STRUCTURAL

DESIGN CRITERIA
(PART-I)

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Discipline Engineer	Discipline Head	Group Head			

CONTENTS

3.4.1 Introduction

Design criteria as used herein include all operational requirements and environmental data which could affect the detailed design of the platform. The design methods described herein shall be followed for design and detail engineering. Contractor's design methods shall only be applicable wherever methods not available in this design criteria. Structural design criteria described herein establishes the minimum requirements of design of fixed offshore platform as per the codes and standards listed here in. This Design Criteria has been prepared as a guide and to be followed during Detailed Engineering for the Platform Project(s) or any other project wherever applicable as per scope.

3.4.2 Scope

The scope of this document includes design philosophy and design parameters for design of fixed offshore platforms. The scope also includes design philosophy of modification jobs, special structures and riser clamps, conductor guides, conductors, riser protector, conductor protector, bridges etc. Environmental parameters, design loads, load combinations, permissible deflections etc. are included in the annexures. Design philosophy and parameters which are not included in this document then API RP 2A and other codes and standards listed in this document shall be applicable. Contractor's design methods shall only be applicable wherever methods not available in this document with the approval of the company.

3.4.3 Definitions and Terms:-

Table-1

Sr. No	Term	Definition
1	Fixed offshore platforms	A platform extending above and supported by the sea bed by means of piling with the intended purpose of remaining stationary over an extended period. It includes both substructure and superstructure
2	Substructure	The substructure consists of Jacket and foundation systems (Piling system) including Jacket appurtenance. Generally Deck stabbing point considered as top of the substructure
3	Superstructure	The term superstructure applies to the structural parts of the topsides facilities including decks, buildings module, helideck, module support frames and skids etc. All Structural framing of Decks including Deck legs, trusses and Crane pedestal etcetera are the main components of superstructure. The superstructure generally supports on Deck Stabbing points to transfer topside loads to substructure.
4	Topside	The term topside of a platform includes superstructure and equipment including all other facilities place on superstructure. Normally topside of a platform start at work point and ends at top of the topside.

5	In-service	Platform in-service design conditions are those, which pertain to the post installation phase of the platform life, and typically include in-place, earthquake, dynamics and fatigue considerations.
6	Pre-service	Design conditions those occur prior to platform operation and shall generally include load out, transportation and installation considerations.
7	Global load conditions	those considered in the analysis and design of the substructure, superstructure trusses and legs and module frames
8	Local load conditions	those considered in the analysis and design of plating, grating, beams, appurtenances and other individual members as applicable
9	Nominal weight of structure	excludes mill tolerances, inaccuracies, contingencies and tolerances due to weight growth
10	Datum weight of a structure	nominal weight increased to allow for mill tolerances, inaccuracies, contingencies and tolerances for weight growth
11	Splash Zone (only for corrosion allowance)	EL (-) 2.00 metre to TOS of jacket walkway.
12	Splash Zone (for marine growth)	EL(-) 2.00 metre to EL(+) 6.00 metre
13	Splash Zone (in general including consideration for protective coating)	EL(-) 2.00 metre to EL(+) 6.00 metre
14	Topside Primary structural member/ element	All truss members, deck primary beams/girders, crane pedestal and deck legs, Helideck main framing beams including trusses & Columns, vent/flare booms, etc.
15	Jacket Primary structural member/ element	All main legs, chords, skirt sleeves, vertical/inclined/ horizontal and vertical/horizontal diagonal bracing, launch truss (if required), piles, boat landings, riser protector, barge bumper and hanger clamp stubs, hanger clamps, transition pieces, shim plates, conductor framing with Conductor guide/Sleeve.
16	Topside Secondary structural member/ element	deck plate, grating, deck secondary beams, stringers, pipe/E&I/equipment support beams, walkways, ladders & stairs, and hand rails, monorail, access platform, crane boom rest.

17	Jacket Secondary structural member/ element	Boat landing secondary members, walkways, riser/ conductor guard, casings, installation aids, appurtenances with their supports, mud mat Plates with Beams and skirt pile guides.

3.4.4 CODES AND STANDARDS

3.4.4.1 Mandatory Indian Statutory Requirements

This document has been prepared to the International Standards; however, the Contractor shall also ensure that the Work is executed in accordance with all mandatory Indian Statutory and Regulatory requirements

3.4.4.2 Codes Standards & Regulations

The requirements of the latest (except API RP 2A –WSD & AISC) published versions of the listed codes, recommended practices, Specifications and standards given shall be met. All other relevant and related Codes concerning the specific job under consideration and/or referred in the above-mentioned Codes shall be followed wherever applicable. Any conflict between the applicable codes and these Design criteria shall be referred to the Company for resolution. Company's decision in this regard shall be final and binding on the Contractor.

List has been placed at **Annexure-3**.

3.4.5 Basic Information

3.4.5.1 Important constant – Refer Annexure-2.

3.4.5.2 Corrosion Zones

Table 2

	For structural design		**For CP Design system**	
	From Elevation (M)	To Elevation (M)	From Elevation (M)	To Elevation (M)
Atmospheric Zone	TOS of Jacket walkway	Upwards		
Splash Zone	(-) 2.0	TOS of Jacket walkway	Chart Datum	AT * + SS #
Submerged Zone	(-) 2.0	Mudline	Chart Datum	Mudline

3.4.5.3 Design Live Loads – Refer Annexure-4

3.4.5.4 System of Units

The SI system of units shall be used throughout the project. All dimensions shall be shown in millimeters and all levels shall be shown in meters.

3.4.5.5 Seabed Feature

The Jackets should be designed for seabed slope and to meet the installation tolerances. If the seabed slope is such as to tilt the Jacket by an angle exceeding 25 minutes, the slope shall be considered in design. Design of the Jacket should also consider mudslide, if any.

The slope in seabed, if any, shall be established by means of a grid survey of bathymetry of a region covering an area 500 meters beyond the footprint of substructure at mud-line using a grid line spacing of 25 meters, before or at the early stage of detailed Engineering. If the slope in seabed is such as to tilt the structure, the detail design shall take into account the slope in seabed in the form of adjustment in framing and/or mud-mat elevations.

3.4.5.6 Platform Configuration

The platform shall be sized and designed in accordance with the approved equipment layout and arrangement. Jacket size at work point level shall be firmed up based on approved equipment layout. Minimum Deck height shall be calculated considering minimum air gap as per API RP 2A. Other Deck height including helideck and building module etc. shall be as per approved equipment layout based on design requirement.

Providing of 'X' braces in between two Jacket horizontal framing in all bays are mandatory for process and LQ platforms. For well head platforms, 'X' braces are not mandatory and same shall be as per design requirement.

3.4.5.7 Chart Datum Level

All elevations shall be referenced to chart datum (0.0M). Chart Datum Shall be 2.51m below MSL. Contractor shall establish Chart Datum as per 3.4.6.1.

3.4.5.8 Platform Location and Orientation

The location and orientation of the platforms shall be as given in DC 3.4 Part – II.

3.4.5.9 Water Depth

The approximate water depths at platform locations are as given in DC 3.4 Part – II. Water Depth at the site of the works may be taken as indicative for preliminary work but the actual water depth shall be determined by Contractor during pre-engineering survey before the commencement of Detailed Engineering. For the design of substructure appurtenances, a provision for the variation of ±750 mm in the actual water depth shall be considered.

3.4.5.10 Marine Growth Thickness

The design of platforms shall include allowance for marine growth on all members of the jacket including Jacket appurtenances such as risers, caissons, conductors, etc. as per values furnished below:

Table-3

Elevation range (meter)	Marine Growth Thickness for all platforms with Design Life of 25 years (mm)	Marine Growth Thickness for WHPs with Design Life of 15 years (mm)
(+) 6.00 to (-) 2.00	150	100
(-) 2.00 to (-) 30.00	100	100
(-) 30.00 to Mudline	50	50

Note:

1. Marine growth shall also be considered for global analysis of boat landing, riser/conductor protector and barge bumper.

3.4.5.11 Geometrical Constraints

a. The top horizontal framing of the substructure shall be at minimum (+) 7.60M elevation above chart datum (CD) level, so as not to be in wave splash zone as defined 3.4.2 above.

b. Minimum air gap requirement shall be as per API RP 2A for computation of elevation of underside of deck. For this purpose still water level shall be CD + LAT + 100% AT + SS.

c. Wave forces on equipment piping, platform components placed below the Cellar/ lowest deck shall be accounted for as per API RP 2A.

3.4.5.12 Deck Heights

Space between the deck levels shall be sufficient to contain the process, utility systems and piping and provide adequate access for operations and maintenance as per approved equipment layout.

3.4.5.13 Corrosion Protection

All structures shall be designed to resist corrosion in different zones defined in the 3.4.5.2 in the following manner for the design life of the structures:

3.4.5.13.1 Corrosion Allowance

Additional external wall thickness (over and above the thickness required as per in-service structural analyses) shall be provided as corrosion allowance for structural members and other components only in splash zone. However, in submerged and atmospheric zone such corrosion allowance shall not be applicable. Splash zone for corrosion allowance shall be (-) 2 meter to TOS of Jacket Walkway level and corrosion allowance shall be as tabulated below:

Table-4

Location	All platforms with Design Life of 25 years (mm) (values are in mm)	WHP having Design life of 15 years (values are in mm)
All jacket Primary structural members.	13	8
All jacket secondary structural members of walkway level.	6	4
Barge Bumper, Boat Landing, Riser/Conductor Protector, Conductor guides, Mooring Chains, Pump casings & Sump Caissons, I-Tube/J-tube.	6	4

NOTE:

1. An additional internal corrosion allowance of 3mm shall be provided for the full length of Caissons, pumps casings.

2. Internal corrosion allowance of 3 mm shall be applied to the I-Tube/J-Tube wall thickness for the full length of I-Tube/J-Tube and bell mouth.

3.4.5.13.2 Cathodic protection

All Steel surfaces considering bare in the submerged zone and splash zone shall be protected against corrosion by a sacrificial anode system. The design conditions pertaining to cathodic protection system are given in Spec. FS 4001.

Contractor shall submit the design/ analysis of anode and anode location drawings to the company for approval. At initial stage of engineering, anode location/ position drawings shall be submitted along with jacket framing structural drawings.

3.4.5.13.3 Painting

In addition to corrosion protection specified in Para 3.4.5.13.1 and 3.4.5.13.2, all steel surfaces in the splash zone and atmospheric zone, including conductors, shall be painted in accordance with Spec. No. 2005 "Protective Coatings". All equipment, stairways and appurtenances such as barge bumpers, boat landings, riser protectors, and conductors at splash zone, etc. including their stabbing guides shall be painted irrespective of the applicable zone.

3.4.5.13.4 Structural Detailing

Areas and joints, which are inaccessible for maintenance and thereby susceptible to corrosion due to ingress of moisture causing crevice-corrosion, shall be suitably sealed by methods such as boxing with plates, etc. and design consideration as per ISO 12944-3.

3.4.5.14 Miscellaneous Accessories

Three identification boards, with name of the platforms shall be provided on North and South faces of the platforms and on the top of the helideck respectively. The details to be written on the boards shall be approved by the Company. The letters on the boards shall be at least 900 mm in size.

3.4.6 Pre-Engineering Survey

3.4.6.1 For New Platform

Prior to proceeding with detailed engineering Contractor shall perform a pre-engineering survey to confirm water depth, to ascertain seabed feature & properties topsoil for mud-mat analysis, existing platform location and orientation, tubular sizes on existing jacket for riser clamp installation, identification of space facilities under modification scope of exiting platforms and space for bridge landing. Obstructions, if any, found for installation of facilities under scope of work shall also be recorded in pre-engineering survey and to be resolved with technically feasible solution.

During Pre-Engineering Survey Contractor shall establish Chart Datum (CD) as per International Practice and Indian Spring Low Water (ISLW) with correlation between ISLW & CD.

3.4.6.2 For Modification/ revamping works

Contractor shall carry out pre-engineering survey of all Decks/ Jacket walkway/ boat landing areas/, etc. for collection of all necessary information regarding replacement of damaged/corroded Plating/ Grating/ Handrails/ supporting structural members/ Barge bumpers/ boat fenders/, etc. as per project specific scope**.**

3.4.7 Design Philosophy

The fixed offshore platform structure shall be designed for stability, integrity, structural adequacy and total safety both in Global and local analysis condition. In-service and pre-service design analysis for Platforms structure for adequacy check of each and every component of the platform structure. All the design analysis shall be carried out based on various loads and load combination defined in this document for extreme and operating environmental storm conditions. All structural analyses shall be performed using a suitable computer program applicable to the design of offshore structures. Mathematical model or Geometry of the platform structure shall be developed suite to specific site condition for design and analysis using suitable computer program. Structural analysis and design of topside, sub-structures, conductors, etc. shall be in accordance with the requirements of API RP 2A, AISC and other relevant codes & standards using working stress design methods. Jacket legs shall be designed as flooded member up-to the Designed Water depth. Pile shall be grouted with the jacket legs and or Skirt Sleeve. Foundation design analysis to be carried out along with Jacket in-place analysis. All pre-service analysis shall also be carried out based on approved installation philosophy. The extent of all the analyses shall be to demonstrate the adequacy of the structural components of the structures under all envisaged forces and anticipated loads at various phases. Analyses shall include but not limited to as stated below:

3.4.7.1 In-service condition analysis

3.4.7.1.1 In-place design analysis for Jacket (with piles).
3.4.7.1.2 In-place design analysis Topsides (Decks with Modules).
3.4.7.1.3 In-Place design analysis of Modules.
3.4.7.1.4 In-Place design analysis for Helideck.
3.4.7.1.5 In-Place design analysis of Jacket Appurtenances.
3.4.7.1.6 In-Place design analysis of Bridge.
3.4.7.1.7 In-Place design analysis of Deck appurtenance if any.
3.4.7.1.8 In-Place analysis of Special structures (Caisson etc.).
3.4.7.1.9 In-Place design analysis for piles Foundation.
3.4.7.1.10 Fatigue design analysis for Jacket & Pile only.
3.4.7.1.11 Seismic and Dynamic analysis.
3.4.7.1.12 FE analysis as per clause 3.4.16.4.22 for connection between Jacket Leg to Skirt Pile sleeve.

3.4.7.2 Pre-service condition analysis

3.4.7.2.1 Pile-drivability design analysis.

3.4.7.2.2 Conductor drivability design analysis.

3.4.7.2.3 Lift design analysis at yard for all lift units of platforms.

3.4.7.2.4 Lift design analysis at offshore for installation all lift units of platforms.

3.4.7.2.5 Load out design analyses for all components of platforms.

3.4.7.2.6 Transportation design analysis including sea fastening design for all units of platforms.

3.4.7.2.7 Jacket lift design analysis at offshore for Installation.

3.4.7.2.8 Jacket floatation and upending design analysis for Installation.

3.4.7.2.9 Jacket launch design analysis for installation as applicable.

3.4.7.2.10 Deck lift design analysis at offshore for Installation.

3.4.7.2.11 Module lift design analysis at offshore for installation.

3.4.7.2.12 Helideck lift design analysis at offshore for Installation.

3.4.7.2.13 Lift design analysis at offshore for installation for appurtenances.

3.4.7.2.14 Topside Float over design analysis for Installation as applicable.

Design Philosophy of Deck extension and modification works shall be based on this document and project specific requirement mentioned in structural design criteria part-II. The loads and load combination for design analysis shall be applicable as stated in this document.

3.4.8 Load Combinations

The minimum load combinations as stated at **Annexure-7** shall be considered in the Analysis for Design of the Platform structures. For other local and Global design analyses which have not been covered under this design criteria, the CONTRACTOR shall develop the necessary basic load cases and load combinations appropriate to the structure in accordance to respective specific International codes/ standards or Industry standard practice.

3.4.9 Permissible Stresses and Factor of Safety

3.4.9.1 Unless otherwise noted in this design criteria permissible stresses and factors of safety shall be as recommended in API RP 2A and AISC.

3.4.9.2 Increase in Permissible Stresses shall be allowed as stated at Annexure – 8.

3.4.10 Load Contingencies, Mill Tolerance and Weld metal

The Contractor shall accurately calculate the pre-service and in-service design loads as described in Sections 3.4.13 and 3.4.19 consisting of dead loads, piping and equipment loads (empty and operating), topside modules, utilities and any other loads to which the system will be subjected during fabrication, transportation, installation and operation, etc.

A minimum of 3% weight allowance to account for mill tolerance and weld metal shall be applied for all analyses. This allowance shall be added to the estimated substructure and superstructure dead weight.

Load contingencies shall be as per **Annexure – 9**.

3.4.11 Material

All materials shall conform to respective specification given in accordance with Spec. 6001F, General Specification for materials, fabrication & installation of structure.

3.4.12 Environmental Parameter

Environmental parameters of all fields have been furnished at Annexure – 13.

3.4.13 Design Loads

The loads described in the following section shall apply to the substructure (Jacket, pile, etc.) and topsides unless specified otherwise.

3.4.13.1 In-services condition

3.4.13.1.1 Structure Dead Load

The structure dead loads shall include the weight of all structural members including deck plate, grating, hand rails, bridge, architectural items, rubber, timber, anodes, etc.

3.4.13.1.2 Equipment Load

Equipment loads shall include the weight of all equipment, bulk material, piping, etc. These loads are to be developed based on equipment layouts. Two basic load conditions shall be considered for global design. These are:

a. Equipment & Piping Dead Weight
b. Equipment & Piping with Operating Contents Weight

For local design, hydrostatic test weights shall be considered, wherever applicable.

Other specific equipment loads are as specified at all relevant annexures.

3.4.13.1.3 Crane Loads

The Contractor shall determine the static and dynamic crane loads and use data provided by the crane manufacturer. The dynamic crane load cases shall consider a range or boom directions to ensure all possible lifting scenarios are adequately checked. A minimum of eight boom directions shall be considered.

3.4.13.1.4 Live Loads for Local and Global Design

The magnitudes of local and global live loads to be used in the in-service analysis and design shall be as defined in Annexure-4. For global analysis and design appropriate percentages of the live loads given for local beam design in Annexure-4 shall be used as specified in respective load combination tables given at Annexure-7.

3.4.13.1.5 Open Area Live Load

Open Area live Load as indicated at Annexure-4 as applicable, shall be used as specified in respective load combination tables given at Annexure-7. The Open Area Live Loads which shall be applied to all clear unoccupied areas of deck and internal areas of the Utility and Equipment rooms. The Open Area live loads shall be used in conjunction with equipment and crane loads for the design of primary and major secondary steel members. Open Area Live Loads should be combined with equipment weight data. Equipment weight as indicated in weight control report or as provided by the Equipment Vendor shall be taken.

3.4.13.1.6 Wind Load

Wind loads shall be calculated according to the requirements of API RP 2A. The wind area for global design of the Topsides shall be calculated assuming that the area between the decks is fully enclosed. Wind area(s) shall also include the equipment located other than above enclosed deck area. Design wind speeds are as detailed at Annexure-13.

a. A minimum of eight or twelve storm directions, depending on the configuration of jacket structure, shall be considered for each load case for the extreme storm and operating storm conditions. For unsymmetrical platforms or structures with skirt piles, the calculation of the environmental forces from additional directions may also be required as per API RP 2A.
b. Wind shall be assumed to act simultaneously and collinearly with wave and current forces.
c. Wind speeds should be adjusted for elevation and gust duration, in accordance with API RP 2A or as listed at Annexure-5.

3.4.13.1.7 Wave & Current Loads

Environmental parameters as defined in Annexure-13 shall be applied to maximize loading on all structural components. Analysis shall be performed for wave approach along grid directions and selected diagonal directions. For each direction of approach, the more severe of the environmental parameters of directions adjacent to it shall be selected from Annexure-13. A minimum of eight or twelve storm directions, depending on the configuration of jacket structure, shall be considered for each load case for the extreme storm and operating storm conditions as per API RP 2A. Waves and current shall be considered concurrent with wind.

The design wave shall be treated as a regular wave. 'Stokes' Fifth Order theory' shall be used to compute water particle kinematics, using apparent wave period computed as per API RP 2A. Wave kinematics factor as given in Annexure-13 shall be used to account for wave directional spreading or irregularity in wave profile shape.

The current speed in the vicinity of the platform shall be reduced by the current blockage factors. The wave particle kinematics multiplied by the wave kinematics factor and the current velocities adjusted for blockage, shall be added vectorially to obtain total velocity vector at any point. The given current profile shall be treated as applicable to water depth equal to still water level. For any other water level at different points along the wave, the velocities shall be calculated based on linear stretching of the current profile. Morison's equation applied to only the normal components of velocity and acceleration shall be used to compute normal wave forces on the individual members. The coefficients of drag and mass (inertia) Cd and Cm values shall be considered as per API RP 2A (i.e. 0.65 and 1.6 respectively for smooth surface and 1.05 and 1.2 respectively for rough surfaces).

Conductor shielding factors shall be considered as per API RP 2A.

At initial stage of engineering upto approval of drawing stage,

a. For Process/LQ platforms, anode effects shall be calculated by increasing Cd & Cm value by 15% on all items in submerged zone

b. For wellhead platforms, anode effects shall be calculated by increasing Cd & Cm value by 8% on all items in submerged zone.

The increase of Cd/Cm shall not be applicable to members in the splash zone since no anode is provided in this zone.

Final stage of Engineering In-place Analysis Anode effects shall be incorporated with calculated Cd & Cm values with respect to structural members. Trapezoidal Anode Cd value of 2.2 and Cm value of 2.51 considering equivalent square section.

3.4.13.1.8 Earthquake Loads

The earthquake loading on the combined Jacket and super structure shall be calculated using the response spectrum method and in accordance with the provisions of API RP 2A. The response spectrum data for this analysis shall follow the guidelines for Zone-IV (western offshore) & Zone III (Eastern offshore) earthquake area as given in Indian Standards IS-1893. The importance factor shall be taken as 2.0 and response spectra Type III to be considered to account for the soil foundation system. Contribution of the marine growth in the added mass shall be considered in the analysis. For building /equipment/ modules an equivalent static analysis shall be carried out with a horizontal seismic coefficient of 0.12.

Earthquake Forces, wherever applicable, shall be taken as occurring in both orthogonal horizontal directions and 50% in the vertical direction.

For the earthquake condition, Still Water Level shall be taken as CD + (LAT) + (50% of Astronomical Tide).

3.4.13.1.9 **Fatigue Loadings** has been described at 3.4.14.

3.4.13.1.10 **Vortex Induced Vibration**

Slender members of Deck, Vent Boom and Flare Tower, bridge, Helideck supports & framing members shall be checked for VIV for wind for in-service Condition & Transportation condition.

Slender members of Jacket shall be checked for VIV for current (in-service condition) and wind for Transportation condition.

3.4.13.1.11 **Wave Slam**

Structural members in the wave zone shall be designed for wave slam forces in accordance with API RP 2A. Bending stresses due to both horizontal and vertical slam forces shall be considered. One-third increase in permissible stress shall be allowed. However, the current velocity components should not be included in the wave kinematics when calculating wave slam loading. For X-braces, members shall be assumed to span the full length. Member lengths shall be reduced to account for Jacket leg ratio. The slam coefficient shall be taken as 5.5.

3.4.13.1.12 **Special Loads:**

Special load other than load specified in this document are specified in the DC 3.4 Part – II (if any) shall also be considered. Accidental load shall be considered as per API RP2A as applicable

3.4.13.2 Pre-service condition

Following Pre-service loads are to be considered for design:

3.4.13.2.1 Load(s) to be considered for Load-out analysis of Substructure and Topside

The proposed method of load out shall be determined by the Contractor and could be by means of continuous or discrete skids, wheel trolleys or by direct lifting. The following should be considered.

a) All dead and equipment loads together with weights for all preinstalled lifting gear, sea-fastenings, loose ship items, etc. should be considered. The loads should be based on the Weight Control Report.

b) For lifted Load out, refer to the criteria described in section 3.4.13.2.3.

c) Skidded or trolleyed load out:
Structures shall be loaded out onto the transportation barge by means of launch ways, continuous or discrete skids, and wheeled dollies. The structures shall be checked for adequacy for the proposed load out operation and for the effects of the localized loadings resulting from change in slope of launch ways/tracks and the change in draft of the transportation barge as the structure moves on to it.
The analysis for substructure to be loaded out on launch cradle shall cover the front end of launch cradle unsupported for various distances (barge moves downward), and two ends of the launch trusses supported (barge moves upward).
For structures loaded out on discrete skids or wheeled dollies, the analysis shall cover cases due to loss of support of one or more supports, including three point support conditions.
For other means of load out the analysis shall be based on the support conditions likely to be experienced.
If the support conditions envisaged during weighting of the deck/module are different from those considered for load out analysis, a separate analysis shall be performed with appropriate support conditions to ensure adequacy of the structure during weighing operations.

d) Bearing capacity of soil in fabrication yard shall be forwarded to design Consultant and taken into account in the analysis.

3.4.13.2.2 Load(s) to be considered for Transportation analysis Substructure and Topside

A. Preliminary transportation Analysis:-

All structures shall be checked for the inertia loads during sea transportation. Consideration shall be given to the support points used for sea fastening. The following should be considered.

a) Dead and equipment loads should be considered together with weights for all preinstalled lifting gear, sea fastening, loose ship items, etc. The loads should be based on the Weight Control Report.

b) For the preliminary transportation condition, pending a detailed transportation and barge motions analysis, the following inertia loads in addition to gravity load shall be considered.

Table-5

Barge Type	Single Amplitude (in 10 Sec. Period)		
	Roll	Pitch	Heave
Small cargo barge (L<76 m or B< 23m)	25º	15º	± 0.2g
Large barges	20º	12.5º	±0.2g
Small Vessel (L<76 m or B< 23m) *	30º	15º	±0.2g

* 20% shall be added to the loadings resulting from pitch motions for small vessels to cover the effect of slamming.

c) The transportation inertia loads shall be combined as:
± Roll ± Heave + W (Self Weight) [Beam Sea]
± Pitch ± Heave + W (Self Weight) [Head Sea]
± 0.8 Pitch ± 0.6 Roll ± Heave + W (Self Weight) [Quartering Seas]
± 0.6 Pitch ± 0.8 Roll ± Heave + W (Self Weight) [Quartering Seas]

d) The effect of wind load in addition to the above need not be considered.

B. Detailed Transportation Analysis

The design of all structures shall accommodate the forces imposed during transportation. The computer analysis shall be performed in accordance with the ABS or any other International Certification Agency rules along with the provisions given therein.

The final transportation analysis shall consist of the following:

I. **Static Stability of barge/structure system**:

a) Intact condition

b) Damaged condition with at least any one compartment of barge flooded.

