.

7 Structural Analysis

7.1 General

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.

7.3 Dynamic Effects

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.

7.5 Static Loads

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.

7.7 Plastic Analysis

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.

7.9 Dynamic Loads

Under dynamic loads, when plastic strains may occur, the considerations specified in 3-2-3/7.5 are to be satisfied and any buckling and destabilizing nonlinear effects are to be taken into account.

9 Allowable Stresses and Load Factors

9.1 Working Stress Approach

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

9.1.1 Basic Allowable Stresses

For structural members and loadings covered by Part 5 of the American Institute of Steel Construction (AISC) *Manual of Steel Construction, ASD*, with the exception of earthquake loadings (see 3-2-3/9.1.4 below) and tubular structural members under the combined loading of axial compression and bending, the basic allowable stresses of the members are to be obtained using the AISC Specification. For tubular members subjected to the aforementioned interaction, stress limits are to be in accordance with the API RP 2A.

9.1.2 Environmental Loads and Dead and Live Loads

Where stresses in members described in 3-2-3/9.1.1 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 3-2-3/9.1.1 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.

9.1.3 Earthquake Loads

When considering loading combinations which include earthquake loads (see 3-2-3/5) 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.

9.1.4 Lifting

The allowable stresses specified in 3-2-3/9.1.2 are to be regarded as the limits for stresses in all structural parts for the marine operations covered in Section 3-2-6, except for lifting, where the one third increase in the basic allowable stress is not permitted. The lifting analysis is to adequately account for equipment and fabrication weight increase.

9.1.5 Equivalent Stress for Two or Three Dimensional Stress Field

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.

9.1.6 Elastic Instability

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

9.3 Plastic Design Approach

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 in *Chapter N (Plastic Design)* of Part 5 of the *AISC Manual of Steel Construction, ASD* or an equivalent code. The capability of the principal structural members to develop their predicted ultimate load capacity is to be demonstrated. For safety against brittle fracture, special attention is to be given to details of high stress concentration and to improved material quality.

11 Structural Response to Earthquake Loads

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.

In United States offshore regions, reference may be made to API RP 2A for design criteria for earthquakes. In other seismically active locations around the world, a seismic report is to be submitted.

13 Fatigue Assessment (1 July 2021)

Fatigue strength is to be assessed using the criteria in the *ABS Guide for the Fatigue Assessment of Offshore Structures (Offshore Fatigue Guide)*. For structural members and joints where fatigue is a probable mode of failure, or for which past experience is insufficient to confirm 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 inspectable 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 (non-critical member or joint/connection). Where such redundancy does not exist or where the desirable degree of redundancy is significantly reduced as a result of fatigue damage (critical member or joint/connection), 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.

For non-inspectable and non-critical structural members and joints, the results of the fatigue assessment are to indicate a minimum expected fatigue life of five times the design life of the structure, and ten times for non-inspectable critical structural members and joints.

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 are to be taken into consideration if they are significant to the structural response.

TABLE 1
Fatigue Life (1 July 2021)

<i>Importance</i>	<i>Degree of Accessibility</i>	
	<i>Inspectable</i>	<i>Non-inspectable</i>
Non-critical	2 times Design Life	5 times Design Life
Critical	3 times Design Life	10 times Design Life

15 Stresses in Connections

Connections of structural members are to be developed to provide 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 API RP 2A.

17 Structure-Pile Connections

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 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 3-2-3/9.1 or 3-2-3/9.3, and with regard to laterally loaded piles in accordance with 3-2-5/7.9.

19 Structural Response to Hydrostatic Loads

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.

21 Deflections

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.

23 Local Structure

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 3-2-3/9 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.

PART 3

CHAPTER 2 Structural Design

SECTION 4 Concrete Structures

1 General

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

1.1 Materials

Unless otherwise specified, the requirements of this Section are intended for structures constructed of materials manufactured and having properties as specified in Part 2, Chapter 1 of these Rules. Where it is intended to use materials having properties differing from those specified in Part 2, Chapter 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 3-2-2/5.9.

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

1.5 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.

1.7 Steel-Concrete Hybrid Structures

The concrete portions of a hybrid structure are to be designed in accordance with the requirements of this Section, and the steel portions in accordance with the requirements of Section 3-2-3.

3 General Design Criteria

3.1 Design Method

3.1.1 General

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

3.1.2 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 = $c_k F_k$).

3.1.3 Design Strength

In the analysis of sections, the design strength of a given material is obtained by multiplying the material strength, f_k , by the appropriate strength reduction factor, f (i.e., design strength = $f f_k$). The material strength, f_k , for concrete is the specified compression strength of concrete (f'_c) after 28 days and for steel is the minimum specified yield strength (f_y).

3.3 Load Definition

3.3.1 Load Categories

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

3.3.2 Combination Loads

Loads taken in combination for the Operating Environmental Conditions and the Design Environmental Condition are indicated in 3-2-4/5.3.

3.3.3 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.

3.5 Design Reference

Design considerations for concrete structures not directly addressed in these Rules are to follow the requirements of the American Concrete Institute (ACI) 318 and ACI 357, or equivalent.

5 Design Requirements

5.1 General

5.1.1 Strength

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:

- i)* Loss of overall equilibrium
- ii)* Failure of critical sections
- iii)* Instability resulting from large deformations
- iv)* Excessive plastic or creep deformation

5.1.2 Serviceability

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:

- i)* Cracking and spalling

- ii) Deformations
- iii) Corrosion of reinforcement or deterioration of concrete
- iv) Vibrations
- v) Leakage

5.3 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:

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

$$U = 1.2(D + T) + 1.2L_{\max} + c_E E_{\max}$$

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

where

D = dead load (see 3-2-4/3.3)

T = deformation load (see 3-2-4/3.3)

L = live load (see 3-2-4/3.3)

L_{\min} = minimum expected live loads

L_{\max} = maximum expected live loads

E_O = operating environmental loads

E_{\max} = design environmental loads

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

= 1.4 for earthquake 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.

5.5 Strength Reduction Factors

The strength of a member or a cross section is to be calculated in accordance with the provisions of 3-2-4/7 and it is to be multiplied by the following strength reduction factor, f .

- i) For bending with or without axial tension, $f = 0.90$
- ii) For axial compression or axial compression combined with bending:
 - a) Reinforced members with spiral reinforcement, $f = 0.75$
 - b) Other reinforced members (excluding slabs and shells), $f = 0.70$

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

- c) Slabs and shells, $f = 0.70$
- iii) For shear and torsion, $f = 0.85$
- iv) For bearing on concrete, $f = 0.70$

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 (f) and the material factors (c_M) are not to be used simultaneously.

5.7 Fatigue

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

- i) The stress range in reinforcing or prestressing steel does not exceed 138 MPa (20,000 psi), or where reinforcement is bent, welded or spliced, 69 MPa (10,000 psi).
- ii) There is no membrane tensile stress in concrete and not more than 1.4 MPa (200 psi) flexural tensile stress in concrete.
- iii) The stress range in compression in concrete does not exceed $0.50 f'_c$ where f'_c is the specified compressive strength of concrete.
- iv) 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.
- v) In situations where fatigue stress ranges allow greater latitude than those under the serviceability requirements given in 3-2-4/5.9.2 TABLE 1, the latter condition is to assume precedence.
- vi) 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.