Prevailing wind speed along the route at the time of transportation of the structure shall be established & considered for calculating the wind forces on the barge freeboard and cargo's surface area for

Intact and Damaged conditions respectively. Wind forces shall be calculated as per ABS Rules.

The following barge stability criteria shall be satisfied.

(i) The positive range of stability (ignoring strength or down flooding consideration) shall be in the range of 30º-40º.

(ii) The righting energy available to resists capsizing shall be at least 1.4 times the energy required by the designed wind to heel the vessel to the same critical angle.

II. **Dynamic motion response analysis for barge/structure system**: In order to determine the maximum loads imposed on the structure and sea fastenings during the course of voyage from fabrication yard to offshore site an analysis of the dynamic motion response for the structure/barge system shall be performed. This analysis shall include the following phases:

a) Determination of fundamental periods of Roll, Pitch, Heave, Yaw, Surge and Sway motions.

b) Response of the system for various sea states. (Ref.: Ocean Wave Statistics" by N. Hogben and P.E. Lumb)

The following shall be considered for the route specific dynamic motion analysis:

i) Wave direction: Beam, Head and Quartering Seas.

ii) The maximum sea state to be considered shall depend upon route of tow and season of tow.
The environmental conditions to be considered shall be based on an average recurrence period of not less than ten years for the season of year when the tow will take place.

iii) In order to obtain the maximum acceleration response, at least three sets of periods shall be chosen for the maximum sea state for each direction of approach depending upon the dynamic characteristics of the barge/structure system and the towing speed of barge.

iv) A reduced wave height (less than the maximum)/period combination, if that is likely to result in near resonant response conditions.

After obtaining the maximum response for various sea states, the structure shall be again analyzed for the corresponding maximum inertia/gravity forces.

Based on the above analysis, the Contractor shall be responsible for the design of sea fastening and the preparation of detailed sea fastening drawings.

Contractor shall also be responsible for verifying the strength of the cargo/launch barge deck and framing system to satisfactorily withstand the loads on it during load out and transportation. Any reinforcement to the barge deck or modification to the sea fastening/ load out arrangement to make the cargo barge safe for the operations is Contractor's responsibility. All engineering related to load out and transportation shall be subject to approval by a Marine Warranty Surveyor (MWS) as described in Spec.

6001F. Copy of approved procedure shall be made available to the COMPANY 30 days in advance prior to load out.

3.4.13.2.3 Lift Operations: Substructure (Jacket, pile etc.) and Topside

All structures shall be checked for the loads applied during lift operations in accordance with API RP 2A. The following shall be considered.

c) Dead and equipment loads should be considered together with weights for all preinstalled lifting gear, sea-fastenings, loose ship items, etc. The loads should be based on the Weight Control Report.

d) A dynamic factor of 2.0 shall be applied to the lift weight of the item for the design of lifting frames, pad/lifting eyes and adjacent members supporting the pad/lifting eyes.

e) A dynamic factor of 1.35 shall be applied to the lift weight for all other members transmitting lifting forces.

f) Where a four sling arrangement is used to lift the item, the analysis shall be carried out in two cases, first assuming all slings equally effective i.e. each diagonal carries 50% of the static lift weight and second with one diagonal sling carry 75% and the other diagonal sling carry 25% of the static lift weight. The dynamic factor for lifting pad eye design for second case i.e. for sling carrying 75%-25% static lift weight shall be 1.35.

g) Rigging shall be designed to limit the swing of the lifted objects within 2 degrees from horizontal about any axis. Static equilibrium during the lifting operation shall be ensured.

h) Structural deflections shall be limited for deflection sensitive equipment, buildings and other items as per **Section 3.4.16.1.3.**

i) For lift operation under marine environment, environmental condition for installation as in DC 3.4 Part – II shall be followed.

A complete three-dimensional idealized mathematical model of the structure shall be analyzed for the stresses developed during lifting operation to comply with the provisions of **API RP-2A.**

The bidder to provide list of major lifts as envisaged by him in the format furnished in DC 3.4 Part – II along with the marine spread proposed for installation.

During Detail Engineering the contractor shall perform a lift study to establish that the modules as conceived are lift-able with the proposed barge crane. This study shall include adverse combinations of variation in centre of gravity / weight. The lifting scheme including requirements of spreader frame shall be finalized based on this study. The weight control report generated shall form the basis of the study. A three-dimensional space frame lift analysis shall be performed for all structures to be lifted.

The load combination shall include appropriate skew load distribution between the two diagonal pair of slings to account for sling length variation.

If the subsequent weight control reports / actual weighing of the module indicate a weight increase of more than 5% and / or a shift in centre of gravity of more than 2% of the corresponding linear dimension, a revised lift analysis shall be carried out to ensure that the permissible stress are not exceeded due to the revised weight / centre of gravity. The analysis shall also be repeated if the framing arrangements of lifting scheme, spreader frame arrangement or components to be lifted are revised to an extent to affect the stress distribution in the structure.

3.4.13.2.4 Other Installation Loads

All structures and structural components shall be checked for all of the loads likely to be imposed during all phases of the installation. The imposed loads shall be appropriate to the method of installation.

3.4.13.2.5 Stab-in Guides and Installation Aids

All stab-in guides and bumpers shall be designed for the following loads, as a minimum:

1. Horizontal impact force = 10% of the static weight of the item.
2. Vertical impact force = 50% of the static weight of the item.

3.4.13.2.6 Fabrication Loads

All structural components shall be checked for the loads applied during fabrication. The CONTRACTOR shall determine details of the loads and the structure support points. Consideration shall be given to the support points used for weighing and load out. Wind loads shall be included with this load condition, appropriate for the site location.

3.4.13.2.7 Floatation and Upending

Flotation and Upending analyses is to investigate the stability, bottom clearance, derrick vessel hook loads and buoyancy requirements at successive stages of the Jacket installation.

3.4.13.2.8 Jacket launch analysis

Jacket launch analysis is a three dimensional launch simulation analysis for determining the jacket stability, bottom clearance and barge-jacket behavior.

3.4.13.2.9 Deck float over analysis

Deck float-over method is one of the deck installation method with single barge.

3.4.14 JACKET FATIGUE DESIGN

3.4.14.1 General

The tubular joints of the Jackets shall be analyzed for fatigue endurance in accordance with API RP 2A. For simplified fatigue analysis, a recalibration has been recommended based on changed tubular joint S-N curve and recommended SCF formulations. This is applicable for L-3 type platforms with natural periods less than 3 seconds constructed of notch-tough ductile steels and having redundant inspectable structural framing except first under water horizontal framing and horizontal framing near to mud line connected with mudmat.

A detailed fatigue analysis should be performed for all other type of structures. A spectral analysis technique shall be used to properly account for the actual distribution of wave energy over the entire frequency range.

Fatigue on account of inline thickness transition shall be carried out for Jacket. Fatigue Analysis for Pile shall be carried out both for In-service Condition and Pre-Service Condition. Pile wall thickness shall be selected such that Pile driving fatigue is minimized and the Pile meets the in-service Fatigue design Life with the factor of safety.

CONTRACTOR shall develop an appropriate fatigue analysis methodology and procedure to include wave selection, estimating stress concentration factors, fatigue S-N curves etc. and submit to the COMPANY for approval.

Further to analysis and design of tubular and non-tubular joints, the methods for weld improvement techniques and such other viable techniques may be resorted to improve the fatigue life.

Corrosion allowances as defined at clause 3.4.5.13.1 shall be halved for fatigue analysis.

3.4.14.2 Fatigue Life

The in-service Fatigue Life Safety Factors of the joints shall be as detailed below:

Table-6

Type of Platform	Fatigue Life Safety Factor	
	Jacket 2nd Level (1st under water Horizontal Framing upto splash Zone) & Mudline Horizontal framing & Piles in Mudline region	All other Levels of Jacket under water and Jacket walkway level primary to primary joints
Process & LQ	10	5
Well Head	5	2

Note: - 1. Design Fatigue life of Structure = (Fatigue Life Safety Factor) x (Design Life of Structure).

3.4.14.3 Loading

i) The environmental parameters to be used for computing the wave loading in the fatigue analysis shall be as given in DC 3.4 Part – II. All required input environmental data shall be generated from the supplied information and shall be used for the analysis after getting the same approved by the company.

The annual wave exceedance data for four orthogonal directions shall be as given in Annexure-13.

ii) Still water depth for fatigue analysis shall be taken as CD + SS + (LAT) + 50% AT. Data for SS, LAT & AT are provided in Annexure-13.

iii) Wave forces shall be computed in accordance with the procedure described in Section 3.4.7.7. Kinematics factors as 1.0, Conductor Shielding Factor 1.0 and hydrodynamic co-efficient as detailed below:

Table-7

	Smooth surface	Rough Surface
Cd	0.5	0.8
Cm	2.0	2.0

iv) Eight Wave Directions shall be considered for Fatigue Analysis. Each direction minimum ten wave height shall be used to compute Stress Range.

v) Ninety phase angle in each wave shall be used to determine maximum & minimum base shear.

vi) Stress range calculation shall be carried out at eight position of each wave. Out of eight positions one position is at maximum base shear, another position is at minimum base shear. Remaining positions shall be selected at equal interval between Maximum & Minimum Base Shear positions.

vii) For Well Platform: The Marine Growth thickness shall be as per Table no. 3 at 3.4.5.10.

3.4.14.4 Analysis Procedure

1) For each location around each member intersection of interest in the structure the stress response for each sea state should be computed, giving adequate consideration to both global and local stress effects.
2) The stress responses should be combined into the longtime stress distribution which should then be used to calculate the cumulative fatigue damage ratio. Alternatively damage ratio may be computed for each sea state and combined to obtain the cumulative damage ratio.
3) Factor of safety for fatigue design shall be applicable as the case in hand as per recommendation of API RP2A.
4) Other rational methods may be used provided adequate representation of forces and member responses can be demonstrated.
5) Grouted leg shall be considered with equivalent thickness as per #4.5 (b) of API RP 2A.

3.4.14.5 Stress Concentration Factors (SCF)

i. The fatigue lives at weld tubular joint locations shall be estimated by evaluating the Hot Spot Stress Range (HSSR) and using it as input in to the appropriate SN curves.

ii. For each tubular joint configuration and each type of brace loading,
SCF = HSSR /Nominal Brace Stress Range
In general SCFs depend on the type of brace cyclic loading (i.e. brace axial load, in-plane bending, out of plane bending) the joint type and details of the geometry. For all welded tubular joints under all three types of loading, a minimum SCF of 1.5 should be used and for Ring stiffened tubular Joints minimum SCF of 2.0 shall be used.
The Fatigue life on both the brace and chord side of the weld shall be calculated using finite element based formula proposed for K, T, Y & X joints by Efthymiou method for obtaining SCF applied to the brace nominal stresses.

iii. Ring stiffened joints:

In lieu of more accurate procedure for analysis these may be checked for simple joints but using modified chord thickness. The effect of ring stiffeners is twofold:

a) An increase in area of the chord, which may be accounted for by calculating the area of the chord shell plus stiffener and from this the effective shell thickness, which by itself will give the same area.

b) An increase in the stiffness of the chord which may be accounted for by calculating the moment of inertia of the chord shell plus stiffener and from this the effective shell thickness, which by itself would give the same moment of inertia.

For external ring-stiffened joints, a minimum stress concentration factor shall be used in Brace members as per API-RP-2A. Minimum SCF of 6.0 shall be used for externally ring stiffened joints.

Refer API RP 2A for SCF of internal ring stiffened joint.

iv. Overlap Joints:
Overlap Joints shall be eliminated for construction of new Platform.

v. Gusset Plate Stiffened Joints:
Gusset Plate Stiffened Joints shall be avoided for construction of new Platform.

vi. Stress Concentration Factor for inline thickness Transition for Tubular Joints and for misalignment of tubular shall be calculated in line with DNV C 203 code.

vii. SCF for Yoke Plate connection to Jacket & skirt Leg, Shear Plate connection between Jacket Leg, Skirt Leg & Yoke Plate shall be worked out through FE Analysis wherever such connections are applicable.

3.4.14.6 S.N. Curves

S-N curves in compliance to API RP 2A WJT / WJ Curve (without applying weld improvement technique) shall be used in the evaluation of fatigue life, which shall be achieved during Pile configuration stage.

S-N Curve as per DNV C203 for Sea water with Cathodic Protection shall be complied to determine fatigue Life for:

a) Inline thickness Transition for thickened Joint CANs,

b) Yoke Plate connection to Jacket & skirt Leg, Shear Plate connection between Jacket Leg, Skirt Leg & Yoke Plate wherever such connections are applicable,

c) Pile fatigue:
Design fatigue life listed in Table under Clause No. 3.4.14.2 shall be followed for the respective zones.
Offshore version for Pile Drivability Analysis shall be used to calculate Pile fatigue.

3.4.14.7 Marking of Joints
Deleted

3.4.15 FOUNDATION DESIGN

3.4.15.1 Soil Data

The soil investigation reports of all the platform locations are included as indicated at DC 3.4 Part – II.

3.4.15.2 Foundation Type

CONTRACTOR shall design the foundation system, appropriate to the structures and soil conditions that meet the requirements of API RP 2A. The foundation system shall be sufficient to develop adequate capacity to resist the maximum computed loads with an appropriate factor of safety in accordance with API RP 2A.

The minimum Factor of Safety (FOS) for a pile foundation shall be 2.0 under operating storms and 1.5 under extreme storm as stipulated in API RP 2A.

In cases where Piles are terminated in Sand Layer, Underlain by clay layer, pile tip shall have minimum clearance of 3 pile diameter above the bottom of Sand Layer.

Pile Self Weight and Soil Plug shall be accounted for computation of Pile Factor of Safety. Company shall provide relevant geotechnical data for any particular pile size required during detailed engineering.

3.4.15.3 Scour

The minimum scour depth around Jacket leg/piling shall be the greater of: -

a) 1.5 times the pile diameter, or

b) The depth computed/stated in approved geotechnical reports.

For Scour depths more than 2 X Dia. of pile, global analysis shall be carried out.

3.4.15.4 Under-drive and Overdrive Allowance

A minimum Overdrive of 3 meter for LQ/Process platforms and 1.5 meter for wellhead platforms shall be considered to account for soil lateral variation.

The pile wall thickness make-up shall be designed to allow for the possibility of pile driving refusal prior to design penetration and overdrive beyond design penetration. The minimum under drive and over drive allowance shall be submitted to COMPANY for approval.

3.4.15.5 Pile Group Effect

Consideration should be given to the effects of closely spaced adjacent piles on the load and deflection characteristics of pile groups. Generally, for pile spacing less than eight diameters, group effects have to be evaluated. Minimum spacing (center to center) of any two pile shall be 3 times the larger pile diameter.

Pile Group Axial Capacity

Piles embedded in clays, the group capacity may be less than a single isolated pile capacity multiplied by the number of piles in the group; conversely, for piles embedded in sands the group capacity may be higher than the sum of the capacities in the isolated piles. The Pile Group Axial capacity shall be calculated using H. G. Poulos & E. H. Davis Method.

Pile Group Settlement

The group settlement in either clay or sand would normally be larger than that of a single pile subjected to the average pile load of the group.

Pile Lateral Behaviour

For piles with the same pile head fixity conditions and embedded in either cohesive or cohesion-less soils, the pile group would normally experience greater lateral deflection than that of a single pile under the average pile load of the corresponding group. The major factors influencing the group deflections and load distribution among the piles are the pile spacing, the ratio of pile penetration to the diameter, the pile flexibility relative to the soil, the dimensions of the group, and the variations in the shear strength and stiffness modulus of the soil with depth.

Following methods to be the most appropriate for use in designing group pile foundations for the given loading conditions:

The Focht-Koch (1973) method [1] as modified by Reese et al. (1984) [2] for defining group deflections and average maximum pile moments for design event loads. Deflections are probably under-predicted at loads giving deflections of 20% or more of the diameter of the individual piles in the group.

Reference:

1. FOCHT, J. A. and Koch K. H (1973), Rational Analysis of the Lateral Performance of Offshore Pile Groups, Proceedings from the 5th Annual Offshore Technology Conference, OTC 1896, Houston, Texas, April/May, 1973.
2. REESE et al. (1984), Analysis of a Pile Group under Lateral Loading, Laterally Loaded Deep Foundations: Analysis and Performance, ASTM, STP 835, pp. 56–71.

3.4.15.6 Shear Keys

Shear keys on piles and the pile sleeves shall be provided. Shear keys shall be designed in accordance with **API RP 2A** and with the following considerations:

a) Load transfer should be considered only through the length over which the shear keys of both pile and leg/sleeve, of jacket, overlap including under drive/overdrive conditions.

b) Design strength of grout shall be taken as 17.25 Mpa whereas the actual grout strength during installation shall not be less than as specified in Spec. 6001 F.

c) Shear key shall be continuous hoop type and uniformly spaced.

d) Skirt sleeve Shear key length at mudline zone shall not be considered for shear key design calculation. This length shall be minimum of (i) two meter from mudline or (ii) one times diameter of pile from mudline. Similarly top one meter of Skirt sleeve shall not be considered for shear key design calculation.

3.4.15.7 Pile Installation

a) Drivability

Drivability Analysis shall be carried out for Hammers designated for Driving. Also the Drivability Analysis shall be carried out for Hammers to be used for Refusal Mitigation. During detail Engineering Pile shall be designed both for (a) Hammer Designated for Driving and (b) Hammer designated for Refusal mitigation.

i) Hammer Designated for Driving

Based on preliminary drivability studies the bidder to list set of hammers proposed to be mobilized by them (Refer DC 3.4 Part – II) to drive the piles proposed in their conceptual design to the design penetration. During detail engineering the Contractor shall perform a detail pile drivability analysis using stress wave equation procedure to ensure that the piles as proposed in his design are drivable to the design penetration with the hammers as listed in DC 3.4 Part – II**.** The Contractor shall also design the pile wall thickness requirements and add-on lengths of the piles from drivability, dynamic and static stress considerations.

For this purpose the analysis shall be done for each type of pile and for each combination of pile/add-on geometry and hammer at discrete penetrations for the full length of each pile. The pile shall be checked with its tip both plugged and unplugged for a range of hammer size with range of Pile minimum Wall thickness for continuous driving & for set up for small duration for pile segment add-on. Both Lower and Upper bound drivability Analysis shall be carried out for Plugged & unplugged driving.

In order to make the pile drivability smooth, Pile impedance needs to be increased. This will facilitate mobilization of lesser capacity Hammer. Lesser the pile impedance, higher is the driving stress and higher the Pile driving Fatigue. Therefore, Pile D/T Ratio of Pile shall be planned less than 60.

Pile shoe length shall be more than one time diameter of pile. Pile shoe thickness shall be minimum 1.5 times the thickness of pile (minimum of all segment of pile).

Maximum 90% hammer efficiency shall be considered during pile drivability analysis for sizing of Hammer.

Plugged Driving: External Skin friction is active + Pile full Cross-section area is active for Bearing.

Un-Plugged Driving: Pile External Wall Skin friction is active + Pile Internal Wall skin friction is active + Pile annulus area is active for Bearing.

ii) Hammer designated for Refusal mitigation (Refer **clause 5.6 of part II of volume I of bidding documents).**

Both Lower and Upper bound drivability Analysis shall be carried out for Plugged & unplugged driving with soil set-up condition.

iii) Conductor Driving

Contractor shall also perform a detail drivability analysis in line with point i) above (read with note- 5 at Table-II of Annexure-10 and conductor wall thickness given as one inch) for the conductors to ensure the conductors are drivable to the design penetration using Hammers specified in Structural Design Criteria, Section 3.4 Part – II of Bid .

OTC Paper 3274 relates to Pile driving experience of Mumbai Offshore. OTC Paper 4205 may be referred regarding consideration of internal friction and general guideline for reference.

b) Pile Section Length

Pile section lengths shall be selected in accordance with **API RP 2A.** Consideration shall also be given to the Contractor's proposed marine spread and the allowable stick-up length for the hammers to be used. The pile make-up shall be planned to avoid pile add-ons when the pile tip is nearer than 3.0m from a stratum where hard driving is expected.

c) Pile Run Down Evaluation

The Contractor shall perform the pile run down evaluation under the following conditions as a minimum requirement. Contractor may also employ any other method suitable to the pertinent soil condition to estimate pile run down.

i) When soil resistance to driving (SRD) is less than the static weight of pile and or pile plus hammer.

ii) When total work done by the pile against soil resistance is less than the potential energy lost by the pile due to free drop

iii) When blow count during initial driving is less than two blows per 30 cm

Drivability Analysis of Conductor shall be similar to that of Piles (with consideration outlined vide Note- 5 at Table-II of Annexure-10 and conductor wall thickness given as one inch).

d) Pile monitoring System with restrike Test:

Bidder shall deploy dynamic pile monitoring system during installation of piles at offshore for all piles (main and/or Skirt) for monitoring the energy transfer to the piles and efficiency of hammer & driving system as well as the pile stresses. Pile monitoring system shall have valid calibration. Adequate standby arrangement for pile monitoring tools & Systems shall be made available at the barge. A procedure for pile monitoring shall be submitted to the company for review.

Refer Spec 6001F for Re-strike Test & further details.

3.4.15.8 Soil Disturbance

Disturbed soil conditions upon withdrawal of jack-up rig shall be considered for the front row piles of well platforms. Disturbed zone shall be equal to the full depth of the estimated jack-up rig footing penetration. The estimated jack-up rig footing penetration shall be as given in DC 3.4 Part – II**.** The sensitivity of the soil in the disturbed zone shall be as given in the soil report. The Contractor shall generate all necessary data for use in the analysis.

3.4.16 DESIGN PROCEDURES

3.4.16.1 Design Requirements

3.4.16.1.1 General

a) Structural design shall conform to the relevant codes listed under clause no-3.4.2 of DC-3.4 part-I, in particular **API RP 2A and AISC**, and other relevant standards and codes.

b) Structural design shall be based on working stress design

c) Where code checks are not applicable, allowable stresses shall be computed using rational procedures and appropriate factors of safety.

d) Major rolled shapes shall be compact sections as defined by AISC.

e) The minimum thickness of structural plates and web of rolled sections as defined by AISC should not be less than 6mm.

f) The minimum thickness of flanges of rolled sections as defined by AISC should not be less than 6mm for secondary member and 10 mm primary members.

g) Deck floor plate shall be chequered type with a raised pattern surface and the minimum thickness should be 8 mm. and deck plating on building module shall be minimum 6 mm. Slope of 1:100 shall be provided at roof top of building module. Deck plating thickness in lay down area shall be minimum 10mm.

h) The minimum thickness of Jacket tubular should be 12 mm except in the splash zone where minimum thickness shall be: 12 mm + applicable corrosion allowance as per clause 3.4.5.13.1.

i) The minimum thickness of deck truss tubular should be 8 mm.

j) Spacing of secondary beams supporting Clear span of plating should not exceed 1200mm.
Plates shall be reinforced if concentrated loads are directly placed on plating.

k) Clear span of grating should not exceed 750mm. Gap between two adjacent gratings which are not supported on beams/tubular shall not be more than 10mm. Gap between two adjacent gratings which are supported on beams/tubular shall not be more than 25mm.

l) Vibration should be considered for any structure supporting major rotating machinery. The structure shall be designed in such a way that the natural frequency of the supporting structure is less than 70% or greater than 140% of the equipment operating frequency. Contractor shall demonstrate this aspect suitably, wherever applicable, during detailed engineering.

m) Member stresses due to aspects which are not specifically covered in the computer structural analysis shall be investigated by manual calculations and results combined with computer results to ensure that the stress and deflection limitations are not exceeded.

n) All major structural members shall meet the following guidelines:

1. Slenderness ratio (K*L/r) of Diagonal Member of Vertical framing shall be limited to 80 and $(Fy*D)/(E*t) \leq 0.069$ for all platforms. Slenderness ratio (K*L/r) of other members are ≤ 100. The buckling coefficient K shall be chosen for each member in accordance with API RP 2A recommendation.
2. Member slenderness ratio: K l/r $\leq$100. The buckling coefficient K shall be chosen for each member in accordance with API RP 2A recommendations.
3. Rolled tubular member diameter to thickness (D/t) ratio: $20 < D/t < 60$.
4. Diameter to thickness (D/t) ratio of Un-grouted Jacket Legs shall not exceed 50. Alternately Piles are grouted to the Jacket Leg for the full length of Leg.
5. In case of concentric tubular for jacket grouted legs with piles the: D/T for tubular for jacket legs shall be ≤ 100.
6. For grouted joints the effective thickness shall be calculated using root mean square formula and limited to 1.75 times outer shell thickness.

o) Use of sections back-to-back, battened and lattice type built up sections shall not be permitted, in order to avoid areas difficult for maintenance.

p) Adequate access for inspection, surveillance, maintenance and repair shall be provided as per ISO 12944-3.

q) The clear gap between conductor and conductor guide shall be minimum 50mm.

3.4.16.1.2 Connections

I. <u>Welded Connections</u>

Basic design philosophy is the member should fail first than joint in compliance to API RP 2A. All connections shall be designed as welded joints. The joints required for removable type structural members shall be considered as bolted joints as approved by the COMPANY during detailed engineering.

a) **Tubular Joints**

Tubular joint design and detailing for both pre-service and in-service conditions shall be in accordance with API RP 2A and shall be designed and detailed as simple joints as per API RP 2A. Overlapped Joint shall not be provided for New Platform construction.

b) **Non-Tubular Joints (Hybrid joints)**

i) Beam to tubular column connection

Combining rolled wide flange sections with tubular sections as used in module trusses, plate girder or wide flange joints shall be designed in accordance with AISC and API RP 2A using rational engineering methods considering leg/column as through member with Ring Stiffener (External and or internal). The joint shall be designed for full capacity of connecting Beam Flange. Joint shall also be checked for Maximum Loads under Pre-Service Analysis

ii) Truss joint connection between tubular brace and beam

Truss brace to chord joints shall be designed for transfer of axial loads from one brace to another across the truss chord in shear. The stiffeners shall be designed to carry in compression the permissible axial tensile load of the brace.

c) **Ring Stiffened Joints**

Appropriate closed ring solutions shall be used to design launch leg ring stiffeners at deck leg/girder intersections as per the provisions of API RP 2A. Such external ring stiffeners shall not be applicable to other tubular to tubular Joints. At Deck Leg(s) / Girder intersection (s) and at Deck / Module lifting Points, external ring and or internal stiffeners may be provided. Design shall be based on Roark’s ring formula in combination of AISC guidelines. Full capacity of Beam flange shall be used for design calculation and critical position of Pre-service Analysis. Full penetration weld shall be provided between Tubular and Ring stiffener.

d) Cross joints, Launch leg joints and other joints in which the load is transferred across the chord shall be designed assuming an effective width of the chord equal to 1.25 times chord diameter, on each side from the centerline of the extreme incoming brace(s) or length of the can whichever is less.

e) Inter coaster Beam Connection: All primary beam of equal depth shall have inter-coaster connection with full penetration weld between web to web and flange to flange. In case of Primary Beam connection for unequal depth have

inter-coaster connection with full penetration weld between web to web, flange to flange (top) and Flange to web.
Web having full penetration weld from both side, such web shall be provided with steel having through thickness property.

f) The connection of top flange of secondary beam with top flange of primary beam shall be full penetration weld. The connection of web and bottom flange of secondary beam with web of primary beam shall be fillet weld from both sides. The bottom flanges of secondary beams shall not be sniped.
g) The connection of stiffeners with flanges of beams shall be full penetration weld & with webs of beam shall be fillet weld from both sides.
h) A drain hole minimum 30mm shall be provided at the bottom of stiffener for drainage of water.