5.9 Serviceability Requirements

5.9.1 Serviceability

The serviceability of the structure is to be checked by the use of stress-strain diagrams (3-2-4/ Figures 1 and 2) with strength reduction factor, $f=1.0$, and the unfactored load combination:

$$U = D + T + L + E_0$$

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 3-2-4/5.9.2 TABLE 1. Additionally for hollow structural cross sections, the maximum permissible membrane strain across the walls is to 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 are to be limited so that the strains at the plane of the prestressing steel do not exceed D_{ps}/E_S , where D_{ps} is as defined in 3-2-4/5.9.2 TABLE 1 and E_S is the modulus of elasticity of reinforcement (see 3-2-4/7.3.7).

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

5.9.2 Liquid-Containing Structures

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

- i) The reinforcing steel stresses are to be in accordance with 3-2-4/5.9.1
- ii) The compression zone is to extend over 25% of the wall thickness or 205 mm (8 in.), whichever is less
- iii) 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 1
Allowable Tensile Stresses for Prestress and Reinforcing Steel to Control Cracking

<i>Stage</i>	<i>Loading</i>	<i>Allowable Stress, MPa (ksi)</i>	
		<i>Reinforcing Steel, f_s</i>	<i>Prestressing Tendons D_{ps}</i>
Construction: where cracking during construction would be detrimental to the completed structure	All loads on the structure during construction	160 (23.0)	130 (18.5)
Construction: where cracking during construction is not detrimental to the completed structure	All loads on the structure during construction	210 (30.0) or $0.6f_y$, whichever is less	130 (18.5)
Transportation and installation	All loads on the structure during transportation and installation	160 (23.0)	130 (18.5)

<i>Stage</i>	<i>Loading</i>	<i>Allowable Stress, MPa (ksi)</i>	
		<i>Reinforcing Steel, f_s</i>	<i>Prestressing Tendons D_{ps}</i>
At offshore site	Dead and live plus operating environmental loads	120 (17.0)	75 (11.0)
At offshore site	Dead and live loads plus design environmental loads	$0.8f_y$	

f_y = yield stress of the reinforcing steel

f_s = allowable stress in the reinforcing steel

D_{ps} = increase in tensile stress in prestressing steel with reference to the stress at zero strain in the concrete.

7 Analysis and Design

7.1 General

Generally, the analysis of structures is to 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 Subsection. The material properties to be used in analysis are to conform to 3-2-7/3. 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 3-2-4/7.13 are satisfied.

7.3 Material Properties for Structural Analysis

7.3.1 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.

7.3.2 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.

7.3.3 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.

7.3.4 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 ($57,000\sqrt{f'_c}$ psi) or determined from

stress-strain curves developed by tests (see 3-2-4/11.7.8 FIGURE 1) the latter method is used, the modulus of elasticity is to be determined using the secant modulus for the stress equal to $0.5 f'_c$.

7.3.5 Uniaxial Compression – Concrete

In lieu of tests, the stress-strain relation shown in 3-2-4/11.7.8 FIGURE 1 may be used for uniaxial compression of concrete.

7.3.6 Poisson Ratio

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

7.3.7 Modulus of Elasticity – Reinforcement

The modulus of elasticity, E_s , of non-prestressed steel reinforcement is to be taken as 200×10^3 MPa (29×10^6 psi). The modulus of elasticity of prestressing tendons is to be determined by tests.

7.3.8 Uniaxial Tension-Reinforcement

The stress-strain relation of non-prestressed steel reinforcement in uniaxial tension is to be assumed as shown in 3-2-4/11.7.8 FIGURE 2. The stress-strain relation of prestressing tendons is to be determined by tests, or taken from the manufacturer's certificate.

7.3.9 Yield Strength-Reinforcement

If the specified yield strength, f_y , of non-prestressed reinforcement exceeds 420 MPa (60,000 psi), the value of f_y used in the analysis is to be taken as the stress corresponding to a strain of 0.35%.

7.5 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.

7.7 Deflection Analysis

Immediate deflections may be determined by the methods of linear structural analysis. For the purposes of deflection analysis, the member stiffness's 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.

7.9 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.

7.11 Analysis and Design for Bending and Axial Loads

7.11.1 Assumed Conditions

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

- i) The strains in steel and concrete are proportional to the distance from the neutral axis
- ii) Tensile strength of the concrete is to be neglected, except in prestressed concrete members under unfactored loads, where the requirements in 3-2-4/5.9 apply
- iii) The stress in steel is to be taken as equal to E_s times the steel strain, but not larger than f_y

- iv)* The stresses in the compression zone of concrete are to be assumed to vary with strain according to the curve given in 3-2-4/11.7.8 FIGURE 1 or any other conservative rule. Rectangular distribution of compressive stresses in concrete specified by ACI 318 may be used
- v)* The maximum strain in concrete at the ultimate state is not to be larger than 0.30%

7.11.2 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.

7.13 Seismic Analysis

7.13.1 Seismic Analysis

For structures to be located at sites known to be seismically active (see 3-2-4/7.15), 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 verify 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.

7.13.2 Design Conditions

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

- i)* The interaction of all components of the structure
- ii)* The compliance of the soil and the dynamic soil-structure interaction
- iii)* The dynamic effects of the ambient and contained fluids.

7.13.3 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.

7.13.4 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 is to be considered.

7.15 Seismic Design

7.15.1 Compressive Strain

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

7.15.2 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.

7.15.3 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:

- i)* The diameter of rods used as stirrups is not to be less than 10 mm (#3 bar)
- ii)* Only closed stirrups (stirrup ties) are to be used
- iii)* The spacing of stirrups is not to exceed the lesser of $d/2$ or 16 bar diameters of compressive reinforcement, 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).

7.15.4 Splices

No splices are allowed within a distance d from a plastic hinge. Lap splices are to be at least 30 bar diameters long but not less than 460 mm (18 in.).

9 Design Details

9.1 Concrete Cover

9.1.1 General

The following minimum concrete cover for reinforcing bars is required:

- i)* Atmospheric zone not subjected to salt spray: 50 mm (2 in.)
- ii)* Splash and atmospheric zones subjected to salt spray and exposed to soil: 65 mm (2.5 in.)
- iii)* Submerged zone: 50 mm (2 in.)
- iv)* Areas not exposed to weather or soil: 40 mm (1.5 in.)
- v)* Cover of stirrups may be 13 mm (0.5 in.) less than covers listed above.

9.1.2 Tendons and Ducts

The concrete cover of prestressing tendons and post-tensioning ducts is to be increased 25 mm (1 in.) above the values listed in 3-2-4/9.1.1.

9.1.3 Sections Less Than 500 mm (20 in.) Thick

In sections less than 500 mm (20 in.) thick, the concrete cover of reinforcing bars and stirrups may be reduced below the values listed in 3-2-4/9.1.1. However, the cover is not to be less than the following:

- i)* 1.5 times the nominal aggregate size
- ii)* 1.5 times the maximum diameter of reinforcement, or 19 mm (0.75 in.)
- iii)* Tendons and post-tensioning duct covers are to have 12.5 mm (0.5 in.) added to the above.