II. Bolted Connection
Bolts specified in Spec 6001F or any other document shall be designed as per AISC guideline.

Bolt Design in Atmospheric Zone:
Bolted connection at the atmospheric Zone shall be designed as non-slip Bolt. Minimum pretension value shall be applied in complied to AISC and pre-tension value shall be specified in the drawing so that same is applied during installation.

Bolt Design in splash zone and submerged zone:
Bolted connections are applicable for supporting Riser, I-Tube or J-Tube.
Bolted connection in splash zone and submerged zone shall be designed for both non-slip bolted joint and Slip Critical bolted joint. In this zone Bolt shall experience cyclic load on account of wave, which shall create fatigue in bolts. Bolts design does not require Fatigue analysis provided Bolt UC ratio are maintain below 0.8.
Designed bolt Pre Tension value shall be derived from maximum of Pre Tension calculation (Torsion, Transverse Shear (combined with torsion), Longitudinal Shear, Pull-off, Effect of member axial stress with Factor of Safety for frictional resistance of 1.5) and Radial Contact Pressure as applicable (Longitudinal Moment, Transverse Shear, Pull –off & Effects of Axial Member Stress with safety factor for Tension due Radial Pressure of 1.2). 20% Bolt relaxation value shall be added with designed pre tension value for Bolt pre tension carried out in one go. Accordingly, 20% gap between bolt full pre tension value & Designed Pre Tension Value shall be maintained. Also minimum pre-tension Criteria need to be met as per AISC.
Clamp Flange Plate and connecting stiffeners shall be designed for bolt full capacity. Welding of Flange Plate to stiffener shall be full penetration Weld from both sides. Flange – stiffener compactness shall be checked. Welding between Stiffeners to Clamp Shell shall be partial penetration weld from both sides. Welding between Flange plates to Clamp Shell shall be full penetration weld from both Sides.

3.4.16.1.3 Deflections
Following Deflection shall be complied for Design of Platform:
i. Horizontal/lateral deflection of platform at mudline

a. The Horizontal framing deflection under operating storm condition at mudline shall be maximum D/10 where D is diameter of pile.

ii. Vertical Deflection for Top Side:
Deflection shall be limited to criteria & equipment operating requirements specified by equipment suppliers or the following, whichever is less:
Deflections shall be checked for the actual equipment live loads and casual area live loads pattern. Deflection shall be within limit as specified at annexure-12.

3.4.16.2 Pile Configuration Proposal

Pile configuration proposal complying bid specified requirements shall be submitted on frozen of Equipment Layout with following:

i. Structural Analysis Model Soft Copy in software format.
ii. Cd & Cm value to be increased by 15% for Process/LQ platforms and 8% for Wellhead Platforms to account for anode effect.
iii. Pile Force extracts.
iv. Pile Factor of Safety Calculation with accounting for self-Weight of pile & weight of Soil Plug.
v. Deflection extract (a) for Pile, (b) at Jacket Leg joints at mudline framing and (c) at Jacket Leg joints at jacket walkway framing.
vi. Selection of Pile wall thickness based Hammers (designated for driving & refusal mitigation Hammer) supported with Pile Drivability Analysis (soft copy in soft format).
vii. Design shall comply with the consideration like Flooded Legs & Grouted connection between Pile & Jacket Structure (Legs and or Skirt sleeve).
viii. On-Bottom Stability Analysis philosophy shall be addressed (regarding use of Stability Tanks and its removal post installation).
viii. Extract of Fatigue Analysis Report with SACS Model input Files.

NOTE: Pile material shall be ordered after design of Pile wall thickness with respect to Hammer mobilization (Both for Designated & Refusal mitigation Hammer).

3.4.16.3 Structural Analysis

All structural analysis shall be performed using a suitable structural analysis computer program. The datum for the axes should be the Chart Datum. The modeling techniques used should be appropriate for the structure being analyzed and in conformance with proven industry practice. All analyses shall be performed with the same Computer Program and should utilize the same base model. i.e. the in-place analysis.

The in-place analyses shall include a combined Jacket and Topsides model to ensure correct soil- pile stiffness interaction.

The Jacket model should consider the effect of environmental loads on the appurtenances including anodes, boat landing, barge bumpers, conductors, risers and riser guard, etc.

<u>UC shall be as below:</u>

<u>For Well head platforms:</u>

All UC ratios of platform structural members, joints and piles shall be as per API RP 2A.

For Process/LQ platforms:
UC ratios of platform structural members, joints and piles shall be restricted to 0.95. Deck Leg and all knee brace members and Joint UC ratio shall be restricted to 0.85.

For all type of platforms:
Deck Leg at knee Brace Joints shall be designed to have 100% Brace Capacity. Strength UC for other joints shall be as per API RP 2A.

3.4.16.4 Miscellaneous Design

3.4.16.4.1 Deck Plate and Grating Design

The local design of deck plating and grating shall be based on the applicable loads defined in applicable annexures of this document.
Deflection of plating shall be not greater than the minimum of L/250 and half the thickness of plate.
Deflection of grating shall be not greater than L/200.
Where "L" is distance between points of supports.

3.4.16.4.2 Beam and Plate Girder Design

The local design of beams and plate girders shall be based on the applicable loads defined in applicable annexures of this document. These shall be designed in accordance with **AISC** specification and shall incorporate the following guidelines.

1. All plate girders shall be compact sections as defined by AISC.
2. Web, Top and bottom flanges at a given section shall be of the same grade of steel and symmetric about the beam's axes.
3. Deflection shall be limited to the criteria specified in Section **3.4.16.1.3.**
4. Welding between flange & web of plate girder/ box girder/ built up girder shall be full penetration weld.

3.4.16.4.3 Handrails, Walkways, Stairways and Ladders

Handrails, walkways, stairways and ladders shall be designed in Accordance with as specified below:

i. Handrail
   a) Handrails shall be provided around the perimeter of all open decks and on both sides of stairways.
   b) Handrails around the perimeter of lay down areas, loading and unloading areas shall be removable type.
   c) The top rail of the handrail shall be supported at maximum 1500 mm intervals. Height of top rail shall at 1100 mm from plating/grating level.
   d) For Cellar Deck & Above: Handrails shall be designed to withstand 100 kg concentrated load acting vertically or horizontally at any point.
   e) Handrails in the wave zone shall also be designed to withstand extreme storm maximum wave loading.
   f) Clear Gap between two handrail posts shall be maximum 50mm.

ii. Walkway, Stair Way

a) Walkways, stairways and landings shall be designed for the following load combinations.
   1. Dead load + live loads
   2. Dead load + extreme storm three second wind gusts and/or extreme storm maximum wave whichever is applicable

b) Stairways shall be provided with Tubular stringer beam with plates for supporting the treads. However, Rolled section is also applicable for stairways stringer beam above Cellar Deck. Stair ways shall be provided with grating treads and hand rail (in compliance to Spec 6001F). The minimum clear width of stairways and walkways shall be 1200 mm for process Platform and 750 mm for un-manned /well platform measured between inside of Handrail.

c) Walkway and stair tread grating shall be seal welded/fillet welded from all around to structural members to prevent crevice corrosion.

d) Stairways in escape routes shall be designed to allow for transportation of injured personnel by use of standard stretchers.

e) Stair Treads shall withstand a foot load of 2000 N (200 kg) on an area of 100 mm x 100 mm at any position without permanent deflection.

f) All treads shall have a toe plate of minimum 50 mm height. All landings shall have a toe plate of minimum 100 mm height. Openings between toe plate and decks or gratings shall not exceed 10 mm.

g) There shall be a maximum of 16 risers in any single stair flight (except Adjustable Stair from Jacket Walkway to Sub-Cellar Deck).

h) Nosing shall be provided to the treads of staircase. All nosing shall have a non-slip surface.

i) Riser height shall be between 150 mm to 175 mm.

j) Maximum Stair angle with horizontal shall be 38°. For adjustable stair maximum slope shall be 45°**.**

k) Width of tread shall be 250 mm minimum excluding nosing/overlap.

l) The Projection of Treads shall overlap /nose one another with minimum 20 mm.

iii. Vertical Ladder:

Minimum width of vertical ladder shall be 450 mm. 20 mm Diameter Rung shall be provided at 250 mm interval. Rungs shall be slotted through the end supports and welded all around the Rung.

Vertical ladders shall be provided with Cage protection when height of Ladder exceeds 3000 mm.

All stairs extending to the substructure walkway level shall be adjustable in length to suit site conditions.

Material for handrails, Kick plates, Walkway gratings, Stairways treads and landing area grating shall be of stainless steel as per Spec 6001F, above from boat landing area to below cellar deck level.

The inclined ladder shall be at angles of 50 degree to 75 degrees from the horizontal.

iv. The Stair in restricted area shall be designed as per OSHA 1917.120 (b) (5) Guidelines. The Stairs shall

1. be at angles of 50 degree to 75 degrees from the horizontal
2. be capable of a single concentrated load of 890 N at the tread centers;

3. have open treads with minimum width of 100 mm with rounded edge.
4. have treads shall be uniformly spaced & have vertical rise between treads of 150 mm to 250 mm.
5. handrails on both sides and that are not less than 750 mm in height from the tread surface at the riser face.
6. Have minimum clear width of 600 mm.

3.4.16.4.4 Access Platforms

Access platforms shall be provided, where required, to allow personnel easy and safe access in elevated locations as per approved equipment layout. Access platforms shall be designed for live loads described in this document and any piping or other imposed loads.

Minimum clear height of access platform from top of plating to bottom of beam shall be as specified elsewhere in the bid.

3.4.16.4.5 Cranes Pedestals

The crane pedestals and the supporting structure shall be designed in accordance with API RP 2A and API SPEC 2C except that the impact factors shall conform to design requirements for the cranes. The supporting structure is defined as the pedestal and all members directly connected to the pedestal.

The deflection of the top of pedestal from the supporting deck shall be limited to H/200 under design loads, where H is the height above the deck. The maximum deflection of loaded condition shall be within limit as specified by the swing bearing manufacturer.

The material for pedestal shall meet or exceed the requirements of API Spec 2H Gr.50Z steel (API 2H-50Z).

Crane pedestal shall be located in elevation and plan such that the crane operator will have a clear line of vision to the deck of supply boat and to the cargo landing zone on the platform.

The fatigue life of crane pedestal and support structure shall be calculated in accordance with API RP 2A for minimum 25000 cycles.

Crane boom rest shall be designed for the maximum loads to which they are subjected when the boom is in stowed position and during the cyclonic and seismic environmental conditions.

3.4.16.4.6 Fire Walls

A firewall / barrier wall with passive fire protection between well head area and process area shall be installed. The fire ratings for the firewall partitions as covered in the scope of the work for walls, ceilings and floors shall be determined by CONTRACTOR following the platform safety case/risk assessment studies. The fire protection system for firewalls shall comply with the specification Passive Fire Protection for Structural steelwork on offshore platforms shall be as detailed elsewhere in the bid document.

The requirement to fire protection of the primary structural steelwork and the platform crane pedestal, if specified, should also be determined by the CONTRACTOR following the Platform Safety Case/Risk Assessment studies.

3.4.16.4.7 Skid Shoe Design

The following should be considered

a) The skid shoes should be designed such that the module reaction forces are spread evenly onto the skid rail. The maximum allowable applied load for the skid rail shall be nominated by CONTRACTOR

b) The skid shoes should be designed to meet the dimensional requirements of the skid rails in the construction yard, as established by CONTRACTOR

c) At the tugging points, a safety factor of 2.0 shall be applied to the attachment points and the structure local to the attachment point. Consideration should be given to the effects of any eccentrically applied loads.

d) No increase in basic allowable member stresses is permitted.

3.4.16.4.8 Boat Landing

Boat landing shall be provided in three stage with minimum elevation difference between any two stages shall be one-meter based on high and low tide variation. Suitable ladder shall be provided.

Boat landings associated connections and local framing shall be designed for boat impact loads as specified in this document, environmental loads, uniform live loads and dead loads. For structural design the load shall be treated as a concentrated load.

RUBSTRIP ON BOATLANDING VERTICAL FACE: Vertical rub-strips along berthing face of the boat landings shall be provided. Mooring bollards shall be provided near each end of the boat landings for supply vessel mooring. Bollard shall be designed to moor 1000 DWT vessel. Two swing ropes shall be provided near the mid-point of each landing, one at the face of the landing and the other 1 meter seawards of the landing face and about 1 meter apart horizontally. Swing ropes shall be supported from the lower deck structure. Proper arrangements for replacing the swing ropes from topside of the lower deck shall be provided.

The boat landing shall be detailed such that there shall be no interference with other items of substructure such as risers, barge bumper etc., during installation operation. In case of boat landing designed to be field installed, it should be detailed to allow a (±) 750 mm elevation adjustment to compensate for variation in the installed height of the jacket. The boat landing shall be designed as removable and readily replaceable with stabbing guide on sub-sea support member.

The Boat landing and its associated connections and local framing shall be designed for the following load combinations:-

a) Dead load + Live Load of 500Kg/m2 on each landing
b) Dead Load + Boat impact load at different points on the berthing face
c) Dead Load + Extreme environmental load.
d) Installation Loads.

The energy to be absorbed in the Boat landing Structural Frame Work from vessel impact shall be 3.0 tonne meter. Where the boat landing is to act integral with a Barge Bumper system, the requirements of the section 3.4.16.4.9 shall also be considered.

Vertical fenders along berthing face of the boat landings shall be provided. Mooring bollards shall be provided near each end of the boat landings for supply vessel mooring. Two swing ropes shall be provided near the midpoint of each landing, one at the face of the landing and the other 1 meter seawards of the landing face and about 1 meter apart horizontally. Swing ropes shall be supported from the lower deck structure. Proper arrangements for replacing the swing ropes shall be provided.

The boat landing shall be detailed such that there shall be no interference with other items of substructure such as risers, barge bumpers etc. during installation or operation. Analysis of jacket framing members shall be carried out for the boat impact loads on barge bumper, for this purpose the force equal to the rated load of the shock cell shall be applied at both the shock cell support points.

No one-third increases in permissible stress shall be allowed in jacket framing member for this analysis.

Tubulars of shock cells shall be designed for environmental loads.

3.4.16.4.9 Barge Bumper

For structural design the load shall be treated as a concentrated load. Local denting of the vertical post shall be neglected.

The barge bumpers shall be designed as removable and readily replaceable with stabbing guide on sub-sea support member.

It is permissible to integrate the design of boat landing and barge bumper systems into a single unit with appropriate energy absorption of loads as given in design criteria.

Analysis of jacket framing members shall be carried out for the boat impact loads on Barge bumper. For this purpose the force equal to the rated load of the shock cell shall be applied at the shock cell support points. No one third increases in permissible stress shall be allowed in Jacket framing member for this analysis. However, one third increases shall be allowed for a vertical member supporting the barge bumpers / shock cells.

The connection of barge bumper with jacket leg shall be as under:

a) Top of barge bumper shall be connected with jacket leg using doubler plate. The doubler plate shall be fillet welded to the jacket legs. The stub of shock cell of barge bumper shall be welded to doubler plate with full penetration weld.
b) Bottom of shock cell shall be supported (with stabbing guide) on the horizontal stub clamped to the jacket leg.

The mooring chains shall be provided to the barge bumper assembly and tightly secured to the jacket legs with pad-eye & doubler plate to prevent the pull out of the shock shells.

The Barge Bumpers and their associated connections to the Jacket shall be designed for the following loading: -

a) Vessel impact directly in the middle 1/3 height of post. Energy to be absorbed in the system shall be 30.4 tonne-meter.
b) Vessel impact lateral in the middle 1/3 height of post. Energy to be absorbed in the system shall be 11.0 tonne-meter.

Barge Bumpers shall be provided at all legs of Process Platforms to protect jacket legs from ship impact as API RP2A guidelines. In case of Well Platforms, where riser protectors are not provided, the Jacket Legs shall be protected from ship impact as per API RP 2A by providing Barge Bumper in both direction.

3.4.16.4.10 Riser Protectors & Riser Protector cum Boat landing

All riser protectors & riser protector cum boat landing, as specified in the scope of the work, shall be designed to absorb concentrated impact energy of 100.0 tonne metre (TM) applied at any point on the face. Plastic collapse analysis shall be performed for this purpose. Any point on the deflected structure shall be at least 300 mm clear from any present or future riser. The support of the riser protector, which is welded to the jacket, shall be designed elastically. No increase in basic permissible stresses shall be considered.

Riser Protectors & riser protector cum boat landing shall be designed as removable and readily replaceable with stabbing guide/ clamps on Sub Sea supporting members.

Riser Protector shall have Vertical members placed @ 2 m interval for entire span with minimum Size 457mm Ø & Horizontal member of minimum 457mm at top and bottom riser protector of Well/process Platform. Forces on account of Riser Protectors shall be considered during detailed engineering of the platforms.

Riser protectors shall bear painted signs “DO NOT BERTH.”

3.4.16.4.11 Conductor Protector

Load for future clamp-on conductor & Conductor protectors shall be considered for Design of Jacket in compliance to Bid scope of work.

In case of work related to Clamp on, Conductor Protector shall be designed for following:

Conductor Protector shall be designed to absorb minimum concentrated impact energy of 100 tonne meters (TM) applied anywhere on face at any point. Plastic collapse analysis needs to be performed for this purpose. Any point on the deflected structure shall be at least 300 mm clear from any present or future conductor. The support of the conductor protector, which are welded to the jacket shall be designed elastically. No increase in basic permissible stresses shall be considered.

Conductor Protectors shall be designed as removable and readily replaceable with stabbing guide on sub-sea support member. This is applicable for new Platform construction.

Conductor Protector shall have Vertical members of minimum Size 457mm placed @ 2 m interval for entire span & Top & bottom Horizontal member shall be minimum 457mm Ø.

Conductor protectors shall bear painted signs “DO NOT BERTH.”

For the purpose of capturing hydrodynamic load center to center of Row-1 of jacket to outermost vertical member of future conductor protector shall be adopted as 3.0 meter. However, for the purpose of fabrication of conductor protector sizing shall as per detailed engineering.

3.4.16.4.12 Conductor Guide Framing

The support/guide for Curved Conductor shall be designed for elastic bending forces of outer casing conductor and subsequent casing/tubing to be installed inside the outer casing as per detail indicated in DC 3.4 Part – II in combination with extreme storm design environmental conditions. The designs of Conductor guide framing shall also consider the load imposed during and after the installation of conductors. A minimum clear gap of 50mm shall be provided between conductor & conductor guide. As a minimum the following criteria shall be considered for the design of Conductor guide framing:

Top Level:
Weight of all the Conductors (Straight and Curved) installed in the substructure prior to drilling or 2 time the weight of the Conductor which will initially pass this level, whichever is governing.
Second Level:
1.5 times the weight of the Conductor, which will initially pass this level and elastic bending forces due to curved conductor, if any.
Subsequent Level:
0.5 times the weight of the Conductor, which will initially pass this level and elastic bending forces due to curved conductor, if any.

3.4.16.4.13 Conductors

All the Conductors shall be driven to 70 meter penetration below seabed or the point of refusal whichever is earlier.
Curved Conductors may be pre-installed in the substructure before the substructure load out. Conductors may be curved or vertical Curvature of curved conductors shall be taken 3^o per 30.5 m of arc length.
The minimum clearance between any two Conductors shall not be less than 600 mm. below mud line and 150 mm above mud line. In case 600 mm could not be met then in consultation with ONGC Drilling section, the spacing can be revised.
Company reserve the right to change the location of Vertical Conductor (VC) to Curved Conductor (CC) or Curved Conductor (CC) to Vertical Conductor (VC) and shall be communicated during early stage of Detail Engineering.
In order to avoid clash between Conductor & Structural Member at Platform North side, the first row of Conductor (parallel to Platform North) shall be placed minimum 1500 mm away from Row – 1 of Platform.
Conductor clash check (with Conductors to conductor, Conductor to Structural members & Conductor to Piles) shall be carried out for Curved Conductors by the Contractor during detail engineering. Such clash shall be brought out with proposal of interchange of Conductor Positions or by shifting the conductor position to the extent of 800 mm and or increase & decrease in orientation ± 10 degree, etc. and shall be decided in consultation with ONGC Drilling Section.
Vacant slots shall have vertical conductors and shall be driven up to 70 M depth below mud line or the point of refusal whichever is earlier.
Additional loads due to future clamp-on structure, if any, consisting of deck extensions, conductors and conductor protector shall be considered in design as per the Scope of Work and structural design criteria.
At the lower end of conductor a driving shoe having wall thickness 6 mm more than the conductor nominal thickness, having length 500 mm with bevel end shall be installed. Uniform internal diameter of the conductor shall also be maintained.

3.4.16.4.14 Design of I-TUBE / J-TUBE

I-tube / J-tube shall be designed as a structural member fitted from jacket level hanger clamp to bending level of flexible pipe, to be laid inside of I-tube / J-tube, shall be supported by adequate number of clamps, are also to be designed as structural member as per Structural Design Criteria:

i) I-Tube / J-Tube Thickness

On firming up of internal diameter of I-Tube / J-Tube during detail engineering, Vortex Induced Vibration (VIV) design spanning studies are carried out to determine the thickness of I-Tube/ J-Tube.

ii) Clamp Location of I-Tube/J-Tube

I-Tube/ J-Tube shall be supported by Hanger clamp at Jacket Level and other (adequate) clamps suitably placed and supported from Jacket member in sub-sea both for new and existing platform. Number of clamps and their location shall be selected by CONTRACTOR to prevent the I-Tube/ J-Tube from becoming overstressed during design storm conditions. I-Tube / J-Tube shall be capable to withstand storm condition and Vortex Shedding Criteria as per DNV rules. Clamp shall be initially padded with 12 mm thick Neoprene sheet bonded to the clamp steel surface by adhesion. Specification of Neoprene specified in Specification No. 2015. However, Contractor shall submit detail Neoprene sheet fixing procedure for Company's approval. Where adjustable clamps are provided, electrical continuity for Cathodic Protection of clamps shall be provided between Jacket and clamps. All bolting on the I-Tube/J-Tube clamps shall utilize fully tightened, double nuts with washer on each end of the struts. All Nuts, Bolts and washers shall conform to ASTM 193, Gr. B7 and ASTM 194, Gr. 2H. All Nuts, Bolts and washers for subsea clamping the I-Tube/J-Tube shall be XYLAN /PTFE COATED.

All nuts & bolts exposed to weather shall be of ASTM A-193 Grade B8M and nuts of ASTM A-194, grade 8M unless otherwise specified in approved drawings.

iii) I-Tube/J-Tube is required to be protected by corrosion allowance as per clause no. 3.4.5.13.1 of structural design criteria Part I along with protective coating system 3(b) as per clause 13.2.3 of Specification for Protective Coating 2005 in lieu of 5 mm monel sheathing.

The I-Tube/J-Tube below the splash zone required to be protected with cathodic protection as per Clause No. 3.4.5.13.2.

I-Tube /J-Tube flexible flow line seal shall be designed to be installed at the end of the bell mouth. The I-Tube/J-Tube hang off clamp shall be designed to allow the addition of corrosion inhibitor and / or Oxygen scavenger inside the I-Tube/J-Tube

iv) Hanger Clamps/ Flange

All I-Tube/J-Tube shall be provided with suitable hanger clamps/ flange for supporting it. I-Tube/J-Tube hanger flanges shall be designed, manufactured and installed by CONTRACTOR as per relevant codes and standards.

Company shall review and approve complete details, design, fabrication and installation of I-Tube/J-Tube.

3.4.16.4.15 Equipment Supports

All equipment supports, pipe supports and other supports steelwork shall be designed to withstand the operating and hydro-test loads specified on the vendor data/ documents.

For transportation condition, in lieu of detail analysis, an equivalent static analysis shall be carried out for following inertia load as minimum:

1. Horizontal Acceleration = 0.7 g
2. Vertical acceleration = 0.2g

3.4.16.4.16 Helideck

The analysis and Design of Heli Deck integrated with the super structure module shall be carried out as per the data and load combinations given at **Annexure-11**. Helideck shall be designed complying CAP 437 guideline (latest edition).

Helideck supports & framing members shall be provided with necessary vortex shedding to avoid vortex induced vibrations.

Helideck Analysis Design:-

The entire helideck primary trusses and frame shall be analyzed as three dimensional space frame based on the guidelines as indicated below and as per the data and load combinations indicated at **Annexure-11.**

a) All functional requirements, including lighting, fire protection system, markings on helideck, protective perimeter fencing, deck drainage system etc. shall be in accordance with CAP 437 & Norsok C-004 guidelines unless specified otherwise in the respective discipline specifications.

b) Aluminium Helideck shall comply with CAP 437 requirement. All helidecks shall be provided with:
   1. Friction factor as recommended in CAP 437.
   2. Provision of fitment of helideck landing nets (to cater for future requirement of net fitment, if any.).

c) Design loads for helideck beams, solar panel platform and firefighting platform shall be as given in relevant annexures in this document.

d) Helideck safety net shall slope upwards at 10 degrees with the outer edge level with the flight deck surface.

e) Helideck safety net shall be fixed with stainless steel clamps with the framing in such a way that head of the bolts should be on top.

   In case of solar panel deck is provided below helideck in well head platform/unmanned installations, perimeter walkway shall be provided below helideck with the provision handrails and grating.

f) Wind Direction Indicator - A heliport shall be equipped with at least one wind direction indicator. A wind direction indicator shall be constructed so that it gives a clear indication of the direction of the wind and a general indication of the wind speed.

   A wind direction indicator shall be located so as to indicate the wind conditions over the final approach and take-off area and in such as a way as to be free from the effects of air flow disturbances caused by nearby objects or rotor downwash. It shall be visible from a helicopter in flight, in a hover or on the movement area.

An indicator should be a truncated cone made of light weight fabric and should have the following minimum dimensions as per CAP 437 guidelines.

The colour of the wind direction indicator should be so selected so as to make it clearly visible and understandable from a height of at least 200 m above the helideck having regard to background. Where practicable, a single colour, preferably white or orange should be used. Where a combination of two colours is required to give adequate conspicuity against changing backgrounds, they should preferably be orange and white, red and white, or black and white, and should be so arranged in five alternative bands, the first and last band being the darker colour.

A wind indicator at a heliport intended for use at night shall be illuminated.

3.4.16.4.17 Bridge Design

The requirements for design of the bridge for in-service conditions are given in this section. The check for pre-service condition shall be same as for super structure.

a) Loading

The bridges between platforms shall be designed to withstand the appropriate operating loads including piping, monorails, cable and cable trays, live loads and contingencies as per relevant annexures of this document, in combination with wind loads. The bridges shall be designed to be installed using suitable pickup sling arrangement.

The following requirements apply to the design criteria for bridges and determination of bridge load for jacket and deck design. For in-place (Operating and Extreme) conditions the piping operating loads computed on the basis of presently planned piping (including any planned future piping) shall be increased by 20% to cater to the possible future needs.

The AFC and as-built drawings of bridge landing for both ends of each bridge shall contain a note indicating the maximum bridge reaction for which the bridge landing has been designed for.

A live load of 250 Kg/sq.m shall be considered on the bridge walkway. The load combination to be considered for the design of bridges shall be as follows:-

i) Dead load of bridge + dead weight of piping, cable and cable trays + piping operating contents weight + extreme storm wind + bridge frictional load.

ii) Dead load of bridge + dead weight of piping, cable and cable trays + piping operating contents weight + walkways live load + monorail live load + operating wind load $\pm$ bridge frictional load.

iii) Dead load of bridge + dead weight of piping, cable and cable trays.

iv) Dead load of bridge + dead weight of piping, cable and cable trays + hydro-test load of any one of the large diameter pipe at a time.

v) Truss Members of bridge shall be checked for Vortex Induced Vibration due to wind for displacement and fatigue damage.

b) **Support Conditions**

The bridge shall be designed to accommodate transverse and longitudinal differential platform movement between the two platforms supporting it. Predicted maximum relative deflection shall be calculated based on a 'worst' case condition i.e. the sum of the maximum absolute deflections of the adjacent platforms. One end of the bridge shall be designed as a hinged support and the other end as a sliding support. The sliding support shall provide guide restraints in the vertical and lateral directions. The sliding as well as pinned support shall have a self-lubricating PTFE bearing element 'FLUOROGOLD' or approved equivalent.

150% of the total predicted translation shall be allowed for in the end connection and bridge design. The hinged connection shall be designed to withstand 150% of the expected axial thrust.

Bridge support shall be capable of accommodating a + 1.0 M tolerance in all direction for final platform location.

The requirements for design of the bridge for in-service conditions are given in this section. The check for pre-service condition shall be same as for super structure.

c) **Deflection**

The maximum deflection of the bridge due to bridge in operation + live load shall be limited to L/400 where 'L' is the average distance between bridge support points. The bridge shall be designed to be fabricated with a built-in camber so that it will remain level after installation. Bridge shall be cambered to compensate for dead-load deflection.

d) The clear width of walkway on bridge shall be minimum 1.20 m. The width of bridge shall be sufficient enough to accommodate piping/pipelines, cables etc. laid from one end to the other end in addition to walkway on the bridge.

e) Bridges connecting process platform shall have Roof covering for weather protection. Slope of roof covering shall be minimum 1:50.

3.4.16.4.18 Flare Boom/Tower

Flare tower are typically wind sensitive and a detailed assessment of wind loads shall be undertaken.

The tower design shall incorporate a means of removing and replacing the flare tip which aims to minimize impact on facility operations.

Truss Members of Flare boom/tower shall be checked for Vortex Induced Vibration due to wind for displacement and fatigue damage.

3.4.16.4.19 Monorail Design

The monorail shall be designed for load lifted, weight of monorail beams, and weight of lifting appliances.

The vertical load shall be increased by 25% to account for impact load.

For dynamic effect the total maximum static wheel load shall be increased by the following percentages:

i) Longitudinal direction: 10%

ii) Transverse direction perpendicular to beam: 20%

Deflection

The maximum deflection of the monorail due to safe working load shall not exceed L/500 for all beams and L/250 for cantilever beams.

End Stoppers

Effective end stoppers shall be provided on the monorail to prevent the trolley either falling from the monorail beams or fouling the structure in which the monorail is installed.

3.4.16.4.20 Hydrostatic Collapse

i. All buoyant member including buoyancy tanks shall be checked for hydrostatic collapse during the pre-service conditions for higher of the two following cases.

   a) Maximum water depth reached during pre-service operations, with a factor of safety of 2.0.

   b) Accidental complete submergence condition i.e. hydrostatic pressure at mud level with a factor of safety of 1.5.

ii. Tubular members shall be checked for in-service condition for hydrostat pressure and in-service stress interaction as per API RP 2A. The factor of safety for axial compression case shall be taken as 1.5 and 2.0 for extreme and operating environmental conditions respectively. For earthquake condition the factor of safety for axial compression case shall be taken as 1.2.

iii. Connection of buoyancy tank with jacket legs shall be designed and checked for Hydrostatic Collapse during launching/lifting of jacket during installation.

3.4.16.4.21 Sump Caissons and Pump Casing

All Sump Caissons and Pump Casing as a special structure as per API RP 2A.

Pump casings in submerged zone shall be protected from corrosion as per NACE Guidelines.

3.4.16.4.22 Connection between Jacket Leg to Skirt Pile sleeve

The Connection between Skirt piles sleeve to Jacket Leg shall be configured using Yoke Plate & Shear Plate connection. Slotted tubular should be provided for stiffening of shear Plate. Calculation for shear transfer from Skirt Pile to Jacket leg shall be supported. FEA Analysis shall be carried for skirt sleeve connection with jacket legs design in addition to Structural Analysis carried out through Structural Analysis Software irrespective of type of connections. SCF Factor for all welded joints shall also be calculated using FEA Analysis for use in Fatigue analysis.

During period of Detail Engineering period, FEA software loaded in Laptop shall be provided at ONGC Office as well as at Design Centre to facilitate review & Approval of Analysis & Drawing.

However, Yoke Plate & Shear Plate connection is not mandatory for WHPs. Tubular connections for such cases maybe applicable. However, in case of tubular connection is selected and designed then also, FE analysis shall be mandatory.

3.4.16.4.23 Design of SSIV/Wye Valve Protection Cage

SSIV/WYE valves assembly shall be provided and installed with protection cages along with CP protection. SSIV/Wye valves cages shall be integrated with pipeline by Clamping arrangement. Contractor shall select one of the following supporting methodologies to support the SSIV/Wye valves and accordingly shall design the Structure with supporting arrangement. The complete SSIV/Wye valves and fittings shall be suitable for operation sub-sea at the water depth and environmental conditions specified and shall be designed and fabricated for a design life of twenty five (25) years. Top protection frame of SSIV/Wye valves shall be designed to withstand the drop object force of 20KJ.

- SSIV/Wye Valve Protection Cage Supported by Pin Pile.
- Increasing the Base weight by Grouting of SSIV/Wye Valve Protection Cage.

3.4.16.4.24 Design Drop Object Protection for Top Side Facility

The location and loading on drop object protection deck, if any, shall be established by the contractor as per safety studies. However, the protective structure shall be designed for the following as minimum requirement:

1. An equivalent static load of 1.5 MT/sq. m over the entire protection area wherein members adequacy is ascertained using allowable stress design concept.
2. Dropped object impact load of 2.0 MT/sq. m of size 2mx2m falling from a height of 3m shall be considered. Ultimate strength analysis (plastic design) shall be used for ascertaining the adequacy of structural members against the dropped object impact load.

3.4.16.4.25 Jacket under water Repair

Refer Design Criteria 3.4 Part – III – wherever applicable.

3.4.16.4.26 Clamp-on Provision on Existing Well Platform:

Clamp-on Conductors shall be driven up to 70 M depth below mud line or the point of refusal whichever is earlier. Process Scope of Work shall be referred to ascertain numbers of Conductor. Conductors shall be provided at the outer face of Row – 1 (north side of Row – 1).

Conductors may be curved or vertical. Curvature of curved conductors shall be taken 3^{o} per 30.5 m of arc length.

The minimum clearance between any two Conductors shall not be less than 600 mm below mud line and 150 mm above mud line. In case 600 mm could not be met then in consultation with ONGC Drilling section, the spacing can be revised.

Company reserve the right to change the location of Vertical Conductor (VC) to Curved Conductor (CC) or Curved Conductor (CC) to Vertical Conductor (VC) and shall be communicated during early stage of Detail Engineering.

Conductor clash check (with Conductors to conductor, Conductor to Structural members & Conductor to Piles) shall be carried out for Curved Conductors by the Contractor during detail engineering. Such clash shall be brought out with proposal of interchange of Conductor Positions or by shifting the conductor position to the extent of 800 mm and or increase & decrease in orientation ± 10 degree, etc. and shall be decided in consultation with ONGC Drilling Section.

Conductor Protector shall be provided with 100 ton-meter energy absorption capacity.

Extension at Cellar Deck & Main deck shall be provided by contractor complying the bid requirement specified elsewhere in the bid.

3.4.16.4.27 Survival Craft Stations

Escape to the sea shall be by Totally Enclosed Motor Propelled Survival Craft (TEMPSC), davit launched lifeboats as approved by company.

Survival craft support structural members shall be designed to support a load factor of 2.2 times the functional loads combined with the design loads specified for survival craft muster areas, in accordance with International Convention for Safety of Life at Sea (SOLAS). In addition, an impact factor of 1.3 shall be applied to the survival craft weight. The functional load defined herein shall include the weight of the survival crafts, blocks and falls and the number of persons the survival craft is deemed fit to carry.

The weight of each person shall be 75 kg for design purposes. The falls shall be inclined at an angle of 15 degrees to the vertical about two axes.

3.4.16.4.28 Antenna Mounting Facility

Suitable walk ways are to be provided to reach antenna locations. The parabolic UHF antenna shall be mounted on 2’ NB schedule 80 pipe stand at the end of the walkway. Contractor shall design all antennas mounting facility limiting the direction of the stand.

3.4.16.4.29 Design of Temporary Members/Props

Temporary members/props and other aids for loadout and transportation shall be designed and used by the Contractor to ensure that there is no overstressing or damage to any permanent member of structure during load out /transportation operations.

3.4.16.5 Pre-Service Design/ Analysis

3.4.16.5.1 Sea fastenings

CONTRACTOR shall assess the extent of sea fastenings. The design of sea fastenings shall accommodate the anticipated loads during Transportation.

3.4.16.5.2 Stab-in Guides and Installation Aids

The following should be considered

a) The aids should be designed such that they fail prior to permanent deformation of any part of the permanent structure. The permanent structural members shall be designed in such way so that they can withstand significantly more load than the aids.
b) Any deflections must be within the elastic limit of the material
c) A 33% increase in allowable member stresses is permitted.

3.4.16.5.3 Jacket Launch

Three dimensional launch simulation analysis shall be performed to determine the jacket stability, bottom clearance and barge-jacket behavior during launching operation.

Three dimensional launch trajectory analyses shall consider the following variation in basic parameters:

a) Launch Weight (-) 3% to (+) 5% of the weight defined in the Weight Control report

b) Longitudinal Centre of Gravity is offset to 1% of length of jacket towards top of jacket
c) Barge Trim is (–) 50% to (+) 50% of the selected trim
d) Coefficient of Friction for skid rails is (+) 25% of estimated value
e) Higher values of variation in the above parameters may be studied, if so required, by the CONTRACTOR
f) Sufficient combinations of the above basic parameters shall be analyzed to produce the worst-case launch scenario.
g) A minimum mud line clearance of 10.00 m at both top and bottom of the jacket shall be ensured during the entire launch operation

The Jacket member and joint stresses shall be checked for code compliance during all phases of the launch. The rocker beam load distribution shall account for the relative stiffness of the rocker beam and launch leg, and shall satisfy moment equilibrium constraints on the rocker beam.

Members with all longitudinal axes, which enter the water within 15 degrees of horizontal, shall be checked for slam effects using predicted velocities from the launch analysis.

3.4.16.5.4 Jacket Flotation and Upending

Flotation and Upending analyses shall be performed to investigate the stability, bottom clearance, derrick vessel hook loads and buoyancy requirements at successive stages of the Jacket installation. Following points shall also be considered during floating and upending analysis:

a) A minimum bottom clearance of 3.0 m shall be maintained throughout the upending operation
b) A minimum reserve buoyancy of 12% over the estimated weight shall be ensured in the design
c) With any one buoyancy component fully flooded, the reserve buoyancy shall be minimum of 6%.

3.4.16.5.5 Jacket on Bottom Stability

Contractor shall also carry out pre-engineering survey for verification of Sea bed slope/profile and top Soil characteristic / bearing capacity upto 3m depth below mud-line. Outcome of same shall be considered for design of Mudmat.

Adequate ballast load shall be applied in Jacket Legs, Skirt Legs & Buoyancy Tanks so that Jacket has adequate Weight (with ballast load) to sustain the installation environment (provided in the Bid) with appropriate size of Mudmat (capable to sustain the Vertical & Horizontal Load & overturning moment).

Mudmat shall limit the penetration of jacket legs / skirt Leg below sea bed level and provide on bottom stability prior to commencement of pile foundation.

A rigid body stability analysis shall be performed for the Jacket to ensure stability:

a) Before pile installation (Un-piled Jacket).
b) During all stages of pile installation (segment wise) in one diagonal of the Jacket Leg / Skirt Leg.
c) 1st Pile or Pile segments shall get complete rundown (self-weight of Pile, self-weight of Pile + Hammer, Driving 2 blows per foot). Till completion of this activity Pile or Pile 2nd segment shall not be place on other corner of Jacket Leg or Skirt Leg.

Both still water and installation environmental conditions shall be considered. The environmental criteria during installation are given in the DC 3.4 Part – II. The Still Water Level may be defined as:-

CD + SS + LAT + 50% AT.

For the on-bottom weight the jacket shall be considered in all its applicable set down ballast and stabbed hanging pile configurations.

The steel/ fiber glass/composite material mudmats shall be sized to provide bearing and sliding resistance. Any slope in the seabed shall be taken into account. The ultimate bearing capacity of the mudmats under combined vertical and horizontal loading shall be calculated using the methods in API RP 2A. Pile sleeve extensions or skirts, where used may be used to enhance the mudmat capacity. Critical wave heights shall be determined and checked against installation environmental conditions for jacket overturning/mudmat uplift, mudmat sliding and bearing failures.

Safety factors of 2.0 for bearing failure and 1.5 for sliding failure shall be applied as per API code.

Stresses on soil at corners of jacket mudmat due to gravity & Gravity with Environmental loads shall be checked during detailed engineering. The stresses at corners shall not exceed the allowable bearing capacity of soil.

Diaphragm closure shall have sufficient strength to sustain hydrostatic pressure during installation of jacket.

3.4.16.5.6 Jacket & Topsides Installation Aids

3.4.16.5.6.1 Substructure Installation Aid

A. Flooding System

Flooding system shall be a suitable and reliable system for the jacket legs or buoyancy Tank and/ or chamber for controlled flooding of the jacket during upending and placing on bottom.

B. Grouting System

Contractor shall provide a reliable grouting system for grouting of the Jacket leg/skirt sleeves with the piles.

The acceptable primary grouting systems are as follows:

a) Pressure grouting system.

b) Single stage grouting system.

In order to minimize soil contamination and to prevent grout material loss (during grouting) Grout packer / Seal shall be provided for any Grouting method adopted. Arrangement for cleaning Annulus shall be provided irrespective of Grouting Method adopted. The system proposed by the Contractor shall be of proven design. The system shall be designed as a fail-safe system to cater for all possible contingencies/eventualities such as failure of any of the components. Should the Contractor propose pressure grouting they shall furnish proof of their experience and capabilities to the satisfaction of the company. In the absence of necessary experience, the Contractor shall appoint a qualified pressure grouting sub-contractor with proven experience for execution of work.

Any of the grouting systems adopted shall have provision for alternate means of grouting in case of failure of the planned system.

In case substructure leg extensions are provided in design, the grout inlet shall be taken below mudline just above the packer and the grout line shall have a protective casing up to mudline.

The Contractor shall also provide two additional diver operated grout ports at appropriate elevations as back-up.

Inflatable grouting packers of proven design shall only be acceptable. Properly sized air supply lines shall extend from each of the grout seals to the substructure top level. All inflatable packers shall be provided with a rupture disc installed above the inflating connections to prevent premature inflation of the packer by hydrostatic pressure in the event of inflation line getting damaged during substructure installation.

Passive Grout Seals of proven design may be provided as an alternative to inflatable grout packers. Two seals shall be provided at each location.

Suitable arrangement shall be provided for collection of return grout from the annulus, in case the pressure grouting system is not utilized.

C. Buoyancy Tanks

Buoyancy tank's supports shall be designed to withstand the effect of maximum hydrostatic pressures and slamming forces during dive as per Section 3.4.16.4.20.

D. Skirt Pile guides

Skirt Pile guides shall be designed for the loads imposed during the installation of the skirt piles. As a minimum following criteria shall be considered for the design of the skirt pile guide and the supporting framework.

Top Level:

a) 1.5 times the weight of the lead pile section.

b) The total weight of all pile including add-on sections supported at this level during piling operation.

c) 0.25 times the weight of the lead section applied lateral to the plane of the supporting frame.

Second Level:

The weight of the pile, which will initially pass this level.

Subsequent Level:

0.5 times the weight of the pile, which will initially pass these levels.

Loading during loadout and transportation shall also be considered in the design.

E. Pile Stabbing Guides

Stabbing guides shall be designed to facilitate centering and alignment and to provide effective support to pile add-on sections.

F. Chaser Pile and Pile Connections

The CONTRACTOR shall provide adequate chaser piles for driving the skirt piles of the substructure. Use of underwater hammer is also acceptable and the use of chaser piles is not mandatory.

Adequate pile connectors shall be used to assemble chaser pile segments and ensure a sound connection of the chaser with the skirt pile during pile driving. In case of difference in sizes of chaser section and skirt pile section, the actual energy transmitted to the skirt pile shall be considered for drivability analysis. Positive type of connectors shall be used to drive skirt piles.

G. Upending Padeyes

Upending padeyes shall be designed for the maximum sling load computed during the upending operation. A lateral load of 5% of the static sling load shall be applied in addition to the lateral load computed during the upending operation. This lateral load shall be applied at the center of the pad-eye pin-hole. A load factor of 2.0 shall be considered for all the above loads.

The orientation of the lower set of padeyes shall be fixed by taking into account the variation of the angle of sling with rotation of the substructure during successive stages of upending operation.

H. Lifting Padeyes

Lifting Padeyes shall be designed as per **API RP 2A**. The substructure legs shall have ring stiffeners at these locations to prevent ovalization of the tubular.

3.4.16.5.6.2 Installation Aids for superstructure

The minimum requirements for different installation aids for the superstructure are given in this section. CONTRACTOR shall design all installation aids to suit his method of installation for the anticipated function and loads. Applicable requirements of **API RP 2A** shall be followed.

a) Lifting Eyes / Trunions

Trunnions shall be used for lifting points with a static sling load of over 600 tonnes. Lifting eyes shall be designed as per requirements of API RP 2A. The design sling load shall be computed based on an assumed tilt of 2º in the most adverse direction.

The lifting eye / trunnions design shall include sufficient reserve strength to allow for future weight growth, load distribution changes and final selection of rigging

b) **Spreader Frames**

Spreader frames shall preferably be connected to the modules by slings. If rigid legs are provided by the Contractor they shall be adequately braced to carry sway forces. The lifting analysis of the module with spreader frames with rigid legs and sway braces shall be carried out as per **clause 3.4.13.2.3** and including a side sway force of 5 percent of the vertical force in the 4 grid directions.

c) **Bumper Guides**

Bumper guides shall be provided on superstructure to arrest the sway of the module being installed over it and to position the module accurately. The guide system configuration and design shall be such that the guide system elements fail prior to any damage to the module or the support structure, and the connections to the support shall be stronger than the guide elements.

The guide system shall be designed for a Normal load of 10 percent of the module weight in the direction of guide support and a friction force of 3 percent of the module weight in the lateral direction acting simultaneously. Basic AISC permissible stresses shall be used in the design.

3.4.16.5.7 Installation of Top Side by Float Over Method

Applicable GL Noble Denton guidelines for Float-over Installation, Load outs, Marine transportation and Moorings will be followed for design and installation of Topside by Float over (FO) method onto host structure. Relevant DNV, API, BV etc. codes pertaining to marine operations will also be followed wherever required. All specific environmental data required for design and installation of topside by FO method except indicated in Design Criteria 3.4 Part II shall be collected by the Contractor .A hydraulic jacking system will be utilized for effective, rapid transfer of loads of topside to piles.

Salient engineering guidelines for installation of Topside onto pre-installed jacket by Float over (FO) are briefly described here under.

A. Environmental Conditions:

The limiting design environmental conditions should be based on weather windows analysis, motions/ clearances during installation, structural strength of the barge, structures and installation components and mooring capability assessment & assurance.

The environmental design criteria for transportation may be derived from latest GL Noble Denton Guidelines for Marine Transportation.

The limiting environmental design criteria for mating operation may be derived from Mating Loads analysis. The limiting sea states for the mating operation will be calculated such that the maximum motions and design loads are considered for design of jacket Legs, fenders, LMUs and hydraulic jacks.

B. **Float over Barge selection**

Selected Float over Barge must satisfy the criteria indicated in latest GL Noble Denton guidelines for Float-over Installation.

Barge stability shall be shown to be adequate throughout the installation operation and attention should be paid to:

1. Stability checks should be carried out for the full range of probable GM values, module weight and COG predicted during installation, this must include the effects of de-ballasting the barge and jacking the module.
2. Any installation with a small metacentric height, where an offset centre of gravity (structure) may induce a heel or trim during the ballasting / weight transfer i.e. when any transverse /longitudinal moment ceases to be restrained by the host structure.
3. Cases where a change of wind velocity or wave direction may cause a significant change of heel and trim during installation.
4. During FO installation it may be necessary to maximize FO clearance by minimizing the barge draught within stability limitations. For this case only intact stability need be considered with a positive GM not less than the Flag state’s minimum requirements.

Intact stability requirements shall be checked as per clause no. B200 of DNV –OS-H101.

It will be also ensured that actual Still Water Bending Moment (SWBM) and Still Water Shear Force (SWSF) at any section of hull never exceed the maximum allowable SWBM and SWSF at the section during transportation and FO operations.

Barge models will be created to compute the stability and motions of the barge during Topside transportation.

Barge mooring analysis for the barge to the Jacket shall be performed to ensure that that mooring winches, wire sizes and soft crossed lines have adequate capacities to be able to hold barge in position and guide it during approach to the jacket.

C. Barge load conditions

The Barge loading condition for each stage of docking, mating, load transfer and undocking operation shall be determined as follows:

1. Docking and Pre-installation case. The minimum FO clearance will be determined based on vessel draught, design of mating cones and receptacles, environmental conditions for the installation and possible maximum motion amplitudes at the mating points.
2. Mating and load transfer stages from the first contact to 100% transfer (0%, 50% & 100%). These stages shall be analyzed for the barge at intermediate draughts to allow for ballasting and fall of tide.
3. Undocking stages from 100% load transfer to separation. These stages and undocking stages shall be analyzed for the barge at deep draught, to maximize separation on a falling tide and under keel clearance.

D. **Motion and Mating Stages:**

1. Devices to assist or control the safe entry of the installation barge in to the host structure slot shall be provided. The engineering properties (strength, stiffness, damping, hysteresis, elastomeric creep) of all components and systems for mating shall be verified by tests which cover the range of conditions (e.g. forces, displacements) anticipated for installation operation.
2. The motions of transportation barge and associated docking, mooring line and fender loads shall be analyzed in time domain for docking, load transfer and undocking positions, including non-linear effects of the host structure/deck/barge, mooring configuration, shock absorbers, fendering system, etc.
3. The motions of barge and associated docking mooring line and fender loads shall be analyzed in the time domain for several docking and undocking positions such as:
   i. Pre-docking, free floating motions with barge aligned with the first row of the structure.
   ii. Docking, intermediate stage with the whole barge engaged with the host structure.
   iii. Docked, with the barge offset from the pre-mating position, prior to finally tensioning the mating moorings.
   iv. Undocking with the barge in an offset position, after full transfer of the deck weight to the host structure and release of the mating moorings.

4. Mating stages shall be selected and analyzed in time domain to identify associated loadings to all the interfaces associated in weight transfer processes. As a minimum this shall include barge docking, load transfer and barge removal:
   i. Pre-mating, with the barge and structure positioned in the host structure, and aligned with but prior to engaging the stabbing cones or positioning system(s) on the LMU's /host structure.
   ii. First contact between the structure and host structure.
   iii. Intermediate load transfer, with the structure weight partially transferred from the barge to the host structure, without any separation or lift off at support points.
   iv. Last contact between the structure and support point on the barge.
   v. Post load transfer, the vessel positioned in the host structure after complete separation from the host structure.
5. A Monte Carlo simulation shall be performed to define maximum values with an acceptable probability of exceedance of 10% or less. The simulation period for each stationary stage shall reflect the actual operational period multiplied by a factor of two to capture a contingency period. The time step to be used shall be selected so as to identify the maximum peak motion.
6. A Leg Mating Unit (LMU) design shall be carried out taking into account the loads, stroke and motion response expected to be applied during load transfer operations. The LMU performance characteristics shall be included in the mating analysis.
7. An assessment shall be made to consider the speed at which the structure and barge can separate. As the barge starts to separate from the structure there will be a tendency for re-contact at the LSF / structure interface due to the barge motions. Mitigations shall be considered to avoid damage to structure and LSF / barge.
8. A jacking system will be utilized for rapid load transfer (active Float-over). The jacking system shall be designed to ensure the stability and restraint of the structure as it is raised above its transportation position. Redundancy shall be provided in the jacking system so that there is no single point of failure in the system. Detailed HAZIDs will be required of the jacking system.

E. **Clearances**

The maximum draft of the installation barge during float-over shall not exceed the maximum loadline draft. The minimum barge freeboard at the maximum barge draft shall be 1.0m to maintain its water-plane area. Minimum freeboard used during the operation shall be confirmed with the barge owner. The limiting seastate should be such that green water cannot occur on the deck of the barge.

During approach of the structure the minimum (static) vertical clearance between the structures stabbing cone and host structure receptacles / jacket leg / piles shall be 1.0m.

The maximum vertical / horizontal movement of the stabbing cone should not normally exceed +/-0.5m during entry and weight transfer.