9.3 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:

$$A_S = (f_t/f_y)bd_e$$

where

- 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 is to 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.

9.5 Reinforcement Details

Generally, lapped joints are to 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.

9.7 Post-tensioning Ducts

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

The inside diameter of ducts is to be at least 6 mm (0.25 in.) larger than the diameter of the post-tensioning tendon in order to facilitate grout injection.

9.9 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 are preferably to be recessed in a pocket which is then filled with concrete. The fill is to 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.

11 Construction

11.1 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.

11.3 Mixing, Placing, and Curing of Concrete

11.3.1 Mixing

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

11.3.2 Cold Weather

In cold weather, concreting in air temperatures below 2°C (35°F) is to 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 (40°F) and the concrete is to be maintained at this or a higher temperature until it has reached a strength of at least 5 MPa (700 psi).

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 is never to be heated nor allowed to come into contact with water at a temperature greater than 60°C (140°F).

11.3.3 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 (90°F) and the maximum temperature due to heat of hydration is not to exceed 65°C (145°F).

11.3.4 Curing

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

11.3.5 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 is to be used.

11.3.6 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 (2 ft) are concreted, the temperature gradients between internal concrete and external ambient conditions are to be kept below 20°C (68°F).

11.3.7 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.

11.3.8 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.

11.5 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.

11.7 Prestressing Tendons, Ducts and Grouting

11.7.1 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.

11.7.2 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.

11.7.3 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.

11.7.4 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.

11.7.5 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.

11.7.6 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.

11.7.7 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.

11.7.8 Procedures

For long vertical tendons, the grout mixes, admixtures, and grouting procedures are to be checked to confirm 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 (50°F) 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 slip forms are to be grouted in the same manner as described above.

FIGURE 1
Stress-Strain Relation for Concrete in Uniaxial Compression

E_c is defined in 3-2-4/7.3.4

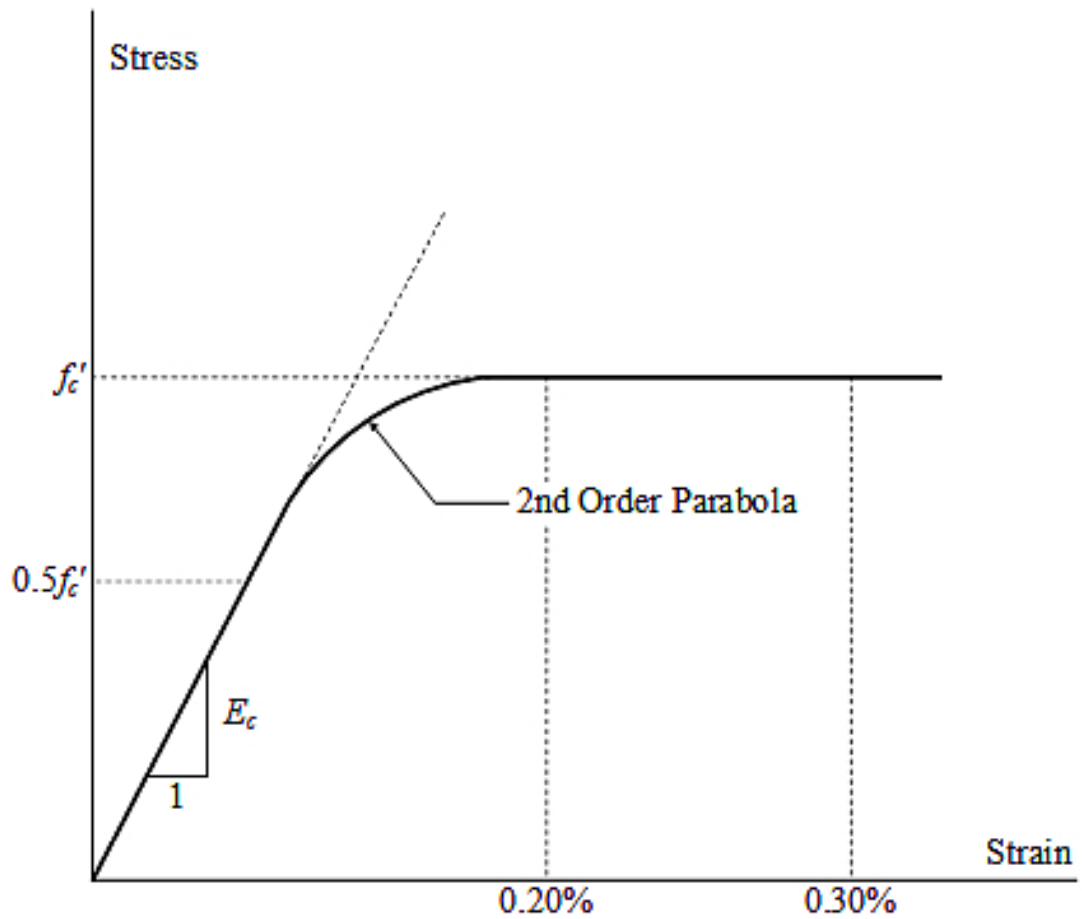
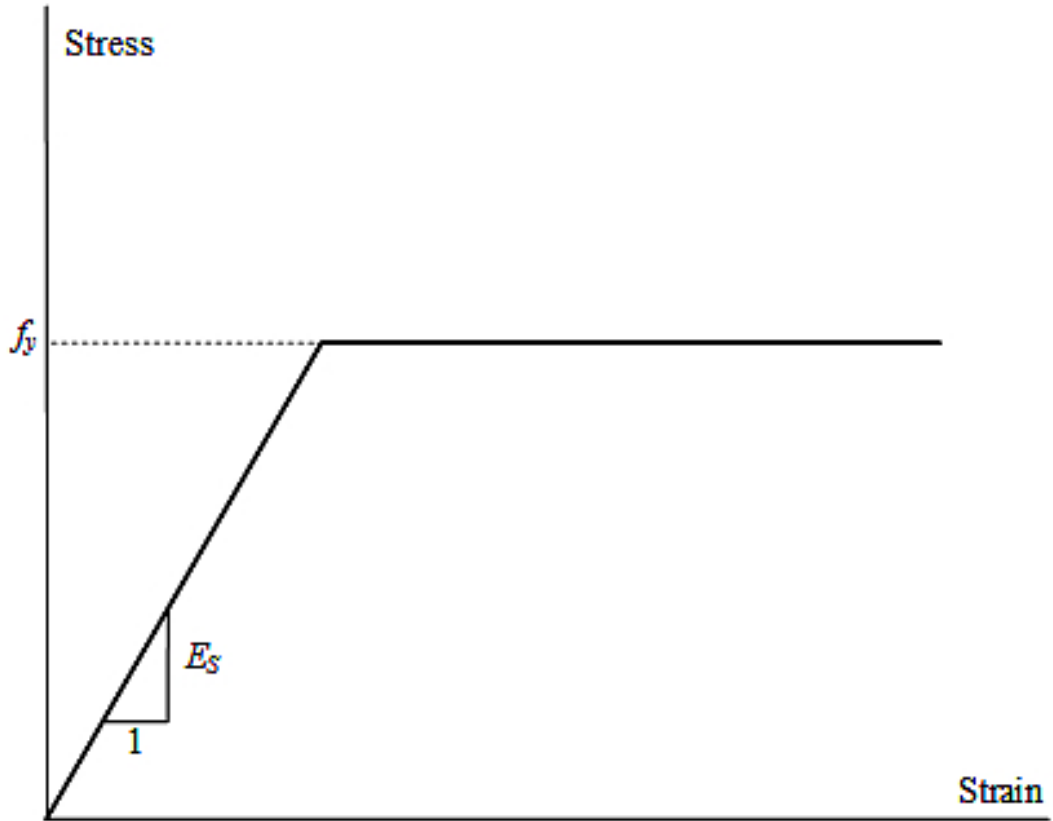


FIGURE 2
Stress-Strain Relation for Non-Prestressed Steel in Uniaxial Tension

$$E_s = 200 \times 10^3 \text{ MPa (29,00 ksi)}$$



1 General

Soil investigations, design considerations for the supporting soil and the influence of the soil on the foundation structure are covered in this section. The degree of design conservatism is to 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.