To allow safe removal of the installation barge the minimum clearance between the keel of the installation barge and any part of the submerged host structure shall be 1.0m after accounting for vessel maximum motions at maximum draft.

The minimum vertical clearance between the LSF and the underside of the structure following completion of load transfer shall be 0.5m after accounting for vessel maximum motions to allow safe removal of the installation barge.

F. **Barge Mooring and Positioning:**

Mooring and positioning of the barge into the host structure can be by:

1. Pre-laid mooring lines/anchors
2. Tugs and pre-laid mooring lines

G. **Barge Mooring and Stand –Off Moorings**

Stand-off mooring shall be provided except for vessels with suitable DP systems.

When required, the installation barge mooring system shall be designed to resist the environmental loads, allowing the barge to maintain position prior to docking. Line integrity and anchor uplift shall also be verified for operational and extreme environment standby cases.

A mooring analysis shall be carried out for the installation barge at the stand-off location and at the incremental stages that comply with the installation procedural steps. The mooring analyses shall satisfy the requirements of GL Noble Denton Mooring Guidelines.

All installation barge mooring lines and tethers shall be capable of being tensioned by the use of winches or capstans.

H. **Clearances around Mooring Lines and Anchors**

Clearances around mooring lines and anchors should comply with GL Noble Denton Mooring Guidelines.

All anchor lines shall be pre-installed and pre-tensioned to maximum operating loads with a safety factor and holding period to be agreed.

I. **Position Keeping During Mating with Tethers**

The tethers shall be designed to hold the barge in the mating position to ensure that the barge motions do not exceed the capture radius of the LMU's during the mating operation. The characteristics of the tethers shall be accurately modeled in the analysis.

Temporary mooring tethers shall be designed for the maximum expected loads and sized based on a factor of safety of 1.67 against the certified break load.

J. **Topside Mating Analysis**

The static analysis of topside structure shall be carried out to ensure integrity of the integrated topside structure during mating condition. The topside geometry used shall be similar to that of transportation analysis.

Mating Load Generation:

Mating loads shall be derived from the dynamic time domain barge motion analysis. The deck will experience impact forces during the following conditions:

1) Initial contact as the barge ballasts down and the deck columns begin to touch the jacket legs.
2) Load transfer stage as the deck weight is 50% transferred to the jacket.
3) Separation stage as the deck weight is fully transferred to the jacket. The LSF begin to separates from the underside of the cellar deck causing impact to the cellar deck beams.

All loads shall be represented as concentrated loads and applied at deck stabbing point to simulate the impact loads occurring during mating conditions.

Structural Analysis and Stress Check:

Linear static analysis shall be carried out to determine structural member forces for each of the load cases considered.

Member stress and joint punching shear code checking shall be undertaken in accordance with API RP 2A, 21st edition. One third increase of AISC basic allowable stresses shall be permitted.

K. **Jacket Mating Analysis**

The jacket structural mating analysis shall be performed to ensure that the structural integrity of substructure and foundation can withstand the impact load occurring during the mating phase of topside float over installation.

Jacket and foundation modeling:

The jacket and pile foundation shall be modeled as a 3D frame using SACS computer program. The model does not include the deck. Nonlinear pile-soil interaction is used as the boundary condition in the analysis.

Mating Load Generation:

Mating loads shall be obtained from the dynamic time domain barge motion analysis. The jacket will experience impact forces during the following conditions:

1. Entry stage describes the loading as the barge carrying the float over deck enters the jacket between Row A and B.
2. Alignment stage describes the loads as the barge setup at position for mating process.
3. Initial contact describes the loads as the barge ballasts down and the deck columns begin to touch the jacket legs.
4. Load transfer stage describes the loads as the deck weight is 50% transferred to the jacket.
5. Load transfer stage describes the loads as the deck weight is almost completely transferred to the jacket
6. Separation stage describes the loads when all the deck weight is transferred to the jacket.
7. Exit stage describes the loads as the unloaded barge exits the jacket.

All loads are represented as concentrated loads and applied at top of receptors to simulate the impact loads occurring during mating conditions.

Structural Analysis and Stress Check:

The pile soil interaction analysis shall be carried out to ensure the structural integrity of the jacket and piles. The pile capacity should have minimum safety factor of 1.5 during mating conditions.

Member stress and joint punching shear code checking shall be undertaken with all mating load stages in accordance with API RP 2A, 21st edition. One third increases of AISC basic allowable stresses shall be permitted.

L. **Barge Fenders**:

Sway fenders will be fitted to jacket legs to reduce the clearances during the mating operations. Design loads will be obtained from mating analysis report.

M. **Leg mating Units (LMU):**

The jacket leg will be fitted with stabbing cones mounted on Top while LMUs will be contained in the topside legs. The LMU consist of vertical and horizontal rubber pads.

N. **Hydraulic jacks:**

Active Float over operation shall be designed using hydraulic jacks.

The topside module shall be supported on the Load out supporting frame at four contact points. Design loads shall be obtained from mating analysis report

O. **Sea Fastening:**

The transportation loads (cargo forces) will be transferred from the Top sides modules through the upper sea fastenings to Load out Support Frame and then through lower sea fastenings to the barge deck. The Philosophy of this arrangement shall be such that only the upper attachments need to be cut prior to installation of the Topsides on the jackets.

The sea fastening structure will be analyzed for various load cases as specified for each condition and checked under the combined axial and bending stresses and shear forces as per AISC and API requirements.

3.4.17 Welding

Following welding detailing shall be incorporated in respective Drawing during drawing approval stage.

B. **Pile Drawings:**

In order to minimize Pile Fatigue, welding in pile shall be provided with full penetration weld from both side applicable for long seams & girth seams. Mudline zone upto 40 m below sea bed full penetration weld shall double equal V from both sides.

C. **Jacket Drawings (all type):**

Welds of long Seam for Jacket tubular shall be provided with full penetration Weld from both sides.

All tubular to tubular Girth Joints shall be provided with full penetration Weld from both sides.

Shear plate & Yoke Plate connection between Main Leg & Skirt Leg shall be provided with full penetration weld from both sides with double equal V wherever such provisions/ connections are applicable.

Shear Key on Skirt sleeve & skirt Pile shall have fillet (partial penetration) weld from both side of shear key.

Welding between Hydrostatic Collapse Ring with jacket structural member shall be full penetration weld from both sides. In the event of Hydrostatic Collapse Ring requirement arising out for pre-service analysis, then partial penetration weld from both side can be permitted with concurrence of MWS.

Bolted connections are not acceptable for Jacket, Boat Landing, and Riser Protector & Conductor Protector.

Conductor guide shall have full penetration weld from both sides.

D. **Welding on Hanger Clamp, Riser guide Clamp and Riser friction Clamp and Grouted Clamps for Jacket Repair:**

These clamps are experiencing cyclic loading caused due to Wave, Current & Wind and with tension loads.

Welding between Clamp Flange Plate and Clamp shell shall be provided with full penetration weld from both sides. Welding between Clamp Flange plates to stiffener shall be provided with full penetration weld from both sides. Hanger clamp flange plate shall be provided with a hole for drainage arrangement. Welding between Stiffeners with Clamp shell shall be provided with fillet (partial penetration) weld on both side of stiffener.

E. **Welding of Deck Framing, Leg Joints, Stiffener Joints, Built-up beam:**

Welding between Flange and Web of Built-up Beam shall be provided with full penetration weld from both sides of web (single web). In case of Beam with Two webs the welding between Web and flange shall be provided with full penetration weld from one side with backing plate inside.

In case of Boxing Plate is used as stiffener or boxed beam is planned as per design calculation, than the weld of box plate shall be provided with full penetration Weld from one side all-around.

Beam to Beam Splice shall be full penetration weld from both sides.

Connection between two Primary Beams shall be provided with Full penetration weld for both for Flange to flange connection and web to web connection.

Connection for Deck leg (or for other similar tubular Columns) & Beam shall be provided with Tubular member as through member with diamond shaped flange plate connection with beams and or internal ring stiffener with full penetration weld from both sides of flange plate and or internal ring stiffener. Kindly refer Clause no. 3.4.8.1.6.1 b) of this document.

Connection between Truss Tubular supported on beams shall be provided with Stiffener Joint. Welding between trusses tubular with beam shall be provided with full penetration weld.

Welding between Flanges of Beam and stiffener shall be provided with full penetration weld from both sides of stiffener both at top end & bottom end with drainage arrangement. Welding between Web & Stiffener shall be fillet weld from both sides of Stiffener.

In case of sector or half pipe is used as stiffener, the welding of sector / half pipe to Flange plate & web Plate shall be full penetration from one side.

In case of flush floor system (Floor plate + stringer + deck beam + main girder) following are to be complied:

a) The connection of top flanges of stringer beams/ Secondary Beams to top flanges of Primary Beams shall be full penetration from both sides.

b) The connection of bottom flanges of stringer beams/ Secondary Beams to web of Primary Beams shall be fillet weld/seal weld from both sides. The bottom flanges of stringer beams/ Secondary Beams shall not be snapped.

c) The connection of webs of stringer beams/ Secondary Beams to web of Primary Beams shall be fillet weld from both sides web.

Items planned (as specified in Bid) or required removable shall be provided with bolted connections.

F. **Welding of Deck Plating, Building Module Floor & Wall Plating:**

Connection between Beams to Deck/Floor Plate shall be provided with seal/fillet weld continuous with beams from bottom side and all around. Connection between two plates shall be provided with full penetration weld from both sides. Connection between wall plating and supporting structural members shall be provided with seal/fillet weld continuous with beams from bottom side and all around.

3.4.18 Deck Extension or Modification:

This provision is applicable when platform requires extension, additions, alteration on the existing facility arising out of addition of (a) Clamp-on conductors with protector & deck extensions, (b) Riser with protector and Deck extension or modification, (c) Addition of helideck, (d) Crane pedestal and crane boom rest, (e) provisions for Modular rigs, (f) addition or replace of Equipment and Piping and related modifications & strengthening, etc.

To carry out this scope of work, Local Analysis or Global analysis for Deck shall be required. Detail of same shall be as specified in DC 3.4 Part – II / Basic bid work.

Primary members shall be extended to support the proposed extension. If required, knee brace and or truss members shall be added for proposed Deck Extension.

In case strengthening of existing Truss members is required same shall be carried out by adding Tubular. In case of Strengthening of Beam, Flange extension plate and or addition of flange plate shall be added. Flange extension plate shall be provided with full penetration weld. Addition of beam flange plate shall be provided with partial penetration weld.

Use of Doubler Plate and or external Ring Stiffener shall be provided to strengthen the Tubular to Tubular Joint. External Ring stiffener shall be provided with full penetration weld. Doubler plate shall not be used for member carrying tensile loads.

A. **Deck Global Analysis:**

SACS Model with mark-up drawings shall be generated with data obtained from the pre-engineering survey. In case SACS Model provided by Company then Pre-Engineering Survey data shall be incorporated in the SACS model.

SACS Model shall be updated with the proposed Extension, Modification and alteration proposed along with the existing structure and various loads for the purpose of topside Global analysis. Based on the analysis, proposal for Strengthening of existing Structural Members and for proposed Deck extension shall be submitted supported with Drawings, Analysis & Design Calculation for review / approval. It shall be ensured that strengthened Member UC Ratio ≤ 1.00

Before carrying out Deck Global analysis, data shall be obtained by carrying out pre-engineering survey:

i) All Primary member (from Jacket walkway to Main deck top level) Size and thickness shall be verified with respect to available drawings/ SACS file provided by company. Mark up Drawing and new SACS file shall be prepared. Thickness gauging shall be carried out using ultrasound.

ii) In case of Drawings / SACS file are not provided in the Bid: All Primary and secondary (from Jacket walkway to Main deck top level) member(s) size and thickness shall be obtained during pre-engineering and mark-up drawing/ SACS file shall be prepared. Thickness gauging shall be carried out using ultrasound.

B. **Deck Local Analysis:**

SACS Model with mark-up drawings shall be generated with data obtained from the pre-engineering survey. In case SACS Model provided by Company Pre-Engineering Survey data shall be incorporated in the SACS model.

SACS Model shall be updated with the proposed Extension, Modification and alteration proposed for the project. SACS Model shall be incorporated with new and existing load(s) in line with the details provided in the bid document for analysis.

Based on the analysis, proposal for Strengthening of existing Structural Members and for proposed Deck extension shall be submitted along with Drawings, Analysis & design calculation for review / approval.

Deck local Analysis shall be limited to nearest Jacket legs for transfer of Load for WHPS and nearest deck leg truss for Process/LQ platforms. Before carrying out Deck local analysis, data shall be obtained by carrying out pre-engineering survey as detailed below:

i. Primary and Secondary member (s) size and thickness shall be verified with respect to available drawings/ SACS file provided by the Company. Mark up Drawing shall be prepared. Thickness gauging shall be carried out using ultrasound.

ii. In case of Drawings / SACS file are not provided in the Bid: Required portion Primary and secondary member (s) (from Jacket walkway to Main deck top level) size and thickness shall be obtained during pre-Engineering survey and mark-up drawing/ SACS file shall be prepared. Thickness gauging shall be carried out using ultrasound.

3.4.19 Weight Control

An effective weight control procedure shall be developed, documented and followed throughout design and construction. The procedure shall collect, collate and distribute weight information to the Contractor’s project team. The NTE (Not to Exceed) weights for the proposed installation methodology should be established.

3.4.19.1 Weight Control Report

The Contractor shall maintain a detailed weight inventory of all equipment, bulk materials and consumable to be installed on the platform in the form of a Weight Control Report.

This report shall be computer generated in which various building / module components constituting the platform top sides are identified under separate heads and the weight assessment of each unit shall be made for the following conditions

a) Inplace mode (for dry, operating and test conditions).
b) Transportation mode.
c) Offshore lifting.

This Report shall be prepared separately for all the modules, which are identified to be lifted separately offshore.

For each of these items weight information shall be generally formatted as follows:

1. Structural steel work
2. Architectural and finish material including coating and insulation.
3. Each of equipment using actual tag number for identification.
4. Piping, valves and supports (identified by name and / or tag number).
5. Electrical cabling including cable trays, supports etc.
6. Instrumentation cabling including cable trays, supports air lines, hydraulic lines, valves etc.
7. Consumable.
8. Appropriate contingencies at various stages.

Initial input of data shall consist of weights in which a high degree of confidence can be placed and which are backed with data taken from Vendors, latest available MTO's etc.

All weight and weight changes shall be periodically monitored throughout the design. The quality of input data shall be progressively refined and ultimately result in the following:

i) Data taken from equipment and valve certificates
ii) Final piping isometrics and MTO's.
iii) Final structural MTO's.
iv) Final MTO for electrical and instrument items.

A similar weight control report shall be prepared for each substructure for the transportation mode.

3.4.19.2 Weight Monitoring and Control

The weight control report shall incorporate appropriate contingencies based on the reliability / accuracy of the source of weight information. These contingencies shall be added in a statistical manner to obtain the best estimate of the component weight.

The load contingencies stated in DC 3.4 Part-II shall be applied to the weights arrived at in the weight control report and shall be used in the pre-service and in-service design of the various components.

As engineering / procurement work progresses, subsequent weight control reports provide updated weight information which shall be used to estimate the margin on weight available at that stage. This margin shall not be less than 5% till the time of weighing of the modules. In case the as- installed weight in excess of 5% is noted redesign of affected component design shall be done at no extra time and cost to COMPANY.

3.4.19.3 Weighing of Decks

The contractor, prior to load out, shall accurately weigh platform Decks. Detailed weighing procedures shall be developed and submitted for Company's approval.

The weighing activity shall include, but not be limited, to the following:

a. Weighing of module as per Company approved procedure.
b. Prepare schedule of items both permanent and temporary on the module at the time of weighing results with the theoretical values.
c. Reconcile weighing results with the theoretical values.
d. Prepare a detail weight schedule of all items, which are yet to be installed, prior to lifting together with any items, which are to be removed i.e., rigging platforms etc.
e. Prepare a final weighing report for every lift containing:
    i. Weighing Results
    ii. Theoretical Prediction
    iii. Item schedule for d) above.

Contractor shall assume full responsibility for all remedial measures required as a result of weight escalation beyond the weights budgeted for sea transport, offshore lifting and final service operations. This Responsibility shall include but not be limited to weight reduction measures, strengthening and stiffening of the module etc.

Actual weight with COG calculation of Deck shall be reported to respective structural Engineer (of Company) and clearance regarding further analysis shall be obtained. Contractor shall also perform a final In-place and lifting analysis of the Decks after the weighing incorporating the results of weighing. Necessary reinforcement of the structures and the modules shall be carried out before load out.

The final In-place analysis of the substructures shall be performed after computation of deck loads based on the above and documented.

3.4.20 Review of Structural Analysis

Structural Analysis related to all In-Service Analysis including Foundation Design/Engineering and related Drawings shall be under approval category. CV (duly certified by Contractor's Design Consultant and by Contractor) of the Respective signatory of the Analysis Reports & Design Calculation shall be incorporated in the respective Report/ Calculation.

Structural Analysis related to all Pre-Service Analysis, Installation Engineering and related Drawings shall be under review category. Approval / Vetting of MWS shall be obtained and submitted for Company review.

Computer terminal with the relevant software shall be made available to the Company during the detailed engineering for the review of the computer generated Structural Analysis at Design Centre and / or at Company Office. Internet access shall be provided at Design Center with printing facility.

Drawing, Analysis & Design calculation Submission sequence for DCI:

1. Foundation Design with related Drawings
2. In-Service Analysis: Inplace Analysis along with framing Drawing applicable for Deck & Jacket.
3. Deck Misc. Design Calculations for Primary & Secondary Structure and Joint Design calculation along with related Drawings.
4. In-Service Analysis: Jacket Fatigue Analysis along with Fatigue Related Drawing.
5. In-Service Analysis: Earthquake Analysis of Deck & Jacket with related Drawings.

6. Jacket Misc. Design Calculations for Primary & Secondary Structure with related Drawings.
7. Pre-Service Analysis: Load out Analysis with related Drawings (Jacket & Deck).
8. Pre-Service Analysis: Load out Analysis with related Drawings (Jacket & Deck).
9. Pre-Service Analysis: Transportation Analysis with Sea fastening Drawings (Jacket & Deck).
10. Pre-Service Analysis: Lift Analysis with related Drawings (Jacket under lift method & Deck).
11. Pre-Service Analysis: Launch Analysis with related Drawings (for Jacket under launch method).
12. Pre-Service Analysis: Floatation & Upending Analysis with related Drawings (Jacket).
13. Pre-Service Analysis: On bottom Stability Analysis with Mud-mat Design with related Drawings (Jacket).
14. Pre-Service Analysis: Pile Drivability Analysis with related Drawings (Jacket piles).
15. Pre-Service Analysis: Installation Engineering.
16. Drawings related to Grouting Line, Flooding Line, cleaning/ flushing Line, etc.
17. Deflection Report shall be generated for:
    a. Each Pile deflection at mud line,
    b. Deflection at all Jacket Leg Joints at each Horizontal Framing levels,
    c. Relative deflection between two horizontal elevation
    d. Cellar Deck & Main Deck deflection at all extreme corners at 1 hour Extreme Environment.

Drawings under approval category shall be taken up for approval after completion of One Round In-service (all) & Pre-Service Analysis (all). In-service Analysis shall be taken up for approval after incorporation of the effects of all Pre-Service analysis.

3.4.21 As-Built Drawing Preparation

Contractor’s Structural Design Consultant shall prepare the AS-Built Structural Drawings by incorporating all subsequent design changes approved by Company, marking actual Yield Strength of material in co-relation to Material Traceability & Mill Test Certificate with Listing of Heat Numbers, Name of Mill, Mill TC Numbers, etc. Fabricator shall provide copy of Material Inspection Report with Mill TC to the Contractor’s Design Consultant for As-Built Drawing preparation.
Spec 6001F Clause 3.17 shall also be referred and complied.

3.4.22 Final Documentation

Contractor shall submit six sets of soft copies in 1TB (minimum) SSD hard drive or better of all approved structural Drawings, Structural analysis reports including Software Analysis models in respective software format (input and output run files) of sub structure and topside including in addition to the As-Built Documentation. Pile Driving records, Weight Control Reports and final platform structural weighing Weights (of top side) shall be part of documentation.
Spec 6001F Clause 3.17 shall also be referred and complied.

ANNEXURES

Annexure-1: Acronyms

Sr. No	Abbreviated Terms	Expanded Term
1	ABS	American Bureau of Shipping
2	AISC	American Institute of Steel Construction
3	AISI	American Institute of Steel and Iron
4	ALARP	As Low As Reasonably Practicable
5	API/RP	American Petroleum Institute/Recommended Practice
6	ASTM	American Society for Testing and Materials
7	AWS	American Welding Society
8	BS	British Standard
9	BOD	Basis of Design
10	BFD	Basis for Design
11	CTOD	Crack Tip Opening Displacement
12	CD	Chart Datum
13	Den	Department of Energy, UK
14	DOE	Department of Environment, UK
15	DnV	Det norske Veritas
16	DEP	Design and Engineering Practice
17	DFI	Design, Fabrication and Installation
18	EL	Elevation (relative to CD)
19	ECP	Engineering Construction and Procurement
20	FLS	Fatigue Limit State
21	HSE, UK	Health and Safety Executive
22	IMR	Inspection, Maintenance and Repair
23	ISO	International Standard Organization
24	LAT	Lowest Astronomical Tide
25	AT	Astronomical Tide
26	SS	Storm Surge
27	MSL	Mean Sea Level
28	NORSOK	Norsk Sokkels Konkuranseposisjon
29	OSHA	The Occupational Safety & Health Administration
30	PWHT	Post Weld Heat Treatment
31	PTFE	Poly Tetra Fluoro Ethylene
32	QRA	Quantitative Risk Analysis
33	ROV	Remotely Operated Vehicle
34	RSR	Reserve Strength Ratio
35	SI	International System (of Units)
36	SSIV	Sub Surface Isolation Valves
37	SOLAS	Safety of Life at Sea
38	SRA	Structural Risk Assessment
39	TEMPSC	Totally Enclosed Motor Propelled Survival Craft
40	VIV	Vortex Induced Vibration
41	WSD	Working Stress Design

42	WHP	Well Head Platform
43	PP	Process Platform
44	LQ	Living quarter Platform

Annexure-2: IMPORTANT CONSTANTS

Sr.no.	Name	Symbol	Values
1	Gravity	g	9.81 m/s^2
2	Density of Water	ρ_w	1000 kg/m^3
3	Density of Sea Water	ρ_{sw}	1025 kg/m^3
4	Density of Marine Growth		1400 kg/m^3
5	Density of Steel	ρ_s	7850 kg/m^3
6	Expansion of steel	V	0.000012 / °C
7	Modulus of elasticity of Steel	E	210000 MPa
8	Shear Modulus of Steel	G	80770 MPa
9	Specific Heat Of Steel		520J / kg °C
10	Poisson’s ratio of steel	ν	0.3

Annexure-3: List of Code & Standards, Functional Specifications

1. **American Institute of Steel Construction (AISC):** Manual of Steel Construction 13th Edition
2. **American National Standards Institute (ANSI)**
   A58.1 Building code Requirements for Minimum Design Loads in Building and Other Structures.
3. **American Petroleum Institute (API)**

Sr. No.	Spec. No.	Description
1	**API RP 2A-WSD-21st Edition**	Recommended Practice for Planning, Design and Constructing Fixed Offshore Platforms – Working Stress Design.
2	**API RP 2X**	Recommended Practice for Ultrasonic and Magnetic Examination of Offshore Structural Fabrication and Guidelines for Qualification of Technicians
3	**API SPEC 2B**	API Specification for Fabricated Structural Steel Pipes.
4	**API SPEC 2F**	Specification for Mooring Chains.
5	**API SPEC 5L**	API Specification for Line Pipes.
6	**API SPEC 2W**	Specification for Steel Plates for Offshore Structures, Produced by Thermo-Mechanical Control Processing (TMCP)
7	**API SPEC 2H**	Specification for carbon and manganese steel plate for Offshore Platform.
8	**API RP 2Z**	Recommended Practice for Pre-Production Qualification for Steel Plates for Offshore Structure.
9	**API SPEC 10A**	Specification for Cement and materials for Well Cementing.

4. **National Association of Corrosion Engineers (NACE)**
   RP-01-76 Recommended Practice for Corrosion Control of Steel, Fixed Offshore Platforms Associated with Petroleum Production
5. **United States Department of Labour – Occupational Safety and Health Administration (OSHA)**

Sr. No	Code	Description
1	29 CFR 1910	General Industry OSHA Safety and Health Standards
2	29 CFR 1917.120	Fixed Stairways in restricted area
3	29 CFR 1917.112	Guarding of Edges
4	29 CFR 1926.501 & 502	Fall Protection
5	29 CFR 3124	Stairways and Ladders

6. **American Society for Testing and Materials (ASTM)**

Sr. No.	Spec. No.	Description
1	**ASTM A6**	Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes and Sheet Pilling.

2	**ASTM A36**	Standard Specification for Carbon Structural Steel
3	**ASTM A53**	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc – Coated Welded and Seamless.
4	**ASTM A106**	Standard Specification for Seamless Carbon Steel Pipe for High Temperature Service.
5	**ASTM A123**	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
6	**ASTM A153**	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
7	**ASTM A193**	Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature Service or High Pressure Service and Other Special Purpose Applications.
8	**ASTM A194**	Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
9	**ASTM A312**	Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
10	**ASTM A578**	Standard Specification for Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications
11	**ASTM C109**	Standard Test Method for Compressive Strength of Hydraulic Cement Mortars.
12	**ASTM C806**	Standard Test Method for Restrained Expansion of Expansive Cement Mortar.
13	**ASTM D2000**	Standard classification system for Rubber Products in Automotive publications.