3 Site Investigation

3.1 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 3-2-5/3.3) to obtain relevant geophysical data
- ii)* Geological Survey (see 3-2-5/3.5) to obtain data of a regional nature concerning the site
- iii)* Subsurface Investigation and Testing (see 3-2-5/3.7) 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 3-2-5/3.9.

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 so that the data obtained are pertinent to the actual location of the structure.

3.3 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:

- i)* Soundings or contours of the sea bed
- ii)* Position of bottom shapes which might affect scour
- iii)* The presence of boulders, obstructions, and small craters
- iv)* Gas seeps
- v)* Shallow faults
- vi)* Slump blocks
- vii)* Ice scour of sea floor sediments
- viii)* Subsea permafrost or ice bonded soils

3.5 Geological Survey

Data of the regional geological characteristics which can affect the design and siting of the structure. Such data are to be considered in planning the subsurface investigation, and they are also to be used to verify 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.

3.7 Subsurface Investigation and Testing

3.7.1 General

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 (50 ft) 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 includes the anticipated shearing failure zone.

3.7.2 Extent of Sample Recovery and Field Testing

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:

- i)* The recovery of the materials to a depth of 12 m (40 ft) 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 (10 ft) intervals to 61 m (200 ft) and approximately 8 m (25 ft) intervals below 61 m (200 ft).
- ii)* At least one undrained strength test (vane, drop cone, unconfined compression, etc.) on selected recovered cohesive samples is to be performed in the field.
- iii)* Where practicable, a standard penetration test or equivalent on each significant sand stratum is to be performed, recovering samples where possible.
- iv)* Field samples for laboratory work are to be retained and carefully packaged to minimize changes in moisture content and disturbance.

3.7.3 Laboratory Testing

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:

- i)* Perform unconfined compression tests on clay strata where needed to supplement field data
- ii)* Determine water content and Atterberg limits on selected cohesive samples
- iii)* Determine density of selected samples
- iv)* 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
- v)* Perform grain size sieve analysis, complete with percentage passing 200 sieve, on each significant sand or silt stratum

3.7.4 Additional Tests

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:

- i)* Shear strength tests with pore pressure measurements. The shear strength parameters and pore-water pressures are to be measured for the relevant stress conditions
- ii)* Cyclic loading tests with deformation and pore pressure measurements to determine the soil behavior during alternating stress
- iii)* Permeability and consolidation tests performed as required

3.9 Documentation

The foundation design documentation mentioned in Section 3-1-1 is to be submitted for review. As applicable, the results of studies to assess the following effects are also to be submitted:

- i)* Scouring potential of the sea floor
- ii)* Hydraulic instability and the occurrence of sand waves
- iii)* Instability of slopes in the area where the structure is to be placed
- iv)* Liquefaction and other soil instabilities

- v) For Arctic areas, possible degradation of subsea permafrost layers as a result of the production of hot oil
- vi) Soils conditions in the vicinity of footprints left by temporarily situated drilling units or other service units
- vii) 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.

5 Foundation Design Requirements

5.1 General

The loadings used in the analysis of the safety of the foundation are to include those defined in 3-2-5/5.13 and those experienced by the foundation during installation. Foundation displacements are to be evaluated to the extent necessary to verify 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.

5.3 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:

- i) Design storm during the initial consolidation phase
- ii) Short-term effects of the design storm
- iii) 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 are to be accounted for when they will affect the design.

5.5 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

5.7 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.

5.9 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.

5.11 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.

5.13 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.

5.15 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.

5.17 Loads and Soil Conditions Due to Temporarily Situated Structures

Changes in soil conditions due to temporarily situated platforms such as self-elevating drilling units, work over 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 so that the structure's function and safety are not impaired.

7 Pile Foundations

7.1 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.

If unexpectedly high or low driving resistance or other conditions are 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.

7.3 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.

7.5 Factors of Safety for Axial Piles

When the pile is subjected to the three loading cases described in 3-2-5/5.13 and the ultimate capacities are evaluated using the above cited API method, the allowable 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.

<i>Loading Condition</i>	Factor of Safety
3-2-5/5.13.i	2.0
3-2-5/5.13ii), 3-2-5/5.13iii)	1.5

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

7.7 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.

7.9 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 3-2-5/5.13. Calculation of the soil capacity and the pile stresses is to be based on consideration of the modified loads.

7.11 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.

7.13 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 is to 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 is to be provided for proper placement of the grout. Reliable means for the introduction of the grout to the annulus are to be provided to provide 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 are to 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.

9 Gravity Structures

9.1 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 3-2-5/3.7 and 3-2-5/5.3. 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 3-2-5/9.3.

When an under pressure 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 3-2-5/5.13ii) and 3-2-5/5.13iii).

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

9.3 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 so 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 3-2-5/5.13, 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.

9.5 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 3-2-5/3.7. 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.

PART 3

CHAPTER 2 Structural Design

SECTION 6 Marine Operations

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 Section 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 are also to be evaluated. In these Rules, marine operations will generally include the following activities, as appropriate to the planned installation:

- i)* Lifting and mooring operations
- ii)* Load-out
- iii)* Construction afloat
- iv)* Towing
- v)* Launching and up righting
- vi)* Submergence
- vii)* Mating
- viii)* Pile installation
- ix)* Final field erection
- x)* 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 confirm that proper procedures are followed. The Operator may also optionally request that a Surveyor be present during a tow.

3 Documentation

The extent of documentation and analysis (3-2-6/5) 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.

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 3-2-6/5. 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.

- i)* Description of the marine operations to be performed and the procedures to be employed
- ii)* For operations which do not govern design of the structure, a description of the engineering logic, experience or preliminary calculations supporting this conclusion
- iii)* For operations which govern design of the structure, the assumptions, calculations and results of the analyses required in 3-2-6/5
- iv)* For structures to be up righted or submerged by selective ballasting, a detailed description of the mechanical, electrical and control systems to be employed, the ballasting schedule and supporting calculations

5 Analysis

5.1 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 is to be included in calculating the total fatigue lives.

5.3 Stress

Where temporary attachments or appurtenances (tie-downs, skid beams, etc.) are utilized, analyses are to be performed to verify 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 Sections 3-2-3 and 3-2-4 for steel structures and concrete structures, respectively, are to be employed in this determination.