7. **American Welding Society (AWS)**
   AWS D1.1 Structural Welding Code-Steel
   AWS D1.3 Structural Welding Code-Steel Sheet
8. **SOLAS**
   Regulations of the International convention for the safety of life at Sea.
9. **Indian Standard Institution (ISI)**

Sr. No.	Spec. No.	Description
1	**IS 1893**	Criteria for Earthquake Resistant Design of Structure
2	**IS 883**	Design of Structural Timber in Building - Code of Practice
3	**IS 2062**	Hot Rolled Medium and High Tensile Structural Steel - Specification
4	**IS 3502**	Specification for chequered plate

10. **Under Writers Laboratory Inc. (UL)**
    Fire Resistant Directory
11. **Department Of Energy, London, UK**
    Offshore Installation: Guidance on Design, Construction and Certification-1990 (4th Edition)
12. **DNV Standard**
    DNV GL Rules for Classification of Steel Ships, Part V, Chapter 2, Section 4 and Part 6Chapter 1
    OS-H202: Sea transport operations
    RP-C205: Environmental Conditions and Environmental Loads

OS-C201: Structural Design of Offshore Units (WSD Method)
RP B401: Recommended Practice, Cathodic Protection Design
RP-C205: Recommended Practice, Environmental condition & Environmental loads

13. AISI

316/316L Stainless Steel

14. Health & Safety Executive, UK (RR: Research Report)

Sr No	Code	Description
1	RR 220	Ship Collision and capacity of brace members of fixed offshore Platform (Research Report 220)
2	RR 031	Development of design guidance for neoprene lined Clamp (Research Report 031)
3	RR 200	TEMPSC Structural Design Basis Determination

15. NORSOK Standard

Sr No	Code	Description
1	N-004	Design of steel structure
2	S-002	Working Environment
3	N-003	Action and action effects
4	M-001	Materials selection
5	M-101	Structural steel fabrication

16. List of Functional Specifications

Sr No	Specifications	Descriptions
1	6001F	Specification For Materials, Fabrication, Installations of Structure
2	2005	Protective Coating
3	2009 F	Welding And Inspections
4	4001	Cathodic Protection System for Offshore Structures
5	5102	Functional Safety Specification
6	6011	Material Specification for Building Module

17. OTC PAPERS

Sr No	Specifications	Descriptions
1	OTC Paper Number 3274	Relates to Pile driving experience of Mumbai Offshore
2	OTC Paper Number 4205	Consideration of internal friction and general guideline for reference

Annexure–4: DESIGN LIVE LOADS

Blanket Area Live Loads for local and global design. These loads described in this section shall apply to the jacket and topsides

Table – 4.01 Local Design- Uniformly distributed area live loads for Deck Plating, Grating and Secondary Beam

Sl. No.	Item/Location	Uniformly distributed area live loads	Remarks
1	Deck Plating of Process Platform	2000 Kg/m^2	Check and reinforce for concentrated load at particular location.
2	Deck Plating of Well Platform	1500 kg/ m^2	
3	Building Module Floor	1000 kg/ m^2	
4	Roof accessible for inspection and repair	125 kg/m^2	
5	Grating Design	500 kg/m^2	

Table – 4.02 Global Design- Blanket / Uniformly distributed Area Live Load

Sl. No	**Item/Location**	**Blanket / Uniformly distributed area live loads**	**Remarks**
1	Plated Area of Process Platform /LQ Cellar Deck	2000 kg/m^2	All beams should be checked for the case of (actual equipment and piping dead weight + operating contents weight + 500kg/m^2 on open area) and reinforced if required.
2.1	Plated Area of Well Platform (design Life 25 years)	1500 kg/m^2	
2.2	Plated Area of Well Platform (design life 15 years)	1200 kg/m^2	
3	Module areas where module skid are supported directly onto the deck main trusses/ framework	-	As per actual
4.	Potable Water Storage tank area	-	As per actual
5.	Access hatches :-		Access hatches shall be checked for appropriate concentrated load also.
5.1	Well Platform (design Life 15 years)	1200 kg/ m^2	
5.2	Well Platform (design Life 25 years)	1500 kg/ m^2	
5.3	Process/ LQ Platform	2000 kg/ m^2	
6.	Building Module floors		
	a). T.G. Room	1500kg/m^2	
	b). HVAC Area, Utility & generator room.	1000kg/m^2	-

	c). Open areas on roofs for open storage, AHU rooms, Store rooms, Document Room, Wire line Shop, Mechanical Shop, Valve repair shop, waste heat recovery system area, laundry, hot oil tank area, Battery rooms, Transformer rooms.		675kg/m2	In addition, Architectural Load shall be added.
			1200 Kg/m2	No Architectural Load.
	d).Electrical shop, Instrument shop. Oil & Gas Laboratory.		500kg/m2.	In addition, Architectural Load shall be added.
			1000 Kg/m2	No Architectural Load.
	e). Switchgear room, T.G control room, Computer and communication room, RTU room, Telemetry room, MCC Room		500kg/m2.	In addition, Architectural Load shall be added.
			1000 Kg/m2	No Architectural Load.
	f). Living rooms, Office areas, Corridors, Toilet, Tea room.		500 kg/m^2	In addition, Architectural Load shall be added.
			1000 Kg/m2	No Architectural Load.
	g). Live load on accessible roof		125kg/m^2.	This Roof is not meant for storage.
7.	Loading / Unloading areas	– Well Platform,	1500 kg/ m^2	-
		– Living Quarter.	1500 kg/ m^2	-
		– Process Platform	2000 kg/ m^2	-
8.	All grated areas		500 kg/ m^2	-
9.	Open deck area live load		500 kg/ m^2	
10	Helideck Design		Case-1: Helicopter Normal Landing	1.5 MTOM+50 Kg/m^2+ Dead Load+ Wind Load (31m/sec)
			Case-2: Helicopter Emergency Landing	2.5 MTOM+50 Kg/m^2+ Dead Load+ Wind Load (31m/sec)
			Case-3: Helicopter at Rest	1.0 MTOM+200 Kg/m^2+wind load in extreme condition
11.	Helideck firefighting & solar panel platform		200 kg/ m^2	For global design only (Refer Table 11.2 of Annexure-11 of DC 3.4 Part-I)
12.	Helideck uniformly distributed area live load (Case-3)		200 kg/ m^2	For global design only (Refer Table 11.2 of Annexure-11 of DC 3.4 Part-I)
13.	Bridge Walkway Live load		150 kg/ m^2	For global design of Deck / Module / Jacket.
14.	Bridge Walkway		250 kg/ m^2	For global Bridge Design

15	Bridge Landing Area	Actual Bridge Reaction Load

Note:

1. During pile configuration stage architectural load shall be estimated from past experience / project.
2. Module reaction shall be calculated as per Annexure-6.

Table – 4.03 Open Deck Area Live Loads

Description	**Area Live Loads Local Design (Kg per sq. m.)**	**Area Live Loads Global Design (Kg per sq. m.)**
Deck Process Area, Utility& Equipment Rooms, Store Rooms, Building Module	500	500

Note: Open Deck area is defined as the area outside 0.50 M from any equipment / skid /building Module footprint area.

Annexure – 5: Gust period for Design Wind Forces/ Load

Wind areas shall also be included for equipment items on the deck and module/storage and wave forces shall be calculated as follows:

Sr No	Type of Analysis	Gust Period
a)	Jacket In-place Analysis	1 Hr. Average
b)	Deck In-place Analysis	1 Min. Average
c)	Building/Module Frame Analysis	5 Sec. gust
d)	Cantilever Structures, towers, vents, flare booms, bridges of length less than 50 M	3 Sec. gust
e)	Exterior Wall panels of buildings, barrier walls, including their stiffeners	3 Sec. gust
f)	Bridge Greater than 50 M length	15 Sec. gust

Annexure–6: Reactions from Building modules for global in-service analysis

(These loads are for actual Equipment (Architectural) load with open area live Load of 500 kg/m2)

Sl. No.	Item	Load to be considered for calculating reactions
1	For deck in-place analysis	Module & Equipment dead weight + Architectural Load + operating content + 375 (75% of 500) kg /sqm on open area of each floor and accessible roof + Wind Load.
2	For jacket in-place conditions and for jacket and deck earthquake analysis.	Module & equipment dead weight + Architectural Load + operating content weight + 300 (60% of 500) kg/sqm on open area of each floor and accessible roof + Wind Load.
3	Jacket uplift condition	Module & equipment dead weight & Architectural Load + Wind Load.

Notes:

(a) The term "Equipment and piping dead weight (Refer Load Combination Table)" includes dead loads of equipment, piping including pipe supports, electrical cables , cables and cable trays, instruments and instrument trays .

(b) Helicopter data shall be as given in Table 11.3 of Annexure-11.

(c) For Global Design appropriate percentages of the live load figures given in Table 4.02 of annexure-4 and this-annexure shall be used as specified in the respective load combination tables.

(d) No live load is to be considered on walkways, landing, stairways, and loading/ unloading areas of the modules for calculating the reactions from building.

(e) For substructure / pile design no live load to be considered on helideck, solar panel, platforms and firefighting platforms for calculating reactions from building modules.

(f) Open deck area is defined as area outside 0.5m from any equipment /skid/building module foot print area.

(g) No live load shall be considered on grated area of jacket walkway, and boat landing for global analysis (Jacket).

Annexure – 7: Load Combinations

Table 7.1: Load Combination for Sub- structure Analysis

The in-place integral - structural analysis of the idealized deck - substructure - pile - soil system shall be performed as a minimum for following load combinations.

Load Combination No.1(a)	Extreme storm condition with operating loads & minimum deck area live loads
Load Combination No.1(b)	Extreme storm condition with maximum deck area live loads or blanket loads
Load Combination No.2(a)	Operating storm condition with operating loads & minimum deck area live loads
Load Combination No.2(b)	Operating storm condition with maximum deck area live loads or blanket loads
Load Combination No.3	Extreme storm condition with empty equipment to check the capacity of the piling under the maximum uplift force.
Load Combination No.4	Earthquake with operating load
Load combination No. 5*	*Modular rig with extreme storm condition*
Load combination No. 6*	*Modular rig with operating storm condition*

***(If modular rig operation over the proposed platform is specified in scope)**

Environmental Parameter furnished in Annexure-13 of DC 3.4 Part-I is not matching (within tolerance of ± 5°) then it shall be derived by linear interpolation from nearest two directions.
In summary the design load combinations for substructure analysis shall be as given in the following Table-7.1.1:

TABLE 7.1.1: Load Combination for Sub- structure Analysis

LOAD CASE	LOAD COMBINATION AS SUM OF LOAD CASE PERCENTAGE							
	1a	1b	2a	2b	3	4	5*	*6
Extreme Storm Wind, Wave & current	100	100	NA	NA	100	NA	100	NA
Operating, Storm Wind, Wave & current	NA	NA	100	100	NA	NA	NA	100
Structural Dead Loads & Buoyancy	100	100	100	100	100	100	100	100
Equipment & Piping Dead Weight	100	0	100	0	100	100	100	100
Equipment & Piping Operating Contents Weight	100	0	100	0	0	100	100	100
Open Deck area live load	50	0	100	0	0	50	50	50
Uniformly distributed deck area live load for plating and grated area. (without any deduction in area of equipment footprint)	0	60	0	60	0	0	0	0
Loading/unloading area of deck	60	60	60	60	0	60	0	0

Crane dead load	100	100	100	100	100	100	100	100
Crane operating loads	0	0	0	0	0	0	0	0
Elastic bending forces due to curved conductors	100	100	100	100	100	100	100	100
Riser dead loads	100	100	100	100	100	100	100	100
Reaction from Bridge including walkway live load	100	100	100	100	100	100	100	100
Reactions from modules	100	100	100	100	100	100	100	100
Earthquake load	NA	NA	NA	NA	NA	100	0	0
Modular rig (Hook load is to be converted as Dead Load)*	0	0	0	0	0	0	100	0
Modular rig (with hook load)*	0	0	0	0	0	0	0	100

(If modular rig operation over the proposed platform is specified in scope)

NOTES:

1 Process Platform Substructure shall be analyzed for load condition No. 1 (1a or 1b) and 2 (2a or 2b), whichever is governed by higher magnitude of deck loads.

2 Well platforms sub structure shall be analyzed for load combination Nos. 1, 2, 3, 4, 5 and 6 with disturbed soil conditions due to jack up rig deployment.

3 Undisturbed soil Conditions shall be considered for load combination No. 4.

4 For uplift condition of substructure and piles only weights of permanently placed equipment and piping shall be considered (Load combination 3).

5 If a monsoon is envisaged to intervene between the installation of substructure and the installation of the deck, the substructure shall also be analyzed separately for extreme storm condition. For well platform, only dead load of temporary deck shall be considered. An appropriate number of risers and no increase in member diameter due to marine growth shall be considered for such an analysis. Coefficients of drag and mass shall be taken corresponding to smooth surfaces.

6 No Blanket area load shall be considered below module foot-print area.

Table 7.2: Load Combination for Deck Analysis

The entire deck structure including all primary and secondary trusses and frames with a portion of substructure shall be analyzed as 3-dimensional space frame. Deck structural analysis shall be carried out as a minimum for the following loading combinations:

Load Combination No.1	Extreme storm condition with operating loads and minimum deck area live loads
Load Combination No.2	Extreme storm condition with maximum deck area live loads or blanket loads

Load Combination No.3	Operating storm condition with operating loads and minimum deck area live loads
Load Combination No.4	Operating storm condition with maximum deck area live loads or blanket loads
Load Combination No. 5	Normal operating loads plus crane operating Load.
Load Combination No. 6	Earthquake with operating loads
Load combination No. 7*	Modular rig loading with extreme storm
Load combination No. 8*	Modular rig loading with operating storm
Analysis for load combinations Nos.1 to 4, 7 and 8 shall be carried out for minimum 8 storm approach directions for each load combination.	

* ***(If modular rig operation over the proposed platform is specified in scope)***

In summary the load conditions shall be as given in the following **Table- 7.2.1**

TABLE – 7.2.1: Load Combinations for Deck Analysis:

LOAD CASE	LOAD COMBINATION AS SUM OF LOAD CASE PERCENTAGE							
	1	**2**	**3**	**4**	**5**	**6**	***7**	***8**
Extreme Storm Wind, Wave & Current	100	100	NA	NA	0	NA	100	NA
Operating Storm Wind, Wave & Current	NA	NA	100	100	0	NA	NA	100
Deck Structural Dead Loads	100	100	100	100	100	100	100	100
Equipment & Piping Dead Weight	100	0	100	0	100	100	100	100
Equipment & Piping Operating Contents Weight	100	0	100	0	100	100	100	100
Open Deck area live load	100	0	100	0	100	50	100	100
Uniformly distributed deck area live load for plating area. (without any deduction in area of equipment footprint)	0	75	0	75	0	0	0	0
Uniformly distributed deck area live load for grated area.	0	75	0	75	0	0	0	0
Loading/unloading area of deck	100	100	100	100	100	60	0	0
Crane dead loads	100	100	100	100	100	100	100	100
Crane operating loads	0	0	0	0	100	0	0	0
Reaction from Bridge including walkway live load	100	100	100	100	100	100	100	100
Reaction from Modules	100	100	100	100	100	100	100	100
Earthquake	NA	NA	NA	NA	NA	100	0	0

Modular rig (Hook load is to be converted as Dead Load on capping Beam)*	0	0	0	0	0	100	100	0
Modular rig (with hook load)*	0	0	0	0	0	100	0	100

(If modular rig operation over the proposed platform is specified in scope)

NOTES:

1. For Earthquake analysis loading on deck shall be considered same as for substructure analysis.

2. Deck crane operating loads shall be considered for 8 orientations of boom in combination with deck equipment and piping operating loads. Crane operating loads shall include impact factors.

3. Deck analysis shall be carried out along with Building Module cum Helideck as integrated module for Well Platform.

4. No Blanket area load shall be considered below module foot-print area.

Table – 7.3 Load Combinations for Module/ Building Frame Analysis

A 3-dimensional analysis of building module shall be performed consisting of all primary trusses and frames of the module. Helideck when an integral part of the building shall be included in the framework. Structural interaction between building module and deck need not be considered. Modules analysis shall be carried out as a minimum for the following loading combinations:

Load combination No.1	Extreme storm condition with operating loads & minimum deck area live loads
Load combination No. 2	Extreme storm condition with maximum deck area live loads or blanket loads
Load combination No.3	Operating storm condition with operating loads & minimum deck area live loads
Load combination No.4	Operating storm condition with maximum deck area live loads or blanket loads
Load combination No.5	Normal operating loads plus crane operating loads.
Load condition No. 6	Earthquake condition with operating loads

The load conditions are summarized in the following **Table- 7.3.1:**

TABLE – 7.3.1 Load Combinations for Building Frame Design:

LOAD CASE	LOAD COMBINATION AS SUM OF LOAD CASE PERCENTAGE					
	1	2	3	4	5	6
Extreme Storm Wind	100	100	NA	NA	NA	NA
Operating Storm Wind	NA	NA	100	100	NA	NA
Dead Load of Module	100	100	100	100	100	100
Equipment & Piping Dead Weight	100	0	100	0	100	100
Equipment & Piping Operating Contents Weight	100	0	100	0	100	100
Live load on each floor and accessible roof	100	0	100	0	100	100
Uniformly distributed area live load on building floor	0	75	0	75	0	0
Crane dead loads	100	100	100	100	100	100
Crane operating loads	0	0	0	0	100	0
Grated areas	0	0	20	20	20	20
Loading/Unloading areas	100	100	100	100	100	100
Helideck Uniformly distributed area Live Load excluding solar panel and firefighting platform	100	100	100	100	100	100
Reaction from Bridge including walkway live loads	0	0	100	100	100	100
Earthquake load	NA	NA	NA	NA	NA	100
Modular Rig Camp Operating Load*	100	100	100	100	100	100

(If modular rig operation Load on the proposed Well Platform if specified in scope)

NOTE:

1. Crane loads are applicable if they are supported by the respective module.

Table- 7.4 <u>Load Combinations for Pre-Service Analysis</u>

Basic Loads	**Load Combinations**			
	Fabrication	Load out	Transportation	Installation
Structure Dead Loads	100	100	100	100
Structure Dead Loads + Buoyancy	-	-	-	100
Dry Equipment, Piping, Cabling etc.	100	100	100	100
Crane Dead Loads	100	100	100	100
Wind Loads:				
Fabrication & transportation	100			
Load out		100		
Transportation at sea			100	
Installation				100
Wave + Current Loads:				
Installation				100
Fabrication Loads	100			
Load out Loads		100		
Sea Transportation Loads			100	
Installation Loads				100

Annexure–8: Increase in Permissible Stresses

Sl No	Type of Analysis	Load Condition	Permissible Percentage increase
1	Global In-Service	Extreme Environment	33%
2		Operating Environment	Nil
3		Earthquake – Jacket & Deck	70%
4		Earthquake – Deck supported structures (Modules)	33%
5	Global Pre-service	Load out	Nil
6		Transportation	33%
7		Launch	Nil
8		On bottom Stability – Installation sea state included in calculation of member forces and stresses	33%
9		Lift	Nil
10	Local In –service	Extreme Environment	33%
11		Operating Environment	Nil
12		Boat Impact (for case other than the design of supports of riser protector welded to the jacket)	33%
13		Wave Slam	33%
14		Vessel Hydro test	Nil
15	Local Pre-service	Launch	Nil
16		Wave Slam	33%
17		Mud-mat & Supports – Installation sea state included in calculation of member forces and stresses	33%

Annexure–9: Minimum Load Contingencies

SL NO	Items	For Process / LQ Platform	For Wellhead Platform
a.	Substructure Dead Weight over and above the weight allowance for accounting mill tolerance (refer 3.4.9 of DC 3.4 Part-I)	5	5
b.	Superstructure Dead Weight over and above the weight allowance for accounting mill tolerance (refer 3.4.9 of DC 3.4 Part-I)	10	5
c.	Building Architectural Items	15	5
d.	Equipment and Piping Dead Weight	15	5
e.	Equipment and Piping Operating Weight	15	5

NOTE:

1 Above stated contingencies shall be considered in all in-service Analysis.

2 Reductions to the amount of contingency to reflect the relative confidence level in the weight data can be considered for pre-Service Analysis at the advance stage of Engineering.

3 Above stated contingencies shall not be applied for pile force analysis under uplift condition.

4 No contingencies for items listed under SL NO c, d and e shall be applicable for in-service analysis after obtaining final WCR in case of well head platform.

Annexure -10: Parameters for Pile Drivability Analysis

I. Dynamic Soil Parameter Input

Soil Type	Damping Coefficient (Sec/M)		Quake (mm)	
	Side	Point	Side	Point
Clay	0.656	0.033	2.54	2.54
Sand	0.164	0.492	2.54	2.54

Notes: For layered soil, weighted average of side damping value shall be used.

II. Soil Resistance to Driving (SRD) Input

Soil Type	Continuous Driving case (Lower Bound)				Set up Driving Case (Upper Bound)			
	Skin Friction (outer wall) w.r.t. Static Capacity	Skin Friction (inner wall) w.r.t. Static Capacity	End Bearing w.r.t. Static Capacit y	Set up factor	Skin Friction (outer wall) w.r.t. Static Capacity	Skin Friction (inner wall) w.r.t. Static Capacity	End Bearing w.r.t. Static Capacit y	Set up factor
CLAY	50%	25%	100%	1.00	85%	42.5%	100%	1.00
SAND	100%	50%	100%	1.00	100%	50%	100%	1.00

NOTE:

1. Pile Drivability Analysis (upto target penetration) shall be carried out with above stated parameters for Pile Plugged & Un- Plugged condition with Continuous Driving (Lower Bound) and soil Set-up condition driving (Upper Bound).
2. In case, Pile Drivability Analysis is not carried out for un-plugged case for Full Set-up Condition then Pile Driving after removal of Soil Plug shall become the part of Drivability Analysis and post Pile driving Soil plug inside the Pile shall be build-up. Cost for removal of soil plug, driving Pile and building up the internal soil Plug shall be borne by Contractor.
3. Unplug Driving Case, the internal skin friction is to be accounted by increasing the pile perimeter value (as per software manual).
4. Blow count obtained from Pile Drivability analysis needs to be less than the blow count limit provided by Software or Hammer Manufacturer for sizing Hammer. Pile refusal Criteria provided by API RP 2A is for field observation only and does not come in to picture for Hammer selection.
5. Hammer Designated for Conductor Driving shall be IHC S-90 /IHC S150 or equivalent. Backup Hammer for Conductor Driving shall be IHC S-150 or equivalent. Maximum operated energy for both Hammer designated and backup hammer for conductor driving shall not exceed 145kJ. Conductor driving refusal criteria with a properly operating hammer is defined as the point where conductor driving resistance exceeds 270 blows per feet (0.3 m) at 145KJ. Conductors are to be driven to 70 meter penetration below seabed or the point of refusal whichever is earlier.

Annexure–11: Helideck Design

Table – 11.1: Helideck Frame Analyses & Design Live Load

The entire helideck primary trusses and frames shall be analyzed as 3-dimensional space frame. Helideck structural analysis shall be performed for the following load combinations:

Load Combination No.1 (Extreme storm condition).

Without helicopter static loads on helideck. Appropriate live load on entire helideck and other dead and live loads under extreme storm conditions. [Case-1]

Load Combination No.2 (Static helicopter under operating storm condition).

Static helicopter load at the center of helideck plus appropriate live load on entire helideck, Fire Fighting Platform, Solar Deck, walkway, stairs and landings in combination with operating storm conditions. [Case-1]

Load Combination No.3 (Helicopter landing condition).

Helicopter landing loads at different positions with wheels at various position plus appropriate dead and live loads (on solar Deck, Firefighting Platform and other grated areas except on helideck). Helicopter Wheel Position at Center of Helideck, at various positions at the periphery (1.5 m inside) and at mid-way positions between Centre & Periphery. [Case-1]

Load Combination No.4 (Helicopter Crush Landing condition).

Helicopter Crush Landing positions with wheels at various position plus appropriate dead and live loads (on solar Deck, Firefighting Platform, and other grated areas except on helideck). Helicopter Wheel Position at Center of Helideck, at various positions at the periphery (1.5 m inside) and at mid-way positions between Centre & Periphery. [Case-2]

Load Combination No.5 (Modular Rig Living Quarter Load, if applicable).

Static helicopter load at the center of helideck over the (Modular Rig Camp) plus appropriate live load on entire helideck, Modular Rig Camp operating load, Fire Fighting Platform, Solar Deck, walkway, stairs and landings in combination with operating storm conditions. [Case-1]

In summary the loads to be considered for various combinations are given in the following Table 15.1.

TABLE – 11.1.1: Load Combination for Helideck Global Analysis

Load Case	Load Combination as sum of load case percentage				
	1	2	3	4	5
Extreme storm wind	100	NA	NA	NA	NA
Operating storm wind	NA	100	NA	NA	100

Structural dead loads and dead loads of solar panel platform, firefighting platform and equipment	100	100	100	100	100
Uniformly distributed area live loads on helideck	50	100	0	0	100
Static helicopter load	NA	100	NA	NA	100
Landing condition load with impact at various position on helideck	NA	NA	100	NA	NA
Crush Landing condition load at various position on helideck	NA	NA	NA	100	NA
Live loads on Grated areas	0	50	50	50	50
Live load on Solar panel platform and firefighting platform	0	50	50	50	50
Modular Rig Camp Load for Well Platform (if applicable).	NA	NA	NA	NA	100

Notes: 1. Four orthogonal & four Diagonal wind directions shall be considered for extreme and operating storm conditions.

2. Wind loads on Solar panels shall be included in the analysis (wherever applicable).

TABLE - 11.2 Helideck Design Load:-

1.	Helideck beam (local design only)	Case-1 Static helicopter load plus uniform live load of 50 kg/ m^2 over the Helideck. Case-2 Helicopter landing & Crush Landing impact load at various position.	For Case -2 Critical position of the Helicopter landing & Crush Landing cases shall be evaluated in the analysis at Center, various position at 1.5 m inside periphery in between above to positions.
2	Helideck firefighting & solar panel platform	200 kg/ m^2	For global design only (Refer Table 10 III)
3.	Helideck uniformly distributed area live load.	200 kg/ m^2	For global design only (Refer Table 10 III)

1. For substructure/pile design no live load to be considered on Helideck, solar panel platforms and firefighting platforms for calculating reactions from building modules.

2. For deck truss design consider a live load of 100 kg/m2 on helideck only for calculating reactions from building modules.

Table - 11.3: Static Helicopter Data Relevant to Helideck Design

DETAIL (1)	**Bell 212 (2)**	**Bell 412** (3)	**Westland WG 30 (4)**	**Sikorsky**		**Dauphin SA** 365 N2 (7)	**MIL Mi8 (8)**	**Sikorsky S-61-N (9)**
				S76 (5)	S76-**B** (6)			
Gross WT (MT)	5.08	5.26	5.80	4.67	5.03	4.30	12.00	9.30
Main Rotor Dia (mm)	14.7	14.02	13.31	13.41	13.41	11.93	21.3	18.9

Overall Length (M)	17.5	17.10	15.91	16.0	16.0	13.68	25.24	22.25
Landing Gear type	SKID	SKID	WHEEL	WHEEL	WHEEL	WHEEL	WHEEL	WHEEL
No of Gears -Nose -Rear	2 2	2 2	1 2	1 2	1 2	1 2	1 2	2 1
No of Wheels Gear -Nose -Rear	- -	- -	1 1	1 1	1 1	1 1	2 1	2 1
Spacing of Wheels (mm) -Nose	-	-	-	-	-	-	275	330
Distance between nose & rear gear (M)	2.3	2.322	5.45	5.0	5.0	3.61	4.26	7.2
Transverse Spacing (M)	2.7	2.178	3.1	2.44	2.44	1.9	4.5	4.3
% of gross WT. Per Gear -Nose -Rear	40 34	10 40	20 40	25 37.5	25 37.5	NA NA	41.67 28.17	43 15
Tyre Pressure (Psi) -Nose -Rear	- -	- -	55 55	140 160	120 135	79.75 123.25	64 78	75 70

NOTE:
1. Helideck for Living Quarters & Process Platform shall be designed for all listed Helicopters. Overall length and Gross weight shall be separate maximum of values given column (2) through (9).
2. Well platforms shall be designed for all Helicopters except MI-8 and SIKORSKY S6IN. Overall length and Gross weight shall be separate maximum of values given in column (2) through (7).