5.5 Stability (1 July 2021)

Analyses are to be performed to verify 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.

In cases where the unit is intended to be wet towed to the installation site (e.g., Self-Elevating Units), an inclining test to determine the lightweight and center of gravity of the unit is required as near to completion of the conversion or new construction as practical and prior to leaving the site. If integration of topsides takes place offshore, an alternative procedure may be applied using an inclining test or lightweight survey of the hull combined with weighing of the topside components to be installed. An inclining test procedure is to be submitted for review prior to the test. The inclining test or lightweight survey is to be carried out in the presence of an ABS Surveyor. Changes to onboard load conditions after the inclining test and during service are to be carefully accounted for. The operations manual is to provide guidance for the maintenance of a weight change log and is to be kept on board.

For Self-Elevating Units intended to be wet towed to the installation site, the subdivision and stability criteria as specified in Part 3, Chapter 3 of the *MOU Rules* are to be applied. The wind speed

specified for "unrestricted service" is to be considered. Wind speed specific to the tow route may be specially considered if the designation (**Self-Installing Unit**) is not applicable. Refer to 3-3-2/5.3 of the *MOU Rules* regarding watertight closures for external openings while the installation is afloat.

Afloat wet tow stability is also subject to flag Administration and coastal state requirements, if any. If the wet tow is unmanned, special consideration may be given for application of only intact stability criteria, subject to agreement from the flag Administration and coastal state. Use of intact stability only (without damage stability) is not acceptable if tow is manned or if the unit has the designation (**Self-Installing Unit**).

7 Fitness to Tow Certificate

Upon request by the Operator and where authorized to do so, ABS 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 ABS. Review by ABS 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.

1 Fillet Welds

1.1 General

The sizes of fillet welds are to be indicated on detail plans or on a separate welding schedule and are subject to approval. The weld throat size is not to be less than 0.7 times the weld leg size. Fillet welds are to be made by an approved manual or automatic technique. Where the gap between the faying surfaces of members exceeds 2 mm ($1/16$ in.) and is not greater than 5 mm ($3/16$ in.), the weld leg size is to be increased by the amount of the opening. Where the gap between members is greater than 5 mm ($3/16$ in.), fillet weld sizes and weld procedures are to be specially approved by the Surveyor. Completed welds are to be to his satisfaction. Special precautions such as the use of preheat or low-hydrogen electrodes or low hydrogen welding processes may be required where small fillets are used to attach heavy members or sections. When heavy sections are attached to relatively light members, the weld size may be required to be modified.

1.3 Tee Connections

Except where otherwise indicated under 1.1, the fillet weld requirement for tee connections is to be determined by the lesser thickness member being joined. Where only the webs of girders, beams or stiffeners are to be attached, it is recommended that the unattached face plates or flanges be cut back. Except for girders of thickness greater than 25 mm (1 in.), reduction in fillet weld sizes may be specially approved in accordance with either 3-2-7/1.3.1 or 3-2-7/1.3.2 specified below. However, in no case is the reduced leg size to be less than 5 mm ($3/16$ in.).

1.3.1

Where quality control facilitates working to a gap between members being attached of 1 mm (0.04 in.) or less, a reduction in fillet weld leg size of 0.5 mm (0.02 in.) may be permitted provided that the reduced leg size is not less than 8 mm ($5/16$ in.).

1.3.2

Where automatic double continuous fillet welding is used and quality control facilitates working to a gap between members being attached of 1 mm (0.04 in.) or less, a reduction in fillet weld leg size of 1.5 mm ($1/16$ in.) may be permitted provided that the penetration at the root is at least 1.5 mm ($1/16$ in.) into the members being attached and the reduced leg size is not less than 5 mm ($3/16$ in.).

1.5 Lapped Joints

Lapped joints are generally not to have overlaps of less width than twice the thinner plate thickness plus 25 mm (1 in.). Both edges of an overlapped joint are to have continuous fillet welds in accordance with 3-2-7/1.1 or 3-2-7/1.7.

1.7 Overlapped End Connections

Overlapped end connections of structural members which are considered to be effective in the overall strength of the unit are to have continuous fillet welds on both edges equal in leg size to the thickness of the thinner of the two members joined. All other overlapped end connections are to have continuous fillet welds on each edge of leg sizes such that the sum of the two is not less than 1.5 times the thickness of the thinner member.

1.9 Overlapped Seams

Unless specially approved, overlapped seams are to have continuous welds on both edges of the sizes required by the approved plans and are to be in accordance with the applicable provisions of 1.1.

1.11 Plug Welds or Slot Welds

Plug welds or slot welds may be specially approved for particular applications. Where used in the body of doublers and similar locations, such welds are generally to be spaced about 300 mm (12 in.) between centers in both directions. Slot welds are generally not to be filled with weld metal. For plate thicknesses up to 13 mm ($1/2$ in.), fillet sizes are to be equal to plate thickness but not greater than 9.5 mm ($3/8$ in.); for thicknesses over 13 mm ($1/2$ in.) to 25 mm (1 in.) fillet sizes are to be 16 mm ($5/8$ in.) maximum.

3 Full Penetration Corner or Tee Joints

Measures taken to achieve full penetration corner or tee joints, where specified, are to be to the satisfaction of the attending Surveyor. Ultrasonic inspection of the member in way of the connection may be required to verify the absence of injurious laminations prior to fabrication which could interfere with the attainment of a satisfactory welded joint.



PART 4

Extension of Use and Reuse

CONTENTS

CHAPTER 1	Extension of Use.....	98
	Section 1 General	99
	Section 2 Requirements for Extension of Use	100
CHAPTER 2	Reuse.....	103
	Section 1 Requirements for Reuse	104

PART 4

CHAPTER 1 Extension of Use

CONTENTS

SECTION 1	General	99
1	Scope.....	99
SECTION 2	Requirements for Extension of Use	100
1	General Requirements.....	100
1.1	Classification.....	100
1.3	In-place Analysis.....	100
1.5	Fatigue Life.....	100
1.7	Surveys.....	101
3	Review of Platform Design Documents.....	101
5	Survey of Platforms.....	101
7	Structural Analyses.....	101
9	Implementing Repairs/Reinspection.....	102

PART 4

CHAPTER 1 Extension of Use

SECTION 1 General

1 Scope

This Chapter pertains to the classification or continuance of classification of an existing platform for extension of service beyond the design life. The classification requires special considerations with respect to the review, surveys and structural analyses in order to verify the adequacy of the platform for its intended services. In general, the reviews and surveys described in Section 4-1-2 are to be followed. However, if the platform is currently classed with ABS, some of these reviews and surveys may not be necessary depending on the condition of the platform.

1 General Requirements

1.1 Classification

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

- i)* Review original design documentation, plans, structural modification records and survey reports.
- ii)* Survey structure to establish condition of platform.
- iii)* Review the results 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.
- iv)* Resurvey platform utilizing results from structural analysis. Make any alterations necessary for extending the service of the structure.
- v)* Review a program of continuing surveys to verify the continued adequacy of the platform.

Items *i)* and *ii)* are to assess the platform to determine the possibility of continued use. If the conclusion is favorable from this assessment, structural analyses are to be carried out.

1.3 In-place Analysis

The in-place analysis is to follow 3-2-3/7 and is to be in accordance with 4-1-2/7. The results of the in-place analysis can be utilized to identify the area's most critical for inspection at the resurvey.

1.5 Fatigue Life (1 July 2021)

The fatigue life can be calculated by means of an analysis as described in 3-2-3/13. This analysis is sensitive to the waves encountered during the past service and future prediction, therefore the long term environment data are to be properly represented. Spectral fatigue analysis is recommended, and in special cases, simplified analysis may be considered if long term environmental data is not available. Supporting documents for waiving spectral fatigue analysis are to be submitted to ABS for review. Safety factors as indicated in 3-2-3/13 are to be applied to the fatigue damage accumulated during past service. The remaining fatigue lives of all the structural members and joints are not to be less than twice the extended service life. For non-inspectable and non-critical structural members and joints, the remaining fatigue lives are to be in accordance with 3-2-3/13. Any area found to be deficient is required to be strengthened to achieve the required fatigue life or monitoring programs are to be developed to monitor these areas with

nondestructive testing on a periodical basis or the weld toe is to be ground to improve fatigue life for joints with full penetration welds.

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 are found to be within the allowable design limits.

1.7 Surveys

Surveys on a periodic basis based on Part 5, Chapter 2 are to be undertaken to ascertain the satisfactory condition of the platform. Additional surveys may be required for platforms which have unique features.

3 Review of Platform Design Documents

Platform design information is to be collected to allow an engineering assessment of a platform's overall structural integrity. It is essential to have the original design reports, documents, original and as-is plans, specifications, survey records during fabrication, installation and past service. The operator is to confirm 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 cannot be provided, an assumption of lower design criteria, actual measurements or testings are to be carried out to establish a reasonable and conservative assumption.

5 Survey of Platforms

Surveying an existing platform witnessed and monitored by an ABS 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, an inspection procedure developed, and a complete underwater inspection required so that an accurate assessment of the platform's condition is obtained. Survey requirements are outlined in 5-2-1/19. The Surveyors will witness and monitor all survey activities for the platform.

The corrosion protection system is to be re-evaluated to confirm that existing anodes are capable of serving the extended design life of the platform. 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 is to be taken into account in the structural analysis. Condition of protective coatings in the splash zone is to be rectified and placed in satisfactory condition.

7 Structural Analyses

The structural analyses of an existing structure must incorporate the results of the platform survey. Specifically, deck loads, wastage, marine growth, scour, and any platform modifications and damages must be incorporated into the analysis model. The original fabrication materials and fit-up details must be established such that proper material characteristics are used in the analysis and any stress concentrations are accounted for. The pile driving records are to 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 are to also be carried out.

The results of the analyses are considered to be an indicator of areas needing careful inspection. Possible alterations of platforms to allow continued use are developed by altering the analysis model to evaluate the

effect of the alterations. 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 are to be evaluated to determine whether the repairs/alterations is needed.

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

9 Implementing Repairs/Reinspection

The initial condition survey in conjunction with structural analysis will form the basis for determining the extent of repairs/alterations which will be necessary to class the platform for continued operation.

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 are to 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 ABS for review and approval. Interval of future periodic surveys is to be determined based on the remaining fatigue lives of these joints.

PART 4

CHAPTER 2 Reuse

CONTENTS

SECTION	1	Requirements for Reuse	104
	1	General.....	104
	3	Removal and Reinstallation Operation.....	104

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 are to be followed, particularly the requirements described in Part 4, Chapter 1, whenever applicable, and survey requirements given in 5-2-1/21 for platform reuse.

Since the platform is to be reused at a new site, the environmental and geotechnical data used in the analysis are to be in accordance with those for the new site. Any alteration to the structure to enable the removal operation to be successfully performed and to suit the new site is to be incorporated in the analysis.

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

3 Removal and Reinstallation Operation

Removal of the sub-structure and superstructure may entail the reversing of the initial installation sequence. Cutting piles, re-floatation, and lifting as envisaged in the platform removal procedure are to be well planned and analyzed to verify that the integrity of the structure has not been compromised. Platform removal plans, procedures, sea fastening drawings, transportation, together with the analysis calculations are to be submitted to ABS for review. In general, Section 3-2-6 is to be followed for the reinstallation of used platforms.



PART 5

Testing and Surveys

CONTENTS

CHAPTER 1	Surveys During Construction and Installation.....	106
	Section 1 General	107
	Section 2 Steel Structures	109
	Section 3 Concrete Structures	112
CHAPTER 2	Surveys After Construction.....	116
	Section 1 Conditions for Surveys After Construction	118
	Section 2 Annual Surveys	121
	Section 3 Special Periodical Surveys.....	122
	Section 4 Structural Deterioration.....	124
	Section 5 Maintenance of Marine Growth.....	125
	Section 6 Statutory Certification.....	126
	Section 7 Crew Habitability on Offshore Installations (2016).....	127

PART 5

CHAPTER 1

Surveys During Construction and Installation

CONTENTS

SECTION	1	General	107
	1	Scope.....	107
	3	Quality Control Program.....	107
	5	Access and Notification.....	107
	7	Identification of Materials.....	107
SECTION	2	Steel Structures	109
	1	Quality Control Program.....	109
	3	Material Quality and Traceability.....	109
	5	Steel Forming.....	110
	7	Welder Qualification and Records.....	110
	9	Welding Procedure Specifications and Qualifications.....	110
	11	Weld Inspection.....	110
	13	Tolerances and Alignments.....	110
	15	Corrosion Control Systems.....	110
	17	Tightness and Hydrostatic Testing Procedures.....	110
	19	Nondestructive Testing.....	110
	21	Installation of Main Structure.....	111
	23	Records.....	111
SECTION	3	Concrete Structures	112
	1	Quality Control Program.....	112
	3	Inspections Prior to Concreting.....	112
	5	Inspection of Batching, Mixing and Placing Concrete.....	113
	7	Inspections of Form Removal and Concrete Curing.....	113
	9	Inspection of Prestressing and Grouting.....	113
	11	Inspection of Joints.....	114
	13	Inspection of Finished Concrete.....	114
	15	Installation of Main Structure.....	114
	17	Records.....	115

1 Scope (1 July 2021)

This Chapter pertains to surveys during the construction and installation of an offshore structure. The requirements of this section are to apply to all structures covered by these Rules regardless of structural type. Additional requirements specifically for steel structures are contained in Section 5-1-2 and additional requirements for concrete structures are contained in Section 5-1-3.

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

For units classed with the designation (**Self-Installing Unit**), the requirements of Part 7, Chapter 1 of *ABS Rules for Building and Classing Mobile Offshore Units* are to be also applied, as applicable.

3 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 ABS for review. ABS 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 verify 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 ABS is a supplement to and not a replacement for inspections to be carried out by the Fabricator or Operator.

5 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.

7 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 is to be retained and made readily available during all stages of construction (see 5-1-2/23 and 5-1-3/17). Such data are to be available to the Surveyors upon request.