Annexure–12: Deflection Limit

Sr. No.	Structural Element	Limiting Deflection
1	Beams	
1.a	Cantilevers	L/180
1.b	Beams supporting major items of equipment	L/360
1.c	Beams supporting sensitive equipment subject to dynamic loads	L/500
1.d	Cantilevers Beams supporting sensitive equipment subject to dynamic loads	L/250

1.e	Secondary beams	L/360
2	Floor plate	L/250
3	Crane gantry beams	
3.a	Vertical Deflection due to static wheel load	L/750
3.b	Horizontal deflection	L/500
4	Bridge	
4.a	Vertical Deflection	L/400
4.b	Horizontal deflection due to wind load	L/500
5	Grating	L/200

Where “L” is the effective span of the member

Annexure – 13: Environmental Parameters

Tide, Wave, Current & Wind Parameters

A. Mumbai High Field (North & South)

Extreme Storm Parameters (100 years)

*Direction (From)	Tide (m)		Max Wave		Current (m/s) (Y is the depth of water and currents are measured from bottom)						Wind (km/hr)
	AT	Storm	Height (m)	Period (sec)	Bottom	Y-1/5	Y-2/5	Y-3/5	Y-4/5	Surface	1-hour average
North	3.261	0.091	13.86	12.20	0.457	0.914	1.097	1.310	1.493	1.676	149.67
North East	3.261	0.152	15.24	12.80	0.426	0.853	1.036	1.219	1.402	1.585	149.67
East	3.261	0.122	14.63	12.60	0.365	0.731	0.914	1.066	1.249	1.402	149.67
South East	3.261	0.183	15.54	12.90	0.396	0.762	0.944	1.097	1.280	1.432	149.67
South	3.261	1.158	19.20	14.70	0.396	0.792	0.975	1.127	1.310	1.463	149.67
South West	3.261	1.127	18.44	14.30	0.396	0.762	0.945	1.097	1.280	1.432	149.67
West	3.261	1.067	17.68	14.00	0.365	0.731	0.914	1.066	1.249	1.402	149.67
North West	3.261	1.097	17.98	14.10	0.426	0.853	1.036	1.219	1.402	1.585	149.67

Operating Storm Parameters (1 year)

*Direction (From)	Tide (M)		Max. Wave		Current (m/sec) (Y is the depth of water and currents are measured from bottom)					Wind (km/h)
	AT	Storm	Height (M)	Period (Sec)	Bottom	Y-1/4	Y-1/2	Y-3/4	Surface	1-Hour average
All Direction	3.26	0.61	11.583	11.00	0.476	0.878	1.049	1.22	1.387	99.22

Environmental Parameters for Installation Condition

Tide (m)	Maximum wave Height (m)	Period (sec)	Current (m/s)		Wind (km/hr)
			Bottom	Surface	1 Minute Sustained

4.39	4.00	7.8	0.426	0.701	48.27

Environmental Parameters for Fatigue Analysis

Deterministic Fatigue

Recommended Wave Period for Specified Wave Height Categories:

Wave Height (m)		Wave Period in Sec (Direction from)							
		N-Dir	NE-Dir	E- Dir	SE-Dir	S-Dir	SW-Dir	W-Dir	NW-Dir
0.00	0.60	5	5	5	5	6.1	6.3	6.3	5.7
0.61	1.21	5.4	5.4	5.4	5.4	6.5	6.7	6.7	6.1
1.22	1.82	5.7	5.7	5.7	5.7	6.8	7	7	6.4
1.83	2.43	6	6	6	6	7.1	7.4	7.3	6.7
2.44	3.04	6.3	6.3	6.3	6.3	7.4	7.8	7.8	7
3.05	3.65	6.6	6.6	6.6	6.6	7.7	8.2	8.1	7.3
3.66	4.26	6.9	6.9	6.9	6.9	8	8.6	8.6	7.6
4.27	4.87	7.2	7.2	7.2	7.2	8.3	9	9	8
4.88	5.48	7.5	7.5	7.6	7.5	8.6	9.4	9.3	8.3
5.49	6.09	7.8	7.7	7.9	7.7	8.9	9.6	9.6	8.5
6.10	7.61		8.1		8.1	9.1	9.9	9.8	8.6
7.62	9.13					9.3	10.1	10	
9.14	10.66						10.4	10.3	
10.67	12.16						10.6		

Number of Waves in 1 Year in Selected Wave Heights Categories:

Wave Height (m)		N-Dir	NE-Dir	E-Dir	SE-Dir	S-Dir	SW-Dir	W-Dir	NW-Dir
0.00	0.60	370901	303197	82423	47098	64761	565182	903701	606393
0.61	1.21	164217	134241	36492	20853	28672	250236	400119	268482
1.22	1.82	70036	57251	15564	8894	12229	106720	170639	114502
1.83	2.43	29868	24417	6637	3793	5215	45514	72776	48833
2.44	3.04	12739	10413	2831	1617	2224	19411	31037	20826
3.05	3.65	5432	4441	1207	690	949	8278	13237	8882
3.66	4.26	2317	1894	515	294	404	3531	5645	3788
4.27	4.87	1188	784	213	122	168	1461	2337	1569
4.88	5.48	472	441	125	71	67	591	945	633
5.49	6.09	63	174	45	22	43	248	396	435
6.10	7.61	0	9	0	4	20	278	444	180
7.62	9.13	0	0	0	0	3	38	70	0

9.14	10.66	0	0	0	0	0	7	6	0
10.67	12.16	0	0	0	0	0	2	0	0

Spectral Fatigue

Average Annual Occurrence of Mean Wave Period in Significant Wave Height for All Directions

Mean wave period (sec)	Significant Wave Height (m)							
	0.00–0.60	**0.61–1.21**	**1.22–1.82**	**1.83–2.43**	**2.44–3.04**	**3.05–4.56**	**4.57 plus**	**Total**
0.0-2.4	2	0	0	0	0	0	0	2
2.5-3.4	14	8	2	0	0	0	0	24
3.5-4.4	55	30	9	3	1	0	0	98
4.5-5.4	70	74	35	13	3	2	0	197
5.5-6.4	69	73	41	23	13	8	0	227
6.5-7.4	34	65	41	24	15	17	1	197
7.5-8.4	10	19	19	17	14	17	2	98
8.5-9.4	6	9	9	8	7	10	1	50
9.5-10.4	6	7	5	4	4	3	0	29
10.5-11.4	5	6	4	3	3	2	0	23
11.5-12.4	3	5	3	3	2	1	0	17
12.5-13.4	3	4	2	2	2	1	0	14
13.5-14.4	2	3	2	2	1	1	0	11
14.5-15.4	2	2	1	1	1	1	0	8
15.5 Plus	1	1	1	1	1	0	0	5
Total	282	306	174	104	67	63	4	1000

Direction	**Percentage Occurrence**
N	12.6
NE	10.3
E	2.8
SE	1.6
S	2.2
SW	19.2
W	30.7
NW	20.6
Total	100

B. Bassein & Satellite and Neelam & Heera Field

Extreme Storm Parameters (100 years)

*Direction (From)	Tide (M)		(Max Wave)		Current (m/s)						Wind (Km/hr)
	AT	Storm	Height (m)	Period (sec)	Bottom	Y-1/5	Y-2/5	Y-3/5	Y-4/5	Surface	1-hour average
North	4.572	0.213	15.24	13.10	0.640	1.036	1.250	1.494	1.707	1.920	149.67
North East	4.572	0.000	10.98	11.20	0.609	1.006	1.189	1.402	1.585	1.767	149.67
East	4.572	0.000	9.45	10.70	0.548	0.945	1.097	1.250	1.372	1.524	149.67
South East	4.572	0.000	11.59	11.40	0.579	0.975	1.128	1.280	1.402	1.554	149.67
South	4.572	1.402	17.68	14.40	0.609	1.006	1.189	1.341	1.524	1.676	149.67
South West	4.572	1.371	17.07	14.00	0.548	0.945	1.097	1.250	1.372	1.524	149.67
West	4.572	1.310	16.46	13.60	0.518	0.914	1.036	1.189	1.311	1.432	149.67
North West	4.572	1.341	16.76	13.80	0.609	1.006	1.219	1.433	1.615	1.828	149.67

Operating Storm Parameters (1 year)

*Direction (From)	Tide (M)		Max. Wave		Current (m/sec) (Y is the depth of water and currents are measured from bottom)					Wind (Km/h)
	AT	Storm	Height (m)	Period (sec)	Bottom	Y-1/4	Y-1/2	Y-3/4	Surface	1-Hour average
All Direction	4.39	0.61	11.58	11.0	0.476	0.878	1.049	1.22	1.387	99.22

Environmental Parameters for Installation Condition

Tide (m)	Maximum wave Height (m)	Period (sec)	Current (m/s)		Wind (km/hr)
			Bottom	Surface	1 Minute Sustained
4.36	4.00	8.3	0.426	0.701	48.27

Environmental Parameters for Fatigue Analysis

Deterministic Fatigue

Recommended Wave Period for Specified Wave Height Categories:

Wave Height (m)		Wave Period in Sec (Direction from)							
		N-Dir	NE-Dir	E-Dir	SE-Dir	S-Dir	SW-Dir	W-Dir	NW-Dir
0.00	0.60	5	5	5	5	6.1	6.3	6.3	5.7
0.61	1.21	5.4	5.4	5.4	5.4	6.5	6.7	6.7	6.1
1.22	1.82	5.7	5.7	5.6	5.7	6.8	7.1	7.1	6.4
1.83	2.43	6	6	5.9	6	7.1	7.4	7.4	6.7
2.44	3.04	6.3	6.3	6.2	6.3	7.4	7.8	7.8	7
3.05	3.65	6.6	6.6	6.5	6.6	7.7	8.2	8.1	7.2
3.66	4.26	6.9	6.9	6.8	6.9	8	8.6	8.5	7.4
4.27	4.87	7.2	7.1		7.2	8.2	8.9	8.8	7.6
4.88	5.48	7.5				8.4	9.1	9	7.8
5.49	6.09	7.8				8.6	9.3	9.3	8.1
6.10	7.61	8.1				8.8	9.6	9.6	8.4
7.62	9.13					9	9.8	9.8	
9.14	10.64						10.1	10.1	

Number of Waves in 1 Year in selected wave height categories:

Wave Height (m)		N-Dir	NE-Dir	E- Dir	SE-Dir	S-Dir	SW-Dir	W-Dir	NW-Dir
0.00	0.60	390830	319488	86851	49629	68240	595550	952261	638976
0.61	1.21	160891	131522	35754	20431	28092	245166	392011	263043
1.22	1.82	63723	52091	14160	8091	11126	97101	155261	104182
1.83	2.43	25238	20631	5609	3205	4407	38458	61493	41262
2.44	3.04	9996	8171	2221	1270	1745	15232	24355	16343
3.05	3.65	3920	3205	1175	497	685	5975	9553	6410
3.66	4.26	1532	1543	282	250	267	2335	3732	2504
4.27	4.87	626	611	0	85	110	951	1524	1022
4.88	5.48	367	0	0	0	48	419	669	449
5.49	6.09	104	0	0	0	18	156	251	244
6.10	7.61	6	0	0	0	16	131	216	88

7.62	9.13	0	0	0	0	1	19	25	0
9.14	10.64	0	0	0	0	0	3	2	0

Spectral Fatigue

Average Annual Occurrence of Mean Wave Period in Significant Wave Height for All Directions

Mean wave period (sec)	Significant Wave Height (m)							
	0.00–0.60	0.61–1.21	1.22–1.82	1.83–2.43	2.44–3.04	3.05–4.56	4.57 plus	Total
0.0-2.4	3	0	0	0	0	0	0	3
2.5-3.4	17	7	1	0	0	0	0	25
3.5-4.4	65	29	8	3	1	0	0	106
4.5-5.4	83	71	33	12	3	2	0	204
5.5-6.4	82	72	39	23	12	6	0	234
6.5-7.4	40	63	38	24	13	13	0	191
7.5-8.4	12	18	18	16	12	12	1	89
8.5-9.4	8	9	8	7	6	7	0	45
9.5-10.4	7	7	5	4	3	2	0	28
10.5-11.4	5	5	4	3	2	1	0	20
11.5-12.4	4	5	3	2	2	1	0	17
12.5-13.4	3	4	2	2	2	1	0	14
13.5-14.4	3	3	2	1	1	1	0	11
14.5-15.4	2	2	1	1	1	1	0	8
15.5 Plus	1	1	1	1	1	0	0	5
Total	335	296	163	99	59	47	1	1000

Direction	**Percentage Occurrence**
N	12.6
NE	10.3
E	2.8
SE	1.6
S	2.2
SW	19.2
W	30.7
NW	20.6
Total	100

C. Tapti Field

Extreme Storm Parameters (100 years)

*Direction (From)	Tide (m)		(Max Wave)		Current (m/s)						Wind (Km/hr)
	AT	Storm	Height (m)	Period (sec)	Bottom	Y-1/5	Y-2/5	Y-3/5	Y-4/5	Surface	1-hour average
North	4.36	0.00	10.97	11.20	0.701	1.067	1.219	1.402	1.554	1.707	149.67
North East	4.36	0.00	10.67	11.10	0.792	1.158	1.341	1.524	1.707	1.890	149.67
East	4.36	0.00	10.36	11.00	0.671	1.006	1.158	1.341	1.494	1.646	149.67
South East	4.36	0.00	11.89	11.50	0.549	0.823	0.945	1.097	1.219	1.341	149.67
South	4.36	1.68	17.22	14.40	0.701	1.067	1.219	1.402	1.554	1.707	149.67
South West	4.36	1.65	16.61	14.00	0.762	1.128	1.311	1.463	1.646	1.798	149.67
West	4.36	1.58	16.00	13.60	0.518	0.792	0.914	1.036	1.158	1.280	149.67
North West	4.36	0.00	10.67	11.10	0.579	0.884	1.036	1.158	1.311	1.433	149.67

Operating Storm Parameters (1 year)

*Direction (From)	Tide (m)		(Max Wave)		Current (m/s)						Wind (km/hr)
	AT	Storm	Height (m)	Period (sec)	Bottom	Y-1/5	Y-2/5	Y-3/5	Y-4/5	Surface	1-hour average
All Directions	4.267	0.884	9.754	10.20	0.579	0.884	1.006	1.158	1.280	1.402	80.47

Environmental Parameters for Installation Condition

Tide (m)	Maximum wave Height (m)	Period (sec)	Current (m/s)		Wind (km/hr)
			Bottom	Surface	1 Minute Sustained
4.36	4.00	7.8	0.70	1.46	48.27

Environmental Parameters for Fatigue Analysis

Deterministic Fatigue

Recommended Wave Period for Specified Wave Height Categories

Wave Height (m)	Wave Period in Sec (Direction from)							
	N	NE	E	SE	S	SW	W	NW
0.000 - 1.523	6.3	5.7	5.7	6.4	8.7	9.6	8.3	6.6
1.524 - 3.047	6.9	6.6	6.6	7.0	9.2	10.1	8.7	7.4
3.048 – 4.571	7.3	7.1	7.1	7.5	9.5	10.3	9.2	7.9
4.572 – 6.095	7.8	7.6	7.6	8.0	9.7	10.4	9.6	8.4
6.096 – 7.619	8.3	8.2	8.2	8.5	9.9	10.5	10.0	8.9
7.620 - 9.143						10.6	10.3	
9.144 – 10.667						10.8	10.6	
10.668 – 12.192						11.0	10.9	

Wave Exceedance Data for fatigue Analysis

Wave Height (m)	**Cumulative numbers of Wave Exceeding a specified Wave Height in one year & Direction from:**							
	N-DIR	NE-DIR	E-DIR	SE-DIR	S-DIR	SW-DIR	W-DIR	NW-DIR
0	1,190,038	184,866	92,433	77,627	86,007	585,669	923,280	1,142,884
1.524	49,065	10,832	5,327	5,747	12,639	208,515	215,658	64,041
3.048	1,925	767	342	427	1,207	37,162	31,560	3,337
4.572	67	48	20	27	100	5,830	4,053	150
6.096	3	3	1	2	8	866	492	6
7.620	0	0	0	0	0	126	59	0
9.144	0	0	0	0	0	18	7	0
10.668	0	0	0	0	0	2	1	0
12.192	0	0	0	0	0	0	0	0

Spectral Fatigue

Average Annual Occurrence of Mean Wave Period in Significant Wave Height for **All Directions**

Mean wave period (sec)	Significant Wave Height (m)							
	0.00–0.60	0.61–1.21	1.22–1.82	1.83–2.43	2.44–3.04	3.05–4.56	4.57 plus	Total
0.0-2.4	4	0	0	0	0	0	0	4
2.5-3.4	23	7	1	0	0	0	0	31
3.5-4.4	86	26	7	3	1	0	0	123
4.5-5.4	110	64	26	10	2	1	0	213
5.5-6.4	108	64	31	18	9	4	0	234
6.5-7.4	52	57	29	19	12	7	0	176
7.5-8.4	17	16	15	14	10	8	0	80
8.5-9.4	10	8	7	6	5	4	0	40
9.5-10.4	9	6	4	4	3	1	0	27

10.5-11.4	7	5	3	3	2	1	0	21
11.5-12.4	5	4	3	2	2	1	0	17
12.5-13.4	4	4	2	2	1	0	0	13
13.5-14.4	4	3	1	1	1	0	0	10
14.5-15.4	3	2	1	1	0	0	0	7
15.5 Plus	1	1	1	1	0	0	0	4
Total	443	267	131	84	48	27	0	1000

Average percentage occurrence of significant wave height: Annual

Direction	Significant Wave Height (m)							
	0.00–0.60	0.61–1.21	1.22–1.82	1.83–2.43	2.44–3.04	3.05–4.56	4.57 plus	Total
N	9	2.3	0.2	0	0	0	0	11.5
NE	8	2	0.1	0	0	0	0	10.1
E	2.6	0.7	0	0	0	0	0	3.3
SE	1.2	0.5	0	0	0	0	0	1.7
S	0.7	1.1	0.9	0.7	0.4	0.2	0	4
SW	2.3	5.3	5.3	4.4	2.7	1.6	0	21.6
W	7.5	10.2	6	3.3	1.7	0.9	0	29.6
NW	13	4.6	0.6	0	0	0	0	18.2
Total	44.3	26.7	13.1	8.4	4.8	2.7	0	100

Direction	**Percentage Occurrence**
N	11.5
NE	10.1
E	3.3
SE	1.7
S	4
SW	21.6
W	29.6
NW	18.2
Total	100

D. Daman Field

Extreme Storm Parameters (100 years)

*Direction (From)	Tide (m)		(Max Wave)		Current (m/s)						Wind (Km/hr)
	AT	Storm	Height (m)	Period (sec)	Bottom	Y-1/5	Y-2/5	Y-3/5	Y-4/5	Surface	1-hour average
North	4.27	0.15	12.50	11.70	0.701	1.036	1.189	1.372	1.524	1.676	149.67
North East	4.27	0.24	12.95	11.90	0.762	1.128	1.311	1.494	1.676	1.859	149.67
East	4.27	0.09	12.07	11.60	0.640	0.975	1.128	1.311	1.463	1.615	149.67
South East	4.27	0.24	12.86	11.80	0.549	0.853	1.006	1.128	1.280	1.402	149.67
South	4.27	1.49	17.50	14.40	0.701	1.036	1.189	1.372	1.524	1.676	149.67
South West	4.27	1.46	16.89	14.00	0.732	1.097	1.280	1.433	1.615	1.768	149.67
West	4.27	1.43	16.25	13.60	0.671	1.006	1.158	1.341	1.494	1.646	149.67
North West	4.27	0.15	12.41	11.70	0.610	0.914	1.067	1.219	1.341	1.494	149.67

Operating Storm Parameters (1 year)

*Direction (From)	Tide (m)		(Max Wave)		Current (m/s)						Wind (km/hr)
	AT	Storm	Height (m)	Period (sec)	Bottom	Y-1/5	Y-2/5	Y-3/5	Y-4/5	Surface	1-hour average
All Directions	**4.267**	**0.884**	**9.754**	**10.20**	**0.579**	**0.884**	**1.006**	**1.158**	**1.280**	**1.402**	**80.47**

Environmental Parameters for Installation Condition

Tide (m)	Maximum wave Height (m)	Period (sec)	Current (m/s)		Wind (km/hr)
			Bottom	Surface	1 Minute Sustained
4.36	4.00	7.8	0.701	1.46	48.27

Environmental Parameters for Fatigue Analysis

Deterministic Fatigue
Recommended Wave Period for Specified Wave Height Categories

Wave Height (m)		Wave Period in Sec (Direction from)							
		N-Dir	NE-Dir	E-Dir	SE-Dir	S-Dir	SW-Dir	W-Dir	NW-Dir
0.00	0.60	5	5	5	5	6.1	6.3	6.3	5.7
0.61	1.21	5.4	5.4	5.4	5.4	6.5	6.7	6.7	6.1
1.22	1.82	5.7	5.7	5.6	5.7	6.8	7.1	7.1	6.4
1.83	2.43	6	6	5.9	6	7.1	7.4	7.4	6.7
2.44	3.04	6.3	6.3	6.2	6.3	7.4	7.8	7.8	7
3.05	3.65	6.6	6.6	6.5	6.6	7.7	8.2	8.1	7.2
3.66	4.26	6.9	6.9	6.8	6.9	8	8.6	8.5	7.4
4.27	4.87	7.2	7.2	7.1	7.2	8.2	8.9	8.8	7.6
4.88	5.48	7.5	7.6	7.4	7.6	8.4	9.1	9	7.8
5.49	6.09					8.6	9.3	9.3	8.1
6.10	7.61					8.8	9.6	9.6	8.4
7.62	9.13					9	9.8	9.8	
9.14	10.65						10.1	10.1	

Number of Waves in 1 Year in selected wave height categories

Wave Height (m)		N-Dir	NE-Dir	E- Dir	SE-Dir	S-Dir	SW-Dir	W-Dir	NW-Dir
0.00	0.60	372496	324740	98695	54123	108246	662216	955119	608092
0.61	1.21	147351	128460	39042	21410	42820	261957	377824	240547
1.22	1.82	56042	48857	14849	8143	16286	99632	143700	91489
1.83	2.43	21315	18583	5648	3097	6194	37893	54653	34796
2.44	3.04	8107	7067	2148	1178	2356	14412	20787	13234
3.05	3.65	3084	2688	817	448	896	5481	7905	5034
3.66	4.26	1292	1057	391	195	325	1985	2864	1914
4.27	4.87	560	543	102	64	88	544	783	1128
4.88	5.48	40	50	8	16	81	494	714	47
5.49	6.09	0	0	0	0	35	212	305	0
6.10	7.61	0	0	0	0	20	114	174	0
7.62	9.13	0	0	0	0	1	14	12	0
9.14	10.65	0	0	0	0	0	2	1	0

Spectral Fatigue

Average Annual Occurrence of Mean Wave Period in Significant Wave Height for **All Directions**

Mean wave period (sec)	Significant Wave Height (m)							
	0.00–0.60	0.61–1.21	1.22–1.82	1.83–2.43	2.44–3.04	3.05–4.56	4.57 plus	Total
0.0-2.4	2	0	0	0	0	0	0	2
2.5-3.4	18	7	1	0	0	0	0	26
3.5-4.4	68	29	8	3	1	0	0	109
4.5-5.4	87	72	31	11	3	2	0	206
5.5-6.4	85	72	36	20	11	7	0	231
6.5-7.4	41	64	34	21	14	12	1	187
7.5-8.4	13	18	17	15	13	12	1	89
8.5-9.4	8	9	8	7	6	8	1	47
9.5-10.4	7	7	5	4	3	2	0	28
10.5-11.4	6	5	3	3	2	1	0	20
11.5-12.4	4	5	3	2	2	1	0	17
12.5-13.4	3	4	3	2	1	1	0	14
13.5-14.4	3	4	2	1	1	1	0	12
14.5-15.4	2	2	1	1	1	1	0	8
15.5 Plus	1	1	1	1	0	0	0	4
Total	348	299	153	91	58	48	3	1000

Direction	**Percentage Occurrence**
N	11.7
NE	10.2
E	3.1
SE	1.7
S	3.4
SW	20.8
W	30
NW	19.1
Total	100

E. Ratna Field

Extreme Storm Parameters (100 years)

*Direction (From)	Tide (m)		(Max Wave)		Current (m/s)						Wind (km/hr)
	AT	Storm	Height (m)	Period (sec)	Bottom	Y-1/5	Y-2/5	Y-3/5	Y-4/5	Surface	1-hour average
North	4.267	0.152	15.545	13.10	0.579	1.036	1.250	1.490	1.710	1.920	149.67
North East	4.267	0.030	12.131	11.50	0.549	1.006	1.220	1.400	1.620	1.798	149.67
East	4.267	0.000	11.765	11.30	0.488	0.884	1.070	1.250	1.400	1.585	149.67
South East	4.267	0.061	12.680	11.70	0.518	0.914	1.100	1.280	1.430	1.615	149.67
South	4.267	1.341	17.831	14.40	0.549	0.975	1.160	1.340	1.490	1.676	149.67
South West	4.267	1.311	17.130	14.10	0.518	0.914	1.070	1.250	1.400	1.554	149.67
West	4.267	1.250	16.429	13.80	0.488	0.884	1.040	1.190	1.340	1.494	149.67
North West	4.267	1.280	16.703	13.90	0.549	1.006	1.220	1.400	1.620	1.798	149.67

Operating Storm Parameters (1 year)