1 Quality Control Program

The quality control program (see 5-1-1/3) for the construction of a steel structure is to include the following items, as appropriate:

- i)* Material quality and traceability
- ii)* Steel Forming
- iii)* Welder qualification and records
- iv)* Welding procedure specifications and qualifications
- v)* Weld inspection
- vi)* Tolerances alignments and compartment testing
- vii)* Corrosion control systems
- viii)* Tightness and hydrostatic testing procedures
- ix)* Nondestructive testing
- x)* Installation of main structure

The items which are to be considered for each of the topics, mentioned above are indicated in 5-1-2/3 through 5-1-2/21.

3 Material Quality and Traceability

The properties of the material are to be in accordance with Part 2, Chapter 1 of these Rules. 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 Chapter 1 of the *ABS Rules for Materials and Welding (Part 2)*. 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 ABS. 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 ABS Surveyor. The Constructor is to maintain a material traceability system for all the Primary and Special application structures.

5 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 are to meet the minimums specified for the original material before forming. ABS will survey formed members for their compliance with the forming dimensional tolerances required by the design.

7 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, the *ABS Rules for Materials and Welding (Part 2)* 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.

9 Welding Procedure Specifications and Qualifications

Welding procedures are to be approved in accordance with the *ABS Rules for Materials and Welding (Part 2)*. 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.

11 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 Section of these Rules.

13 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 verify 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 are to be monitored to verify consistent production of quality welds.

15 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.

17 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.

19 Nondestructive Testing

A system of nondestructive testing is to be included in the fabrication specification of the structures. The minimum extent of nondestructive testing is to 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.

21 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 ABS Surveyor. All load-out, transportation and installation procedures are to be submitted to ABS for review and approval as described in Section 3-2-6.

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:

- i)* Load-out and Tie-down
- ii)* Launching, flotation, lifting and up-ending
- iii)* Positioning at the site and leveling
- iv)* Installation of Decks and Modules
- v)* Piling and Grouting
- vi)* Welding and Nondestructive Testing
- vii)* Final field erection and leveling
- viii)* 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 resubmittal of supporting documentation to provide an assessment of the significance of deviation and any necessary remedial actions to be taken.

To confirm that overstressing of the structure during transportation has not occurred, ABS is to have access to towing records to ascertain if conditions during the towing operations exceeded those employed in the analyses required in Section 3-2-6.

23 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, 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.

1 Quality Control Program

The quality control program (see 5-1-1/3) for a concrete structure is to cover the following items, as appropriate:

- i)* Inspections prior to concreting
- ii)* Inspection of batching, mixing and placing concrete
- iii)* Inspections of form removal and concrete curing
- iv)* Inspection of prestressing and grouting
- v)* Inspection of joints
- vi)* Inspection of finished concrete
- vii)* Installation of Main Structure
- viii)* Tightness and Hydrostatic testing as applicable (See 5-1-2/17)

The items which are to be considered for each of the topics mentioned above are indicated in 5-1-3/3 through 5-1-3/15.

3 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 weather tight 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 verify 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.

5 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:

- i) Consistency
- ii) Air content
- iii) Density or Specific Gravity
- iv) 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.

7 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 is not to be submerged until 28 days after placing. (See also 3-2-4/11.3.5.)

9 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 if the variation of measurements exceeds 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 completely fill the ducts.

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

11 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.

13 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.

15 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 ABS Surveyor. All load-out, transportation and installation procedures are to be submitted to ABS 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:

- i)* Load-out and tie-down
- ii)* Towing arrangements
- iii)* Positioning at the site
- iv)* Installation
- v)* Final field erection
- vi)* Pre-Tensioning

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

To confirm that overstressing of the structure during transportation has not occurred, ABS is to have access to towing records to ascertain if conditions during the towing operations exceeded those employed in the analyses required in Section 3-2-6. Results are to be submitted to demonstrate compliance with the reviewed design analysis.

17 Records

Reference is to be made to 5-1-2/23 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.

PART 5

CHAPTER 2 Surveys After Construction

CONTENTS

SECTION	1	Conditions for Surveys After Construction	118
	1	Damages, Failure and Repair.....	118
	1.1	Examination and Repair.....	118
	1.3	Repairs on Site.....	118
	1.5	Representation.....	118
	3	Notification and Availability for Survey.....	118
	5	Annual Surveys.....	119
	7	Special Periodical Surveys.....	119
	9	Continuous Surveys.....	119
	11	Reactivation Surveys.....	119
	13	Incomplete Surveys.....	119
	15	Alterations.....	119
	17	Self-Elevating Units Deployed as Offshore Installation.....	119
	19	Survey for Extension of Use.....	120
	21	Relocation of Existing Installations.....	120
	23	Survey After Severe Weather Event.....	120
SECTION	2	Annual Surveys	121
	1	General.....	121
	3	End of Design Life.....	121
SECTION	3	Special Periodical Surveys.....	122
	1	General.....	122
	3	Corrosion Protection.....	122
	5	End of Design Life.....	122
SECTION	4	Structural Deterioration.....	124
SECTION	5	Maintenance of Marine Growth.....	125

SECTION	6	Statutory Certification.....	126
SECTION	7	Crew Habitability on Offshore Installations (2016).....	127

PART 5

CHAPTER 2 Surveys After Construction

SECTION 1 Conditions for Surveys After Construction

1 Damages, Failure and Repair

1.1 Examination and Repair

Damage, failure, deterioration or repair to the classed structure, which affects or may affect classification, is to be submitted by the Owner or their representatives for examination by the Surveyor at first opportunity. All repairs found necessary by the Surveyor are to be carried out to his satisfaction.

1.3 Repairs on Site

Where repairs to the structure, which affect or may affect classification, 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. The above is not intended for routine maintenance.

1.5 Representation

Nothing contained in this section or in a regulation of any government or other administration, or the issuance of any report or certificate pursuant to this section or such a rule or regulation, is to be deemed to enlarge upon the representations expressed in the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1B)* and Part 1 of these Rules.

3 Notification and Availability for Survey

The Surveyors are to have access to a classed structure at all reasonable times. The Surveyors are to undertake all surveys on classed installation upon request, with adequate notification, from the Owners or their representatives and are to report thereon to the Committee. Should the Surveyors find occasion during any survey to recommend repairs or further examination, notification is to be given immediately to the Owners or their representatives so that appropriate action may be taken. The Surveyors are to avail themselves of every convenient opportunity for carrying out periodical surveys in conjunction with surveys of damages and repairs in order to avoid duplication of work. For the purpose of Surveyor monitoring, monitoring Surveyors are also to have access to classed offshore installations at all reasonable times. Such access may include attendance at the same time as the assigned Surveyor or during a subsequent visit without the assigned Surveyor.

5 Annual Surveys

Annual Class Surveys of the structures are to be made within three months either way of each annual anniversary date of crediting of the previous special survey or original construction 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 and special surveys such that all periodical survey due dates can be harmonized.

7 Special Periodical Surveys

Special Periodical Surveys are to be carried out at least once every five years. If a Special Periodical 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 Periodical Survey is not overdue by more than six (6) 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 Periodical Surveys so that the due dates for all periodical surveys can be harmonized.

9 Continuous Surveys

At the request of the Operator, and upon approval of the proposed arrangement, a system of Continuous Surveys may be undertaken whereby all the Special Periodical Survey requirements are carried out in regular rotation and completed within the normal Special Periodical Survey interval. For Continuous Surveys, a suitable notation will be entered in the *Record* and the date of completion of the cycle published. If any defects are found during this Survey, they are to be examined and dealt with to the satisfaction of the Surveyor.

11 Reactivation 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.

13 Incomplete Surveys

When a survey is not completed, the Surveyors are to report immediately upon the work done so that the Operator and the Committee are advised of the parts still to be surveyed.

15 Alterations

No major alterations which affect classification of the installation are to be made to a classed structure unless plans of the proposed alterations are submitted and approved by ABS before the alterations are undertaken. Such alterations are to be carried out to the satisfaction of the Surveyors. Nothing contained in this section or in a rule or regulation of any government or other administration, or the issuance of any report or certificate pursuant to this section or such a rule or regulation, is to be deemed to enlarge upon the representations expressed in Section 1B-1-1 of the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1B)* and the issuance and use of any such reports or certificates are to be, in all respects, governed by Section 1B-1-1 of the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1B)*.

17 Self-Elevating Units Deployed as Offshore Installation (1 July 2021)

Self-elevating Offshore Units will be subjected to surveys as applicable in these sections in addition to the applicable examinations required by the *ABS Rules for Building and Classing Mobile Offshore Units (MOU Rules)*. Surveys are to include Annual and Special Surveys with an underwater exam in lieu of dry-docking of the above mudline sections of the legs, mats, spud cans and platform twice in each five year Special Survey period in accordance with applicable sections of the *MOU Rules*. Spud cans and mats which will be located below the mud line will be considered inaccessible and fatigue, structural and

corrosion analyses are to be provided to justify the integrity of these inaccessible areas for the design life of the installation.

19 Survey for Extension of Use

Existing installations 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 platform. The extent of the survey will depend on the completeness of the existing survey documents. ABS will review and verify maintenance manual, logs and records. Any alterations, repairs, or installation of equipment since installation are to be included in the records.

Those survey requirements in Section 5-2-3 for the Special Periodical Survey have to be included in the survey for extension of use. The surveys generally cover examination of splash zone, inspection of above water and underwater structural members and welds for damages and deteriorations, examination and measurements of corrosion protection systems and marine growth, sea floor condition survey, examination of secondary structural attachments, risers and riser clamps. Special attention is to be given to the following critical areas:

- i) Areas of high stress
- ii) Areas of low fatigue life
- iii) Damage incurred during installation or while in service
- iv) Repairs or modifications made while in service
- v) Abnormalities found during previous surveys
- vi) An inspection report of the findings is to be submitted to ABS for review and evaluation of the condition of the platform

The need for more frequent future periodical surveys will be determined based on the calculated remaining fatigue life described in Part 4, Chapter 1 and past inspection results.

21 Relocation of Existing Installations

Existing installations that are classed at a specified location require special consideration when relocation to a new site is proposed. The Owner is to advise ABS of the proposal to change locations addressing removal, transportation and reinstallation aspects of the change. Survey requirements described in Part 5, Chapter 1 and 5-2-1/19, wherever applicable, is to be complied with in addition to an engineering analyses required to justify the integrity of the installation for the design life at the new location.

23 Survey After Severe Weather Event (1 July 2022)

In areas of the world where Tropical Revolving Storms or equivalent weather events are common, timely inspection of an offshore structure following Tropical Revolving Storms (such as hurricane, cyclone, typhoon, or similar) is critical before the operator re-mans the unit/facility and brings production back on-line. The inspection after a severe weather event may be conducted by the owner, and ABS is to be notified. The Survey Planning Document (SPD) is required to contain owner's above-water and underwater inspection procedures.

The API Bulletin "API BULL 2HINS: Guidance for Post-Hurricane Structural Inspection of Offshore Structures" can be referred to as a guideline for preparing the survey plan and procedures. For specific survey requirements, see Appendix 7-2-A6 of the *ABS Rules for Building and Classing Mobile Offshore Units (MOU Rules)*.



PART 5

CHAPTER 2 Surveys After Construction

SECTION 2 Annual Surveys

1 **General** *(1 July 2021)*

Each Annual Survey is to include a thorough visual examination of all above-water structure. 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 diver, underwater camera, submersible, or other suitable means, of the underwater structure, the sea floor, and the corrosion control system is to 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.

For Self-Elevating Units deployed as Offshore Installations, the requirements of 5-2-1/17 of these Rules are also applicable.

3 **End of Design Life**

The Annual Survey is also to include verification that the approved design life has not been exceeded. The Surveyor is to confirm the design life limits and the Engineering Office is to be consulted for verification. If the end of the design life has been reached, then the provisions of Part 4, Chapter 1 are to be applied and specific requirements for maintaining the class of the structure are to be obtained from the Engineering Office.

1 General (1 July 2021)

The requirements of the Annual Survey are to be met during the Special Periodical 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.

The testing, cleaning, and inspection services are to be provided by the Operator and monitored by a Surveyor. Divers carrying out structural inspections and nondestructive testing on the structures are to be suitably qualified.

Thickness gaugings are required to be taken at each Special Periodical Survey. Suspect areas including structures in way of the splash zone are to be gauged for thickness to the satisfaction of attending Surveyor.

For Self-Elevating Units deployed as Offshore Installations, the requirements of 5-2-1/17 of these Rules are also applicable.

3 Corrosion Protection

The Special Periodical 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.

5 End of Design Life

The Special Periodical Survey is also to include verification that the approved design life has not been exceeded. The surveyor is to confirm the design life limits and the Engineering Office is to be consulted for verification. If the end of the design life has been reached then the provisions of Part 4, Chapter 1 are to

be applied and specific requirements for maintaining the class of the structure are to be obtained from the Engineering Office.



PART 5

CHAPTER 2 Surveys After Construction

SECTION 4 Structural Deterioration

Where thickness measurement and visual examination show evidence of significant structural deterioration, the structural integrity of the structure for continuous use is to be justified by engineering analyses. Deteriorated structural members are to be modeled such that they will add hydrodynamic or wind loads to the platform, but will not continue the strength of platform.

Results of these analyses are to be submitted to ABS for review and approval. If the results show that overall structural integrity of platform is adequate, the deteriorated structural members may be left as it is. Otherwise the deteriorated structural members are to be suitably reinforced or removed and replaced with new materials having required dimensions and properties in accordance with approved procedure.



PART 5

CHAPTER 2 Surveys After Construction

SECTION 5 Maintenance of Marine Growth

During any Annual or Special Periodical Survey, assessment of the degree of marine growth is to be carried out. If 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. The Operator is to at least submit an in-place analysis to justify that the installation is capable of withstanding environmental wave loads resulting from the maximum marine growth that the Operator is prepared to maintain.



PART 5

CHAPTER 2 Surveys After Construction

SECTION 6 Statutory Certification

When ABS is authorized to perform certification on behalf of a governmental authority, or when requested by the Operator, requirements as specified by the governmental authority or Operator are to be certified accordingly, and the reports and certificates in accordance with those requirements are to be issued as appropriate.



PART 5

CHAPTER 2 Surveys After Construction

SECTION 7 Crew Habitability on Offshore Installations (2016)

See Sections 7-2-10 of the *ABS Rules for Building and Classing Floating Production Installations* for the survey requirements.