*Direction (From)	Tide (m)		(Max Wave)		Current (m/s)						Wind (km/hr)
	AT	Storm	Height (m)	Period (sec)	Bottom	Y-1/5	Y-2/5	Y-3/5	Y-4/5	Surface	1-hour average
North	4.267	0.091	6.309	8.20	0.488	0.884	1.036	1.189	1.311	1.463	69.20
North East	4.267	0.030	4.938	7.50	0.457	0.823	0.975	1.097	1.250	1.372	69.20
East	4.267	0.000	4.785	7.40	0.396	0.732	0.853	0.975	1.067	1.189	69.20
South East	4.267	0.061	5.151	7.60	0.427	0.762	0.884	1.006	1.097	1.219	69.20
South	4.267	0.640	8.443	9.10	0.457	0.792	0.914	1.036	1.158	1.280	69.20
South West	4.267	0.732	10.272	10.30	0.427	0.792	0.914	1.036	1.158	1.280	80.47
West	4.267	0.701	9.815	10.00	0.396	0.732	0.853	0.975	1.067	1.189	77.25
North West	4.267	0.762	6.797	8.50	0.457	0.823	0.975	1.128	1.250	1.402	69.20

Environmental Parameters for Installation Condition

Tide (m)	Maximum wave Height (m)	Period (sec)	Current (m/s)		Wind (km/hr)
			Bottom	Surface	1 Minute Sustained
4.39	3.6	7.8	0.426	0.701	48.27

Environmental Parameters for Fatigue Analysis

Deterministic Fatigue

Recommended Wave Period for Specified Wave Height Categories

Wave Height (m)	Wave Period in Sec (Direction from)							
	North	NE	East	SE	South	SW	West	NW
0.000 - 1.523	6.3	5.7	5.7	6.4	8.7	9.6	8.3	6.6
1.524 - 3.047	6.9	6.6	6.6	7.0	9.2	10.1	8.7	7.4
3.048 – 4.571	7.3	7.1	7.1	7.5	9.5	10.3	9.2	7.9
4.572 – 6.095	7.8	7.6	7.6	8.0	9.7	10.4	9.6	8.4
6.096 – 7.619	8.3	8.2	8.2	8.5	9.9	10.5	10.0	8.9
7.620 - 9.143						10.6	10.3	
9.144 – 10.667						10.8	10.6	
10.668 – 12.192						11.0	10.9	

Wave Exceedance Data for fatigue Analysis

Wave Height (m)	**Cumulative numbers of Wave Exceeding a specified Wave Height in one year & Direction from:**							
	North	NE	East	SE	South	SW	West	NW
0	1,190,038	184,866	92,433	77,627	86,007	585,669	923,280	1,142,884
1.524	49,065	10,832	5,327	5,747	12,639	208,515	215,658	64,041
3.048	1,925	767	342	427	1,207	37,162	31,560	3,337
4.572	67	48	20	27	100	5,830	4,053	150
6.096	3	3	1	2	8	866	492	6
7.620	0	0	0	0	0	126	59	0
9.144	0	0	0	0	0	18	7	0
10.668	0	0	0	0	0	2	1	0
12.192	0	0	0	0	0	0	0	0

Spectral Fatigue

Average Annual Occurrence of Mean Wave Period in Significant Wave Height for All Directions

Mean wave period (sec)	Significant Wave Height (m)							
	0.00–0.60	0.61–1.21	1.22–1.82	1.83–2.43	2.44–3.04	3.05–4.56	4.57 plus	Total
0.0-2.4	2	0	0	0	0	0	0	2
2.5-3.4	15	8	2	0	0	0	0	25
3.5-4.4	57	29	9	3	1	0	0	99

4.5-5.4	73	73	36	13	3	2	0	200
5.5-6.4	72	73	43	24	13	7	0	232
6.5-7.4	35	65	41	24	14	13	1	193
7.5-8.4	11	19	19	18	13	14	1	95
8.5-9.4	7	9	9	8	7	9	1	50
9.5-10.4	5	7	5	4	4	2	0	27
10.5-11.4	4	6	4	3	2	1	0	20
11.5-12.4	3	5	4	3	2	1	0	18
12.5-13.4	3	4	3	2	2	1	0	15
13.5-14.4	2	3	2	2	1	1	0	11
14.5-15.4	2	2	1	1	1	1	0	8
15.5 Plus	1	1	1	1	1	0	0	5
Total	292	304	179	106	64	52	3	1000

Average percentage occurrence of Significant wave height: Annual

Direction	Significant Wave Height (m)							
	0.00–0.60	0.61–1.21	1.22–1.82	1.83–2.43	2.44–3.04	3.05–4.56	4.57 plus	Total
N	8.8	8.1	3.5	1	0.2	0.1	0	21.7
NE	4.5	2.4	0.4	0	0	0	0	7.3
E	1.8	0.9	0.1	0	0	0	0	2.8
SE	0.8	0.4	0.1	0	0	0	0	1.3
S	0.3	0.7	0.5	0.3	0	0	0	1.8
SW	0.8	2.5	3	2.8	2.3	1.9	0.1	13.4
W	2.4	5.9	5.7	4.8	3.4	3	0.2	25.4
NW	9.8	9.5	4.6	1.7	0.5	0.2	0	26.3
Total	29.2	30.4	17.9	10.6	6.4	5.2	0.3	100

Direction	**Percentage Occurrence**
N	21.7
NE	7.3
E	2.8
SE	1.3
S	1.8
SW	13.4
W	25.4
NW	26.3
Total	100

F. D1 / NBP Field

Extreme Storm Parameters (100 years)

*Direction (From)	Tide (m)		(Max Wave)		Current (m/s)						Wind (km/hr)
	AT	Storm	Height (m)	Period (sec)	Bottom	Y-1/5	Y-2/5	Y-3/5	Y-4/5	Surface	1-hour average
North	2.99	0.183	15.850	13.10	0.427	0.853	1.036	1.219	1.402	1.585	149.67
North East	2.99	0.183	15.545	12.90	0.396	0.792	0.975	1.158	1.311	1.494	149.67
East	2.99	0.122	15.088	12.70	0.335	0.671	0.823	1.006	1.158	1.311	149.67
South East	2.99	0.183	16.002	13.20	0.366	0.732	0.884	1.036	1.189	1.341	149.67
South	2.99	1.097	19.507	14.80	0.366	0.762	0.914	1.067	1.219	1.372	149.67
South West	2.99	1.067	18.745	14.40	0.366	0.732	0.884	1.036	1.189	1.341	149.67
West	2.99	1.006	17.983	14.10	0.335	0.671	0.823	1.006	1.158	1.311	149.67
North West	2.99	1.036	18.288	14.30	0.396	0.792	0.975	1.158	1.311	1.494	149.67

Operating Storm Parameters (1 year)

*Direction (From)	Tide (m)		(Max Wave)		Current (m/s)						Wind (Km/hr)
	AT	Storm	Height (m)	Period (sec)	Bottom	Y-1/5	Y-2/5	Y-3/5	Y-4/5	Surface	1-hour average
North	2.99	0.122	6.492	8.20	0.335	0.671	0.823	0.945	1.097	1.219	69.20
North East	2.99	0.122	6.340	8.10	0.305	0.610	0.762	0.884	1.036	1.158	69.20
East	2.99	0.091	6.157	8.10	0.244	0.488	0.610	0.762	0.884	1.006	69.20
South East	2.99	0.122	6.553	8.20	0.274	0.549	0.671	0.792	0.914	1.036	69.20
South	2.99	0.518	9.266	9.00	0.305	0.610	0.732	0.853	0.945	1.067	69.20
South West	2.99	0.610	11.247	8.80	0.305	0.640	0.762	0.884	0.975	1.097	80.47
West	2.99	0.579	10.759	8.60	0.305	0.610	0.732	0.853	0.945	1.067	77.25
North West	2.99	0.732	7.468	8.70	0.305	0.610	0.762	0.884	1.036	1.158	69.20

Environmental Parameters for Installation Condition

Tide (m)	Maximum wave Height (m)	Period (sec)	Current (m/s)		Wind (km/hr)
			Bottom	Surface	1 Minute Sustained
4.36	3.6	8.3	0.426	0.701	48.27

Deterministic Fatigue

Recommended Wave Period for Specified Wave Height Categories

Wave Height (m)	Wave Period in Sec (Direction from)							
	North	NE	East	SE	South	SW	West	NW
0.000 - 1.523	6.3	5.7	5.7	6.4	8.7	9.6	8.3	6.6
1.524 - 3.047	6.9	6.6	6.6	7.0	9.2	10.1	8.7	7.4
3.048 – 4.571	7.3	7.1	7.1	7.5	9.5	10.3	9.2	7.9
4.572 – 6.095	7.8	7.6	7.6	8.0	9.7	10.4	9.6	8.4
6.096 – 7.619	8.3	8.2	8.2	8.5	9.9	10.5	10.0	8.9
7.620 - 9.143						10.6	10.3	
9.144 – 10.667						10.8	10.6	
10.668 – 12.192						11.0	10.9	

Wave Exceedence Data for fatigue Analysis

Wave Height (m)	**Cumulative numbers of Wave Exceeding a specified Wave Height in one year & Direction from:**							
	N-DIR	NE-DIR	E-DIR	SE-DIR	S-DIR	SW-DIR	W-DIR	NW-DIR
0	1,190,038	184,866	92,433	77,627	86,007	585,669	923,280	1,142,884
1.524	49,065	10,832	5,327	5,747	12,639	208,515	215,658	64,041
3.048	1,925	767	342	427	1,207	37,162	31,560	3,337
4.572	67	48	20	27	100	5,830	4,053	150
6.096	3	3	1	2	8	866	492	6
7.620	0	0	0	0	0	126	59	0
9.144	0	0	0	0	0	18	7	0
10.668	0	0	0	0	0	2	1	0
12.192	0	0	0	0	0	0	0	0

Spectral Fatigue

Average Annual Occurrence of Mean Wave Period in Significant Wave Height for All Directions

Mean wave period (sec)	Significant Wave Height (m)							
	0.00–0.60	0.61–1.21	1.22–1.82	1.83–2.43	2.44–3.04	3.05–4.56	4.57 plus	Total
0.0-2.4	2	0	0	0	0	0	0	2

2.5-3.4	13	8	2	0	0	0	0	23
3.5-4.4	51	30	9	3	1	0	0	94
4.5-5.4	66	74	37	13	4	2	0	196
5.5-6.4	65	73	43	24	13	9	0	227
6.5-7.4	32	66	42	25	15	17	1	198
7.5-8.4	10	19	20	19	14	17	2	101
8.5-9.4	6	9	9	8	7	12	1	52
9.5-10.4	5	7	5	4	4	3	1	29
10.5-11.4	4	6	4	3	3	2	0	22
11.5-12.4	3	5	4	3	2	1	0	18
12.5-13.4	2	4	3	2	2	1	0	14
13.5-14.4	2	3	2	2	1	1	0	11
14.5-15.4	2	2	1	1	1	1	0	8
15.5 Plus	1	1	1	1	1	0	0	5
Total	264	307	182	108	68	66	5	1000

Average percentage occurrence of Significant wave height: Annual

Direction	Significant Wave Height (m)							
	0.00–0.60	0.61–1.21	1.22–1.82	1.83–2.43	2.44–3.02	3.04–4.56	4.57 plus	Total
N	5.8	4.7	1.6	0.4	0.1	0	0	12.6
NE	4.9	3.8	1.3	0.3	0	0	0	10.3
E	1.4	1	0.3	0.1	0	0	0	2.8
SE	0.7	0.5	0.3	0.1	0	0	0	1.6
S	0.4	0.7	0.6	0.4	0.1	0	0	2.2
SW	1.4	3.6	3.9	3.6	3.1	3.3	0.3	19.2
W	4.5	8.7	6.5	4.5	3.1	3.2	0.2	30.7
NW	7.4	7.5	3.7	1.4	0.5	0.1	0	20.6
Total	26.5	30.5	18.2	10.8	6.9	6.6	0.5	100

Direction	**Percentage Occurrence**
N	12.6
NE	10.3
E	2.8
SE	1.6
S	2.2
SW	19.2
W	30.7

NW	20.6
Total	100

G. GK Field

Extreme Storm Parameters (100 years)

*Direction (From)	Tide (m)		(Max Wave)		Current (m/s)						Wind (km/hr)
	AT	Storm	Height (m)	Period (sec)	Bottom	Y-1/5	Y-2/5	Y-3/5	Y-4/5	Surface	1-hour average
North	3.688	0.091	12.710	11.80	0.640	1.036	1.250	1.433	1.646	1.829	149.67
North East	3.688	0.030	12.009	11.30	0.610	0.975	1.158	1.341	1.524	1.707	149.67
East	3.688	0.000	10.759	10.60	0.549	0.884	1.036	1.219	1.372	1.524	149.67
South East	3.688	1.341	17.313	14.20	0.579	0.914	1.067	1.250	1.402	1.554	149.67
South	3.688	1.402	17.648	14.30	0.610	0.945	1.097	1.280	1.433	1.585	149.67
South West	3.688	1.372	16.947	14.00	0.549	0.884	1.036	1.189	1.341	1.494	149.67
West	3.688	1.311	16.246	13.70	0.518	0.853	1.006	1.158	1.280	1.433	149.67
North West	3.688	1.341	16.459	13.80	0.610	0.975	1.158	1.341	1.524	1.707	149.67

Operating Storm Parameters (1 year)

*Direction (From)	Tide (m)		(Max Wave)		Current (m/s)						Wind (km/hr)
	AT	Storm	Height (m)	Period (sec)	Bottom	Y-1/5	Y-2/5	Y-3/5	Y-4/5	Surface	1-hour average
North	3.688	0.061	5.182	7.6	0.488	0.884	1.036	1.189	1.311	1.463	69.20

North East	3.688	0.030	4.877	7.5	0.457	0.823	0.975	1.097	1.250	1.372	69.20
East	3.688	0.000	4.389	7.2	0.427	0.762	0.884	1.006	1.097	1.219	69.20
South East	3.688	0.823	7.071	8.7	0.457	0.792	0.914	1.036	1.128	1.250	69.20
South	3.688	0.701	8.352	9.1	0.457	0.792	0.914	1.036	1.158	1.280	69.20
South West	3.688	0.792	10.119	10.3	0.427	0.792	0.914	1.036	1.158	1.280	80.47
West	3.688	0.762	9.662	10.2	0.396	0.732	0.853	0.975	1.067	1.189	77.25
North West	3.688	0.823	6.706	8.5	0.457	0.823	0.975	1.097	1.250	1.372	69.20

Environmental Parameters for Installation Condition

Tide (m)	**Maximum wave Height (m)**	**Period (sec)**	**Current (m/s)**		**Wind (km/hr)**
			Bottom	**Surface**	**1 Minute Sustained**
4.36	4.00	7.8	0.701	1.46	48.27

Environmental Parameters for Fatigue Analysis

Deterministic Fatigue

Recommended Wave Period for Specified Wave Height Categories

Wave Height (m)	Wave Period in Sec (Direction from)							
	N-DIR	NE-DIR	E-DIR	SE-DIR	S-DIR	SW-DIR	W-DIR	NW-DIR
0.000 - 1.523	6.3	5.7	5.7	6.4	8.7	9.6	8.3	6.6
1.524 - 3.047	6.9	6.6	6.6	7.0	9.2	10.1	8.7	7.4
3.048 – 4.571	7.3	7.1	7.1	7.5	9.5	10.3	9.2	7.9
4.572 – 6.095	7.8	7.6	7.6	8.0	9.7	10.4	9.6	8.4
6.096 – 7.619	8.3	8.2	8.2	8.5	9.9	10.5	10.0	8.9
7.620 - 9.143						10.6	10.3	
9.144 – 10.667						10.8	10.6	
10.668 – 12.192						11.0	10.9	

Wave Exceedance Data for fatigue Analysis

Wave Height (m)	Cumulative numbers of Wave Exceeding a specified Wave Height in one year & Direction from:							
	North	NE	East	SE	South	SW	West	NW
0	1,190,038	184,866	92,433	77,627	86,007	585,669	923,280	1,142,884
1.524	49,065	10,832	5,327	5,747	12,639	208,515	215,658	64,041
3.048	1,925	767	342	427	1,207	37,162	31,560	3,337
4.572	67	48	20	27	100	5,830	4,053	150
6.096	3	3	1	2	8	866	492	6
7.620	0	0	0	0	0	126	59	0
9.144	0	0	0	0	0	18	7	0
10.668	0	0	0	0	0	2	1	0
12.192	0	0	0	0	0	0	0	0

Spectral Fatigue

Average Annual Occurrence of Mean Wave Period in Significant Wave Height for All Directions

Mean wave period (sec)	Significant Wave Height (m)							
	0.00–0.60	0.61–1.21	1.22–1.82	1.83–2.43	2.44–3.04	3.05–4.56	4.57 plus	Total
0.0-2.4	2	0	0	0	0	0	0	2
2.5-3.4	12	7	2	0	0	0	0	21
3.5-4.4	46	26	10	4	1	0	0	87
4.5-5.4	60	67	38	16	5	2	0	188
5.5-6.4	58	66	44	31	17	10	0	226
6.5-7.4	28	58	44	32	21	19	1	203
7.5-8.4	9	17	21	23	20	20	1	111
8.5-9.4	5	8	9	9	9	14	1	55
9.5-10.4	4	6	6	5	4	3	1	29
10.5-11.4	3	5	4	4	3	2	0	21
11.5-12.4	3	4	4	3	2	2	0	18
12.5-13.4	2	4	3	3	2	1	0	15
13.5-14.4	2	2	2	2	1	1	0	10
14.5-15.4	2	2	2	1	1	1	0	9
15.5 Plus	1	1	1	1	1	0	0	5
Total	237	273	190	134	87	75	4	1000

Average percentage occurrence of significant wave height: Annual

Direction	Significant Wave Height (m)							
	0.00–0.60	0.61–1.21	1.22–1.82	1.83–2.43	2.44–3.04	3.05–4.56	4.57 plus	Total
N	5.3	3.6	0.9	0.1	0	0	0	9.9
NE	5.8	3.5	0.7	0.1	0	0	0	10.1

E	1.6	0.8	0.2	0	0	0	0	2.6
SE	0.4	0.5	0.3	0.1	0	0	0	1.3
S	0.4	0.8	0.9	0.7	0.3	0.2	0	3.3
SW	1.2	4.3	5.8	5.7	4.5	4.1	0.3	25.9
W	2.9	7.5	7.1	5.5	3.6	3.1	0.1	29.8
NW	6.1	6.3	3.1	1.2	0.3	0.1	0	17.1
Total	23.7	27.3	19	13.4	8.7	7.5	0.4	100

Direction	**Percentage Occurrence**
N	9.9
NE	10.1
E	2.6
SE	1.3
S	3.3
SW	25.9
W	29.8
NW	17.1
Total	100

H. MB-OSN Field

Extreme Storm Parameters (100 years)

*Direction (From)	Tide (m)		(Max Wave)		Current (m/s)						Wind (km/hr)
	AT	Storm	Height (m)	Period (sec)	Bottom	Y-1/5	Y-2/5	Y-3/5	Y-4/5	Surface	1-hour average
North	3.200	0.000	10.272	11.00	0.579	0.853	1.006	1.158	1.311	1.463	149.67
North East	3.200	0.152	12.436	11.70	0.701	1.036	1.219	1.372	1.554	1.707	149.67
East	3.200	0.335	13.259	12.00	0.671	0.975	1.128	1.311	1.463	1.615	149.67
South East	3.200	0.610	14.112	12.30	0.610	0.884	1.036	1.189	1.341	1.494	149.67
South	3.200	1.554	17.435	14.40	0.640	0.945	1.097	1.280	1.433	1.585	149.67
South West	3.200	1.524	16.825	14.00	0.671	0.975	1.158	1.311	1.494	1.646	149.67
West	3.200	1.494	16.215	13.60	0.610	0.914	1.067	1.219	1.372	1.524	149.67
North West	3.200	0.000	10.638	11.10	0.549	0.823	0.975	1.097	1.250	1.372	149.67

Operating Storm Parameters (1 year)

*Direction (From)	Tide (m)		Max. Wave		Current (m//sec) (Y is the depth of water and currents are measured from bottom)						Wind (km/hr)
	AT	Storm	Height (m)	Period (sec)	Bottom	Y-1/5	Y-2/5	Y-3/5	Y- 4/5	Surface	1-Hour average
All Directions	3.2	0.9	9.7	10.2	0.5	0.8	0.9	1.1	1.2	1.3	80.47

Environmental Parameters for Installation Condition

Tide (m)	Maximum wave Height (m)	Period (sec)	Current (m/s)		Wind (km/hr)
			Bottom	Surface	1 Minute Sustained
4.36	4.00	7.8	0.701	1.46	48.27

Environmental Parameters for Fatigue Analysis

Deterministic Fatigue
Recommended Wave Period for Specified Wave Height Categories

Wave Height (m)		Wave Period in Sec (Direction from)							
		N-Dir	NE-Dir	E-Dir	SE-Dir	S-Dir	SW-Dir	W-Dir	NW-Dir
0.00	0.60	5	5	5	5	6.2	6.4	6.4	5.4
0.61	1.21	5.4	5.4	5.4	5.5	6.5	6.8	6.8	5.8
1.22	1.82	5.7	5.7	5.7	5.8	6.8	7.2	7.2	6.1
1.83	2.43	6	6	6	6.1	7.1	7.6	7.6	6.4
2.44	3.04	6.3	6.3	6.3	6.4	7.4	7.9	7.9	6.7
3.05	3.65	6.6	6.6	6.6	6.7	7.7	8.1	8.1	6.9
3.66	4.26	6.9	6.9	6.9	7	7.9	8.3	8.3	7
4.27	4.87		7.2	7.2	7.3	8.1	8.5	8.5	7.1
4.88	5.48		7.4	7.5	7.6	8.3	8.7	8.7	
5.49	6.09					8.5	9	9	
6.10	7.61					8.7	9.3	9.3	
7.62	9.13					8.9	9.7	9.7	

9.14	10.65						10.1	10.1	

Number of Waves in 1 Year in Selected wave height categories

Wave Height (m)		N-Dir	NE-Dir	E- Dir	SE-Dir	S-Dir	SW-Dir	W-Dir	NW-Dir
0.00	0.60	385957	325351	95692	54225	89313	644324	953727	641135
0.61	1.21	152221	128319	37741	21387	35224	254122	376150	252863
1.22	1.82	57720	48656	14310	8109	13357	96359	142630	95882
1.83	2.43	21886	18450	5427	3075	5065	36537	54083	36357
2.44	3.04	8239	6945	2042	1157	1906	13754	20358	14186
3.05	3.65	4629	2234	657	373	613	4424	6549	6527
3.66	4.26	500	1640	484	262	292	2106	3116	1462
4.27	4.87	0	377	102	59	168	1210	1792	31
4.88	5.48	0	73	29	20	69	495	732	0
5.49	6.09	0	0	0	7	28	203	300	0
6.10	7.61	0	0	0	0	16	109	174	0
7.62	9.13	0	0	0	0	1	14	11	0
9.14	10.65	0	0	0	0	0	2	1	0

Spectral Fatigue

Average Annual Occurrence of Mean Wave Period in Significant Wave Height for **All Directions**

Mean wave period (sec)	Significant Wave Height (m)							
	0.00–0.60	0.61–1.21	1.22–1.82	1.83–2.43	2.44–3.04	3.05–4.56	4.57 plus	Total
0.0-2.4	3	0	0	0	0	0	0	3
2.5-3.4	19	7	1	0	0	0	0	27
3.5-4.4	74	27	7	3	1	0	0	112
4.5-5.4	94	68	28	10	3	2	0	205
5.5-6.4	93	69	33	19	12	7	0	233
6.5-7.4	47	61	31	19	14	12	0	184
7.5-8.4	15	17	16	15	13	12	1	89
8.5-9.4	9	8	7	7	6	9	1	47
9.5-10.4	7	6	5	4	3	2	0	27

10.5-11.4	6	5	3	3	2	1	0	20
11.5-12.4	4	4	3	2	2	1	0	16
12.5-13.4	3	4	3	2	1	1	0	14
13.5-14.4	3	4	1	1	1	1	0	11
14.5-15.4	2	2	1	1	1	1	0	8
15.5 Plus	1	1	1	1	0	0	0	4
Total	380	283	140	87	59	49	2	1000

Average percentage occurrence of significant wave height**: Annual**

Direction	Significant Wave Height (m)							
	0.00–0.60	0.61–1.21	1.22–1.82	1.83–2.43	2.44–3.04	3.05–4.56	4.57 plus	Total
N	8.5	3.2	0.4	0	0	0	0	12.1
NE	6.1	3.4	0.7	0	0	0	0	10.2
E	1.6	1.1	0.3	0	0	0	0	3
SE	0.8	0.6	0.2	0.1	0	0	0	1.7
S	0.5	0.8	0.6	0.4	0.3	0.2	0	2.8
SW	1.7	4.3	4.5	4	3	2.6	0.1	20.2
W	5.5	9.1	6.4	4.1	2.6	2.1	0.1	29.9
NW	13.3	5.8	0.9	0.1	0	0	0	20.1
Total	38	28.3	14	8.7	5.9	4.9	0.2	100

Direction	**Percentage Occurrence**
N	12.1
NE	10.2
E	3.0
SE	1.7
S	2.8
SW	20.2
W	29.9
NW	20.1
Total	100

I. Saurashtra Field

Extreme Storm Parameters (100 years)

*Direction (From)	Tide (m)		(Max Wave)		Current (m/s)						Wind (km/hr)
	AT	Storm	Height (m)	Period (sec)	Bottom	Y-1/5	Y-2/5	Y-3/5	Y-4/5	Surface	1-hour average
North	2.316	0.122	15.149	12.80	0.366	0.762	0.914	1.097	1.250	1.402	149.67
North East	2.316	0.030	12.984	11.40	0.335	0.671	0.823	0.975	1.097	1.250	149.67
East	2.316	0.061	14.143	12.10	0.366	0.732	0.884	1.067	1.219	1.372	149.67
South East	2.316	0.884	17.496	14.00	0.396	0.823	1.006	1.158	1.341	1.494	149.67
South	2.316	1.097	19.660	14.90	0.366	0.762	0.914	1.097	1.250	1.402	149.67
South West	2.316	1.067	19.202	14.70	0.366	0.701	0.853	1.006	1.128	1.280	149.67
West	2.316	1.036	18.745	14.50	0.366	0.762	0.945	1.097	1.280	1.433	149.67
North West	2.316	0.975	18.288	14.30	0.396	0.823	1.006	1.189	1.341	1.524	149.67

Operating Storm Parameters (1 year)

*Direction (From)	Tide (m)		(Max Wave)		Current (m/s)						Wind (km/hr)
	AT	Storm	Height (m)	Period (sec)	Bottom	Y-1/5	Y-2/5	Y-3/5	Y-4/5	Surface	1-hour average
North	2.316	0.091	6.096	8.30	0.305	0.610	0.732	0.884	1.006	1.128	69.20
North East	2.316	0.030	5.243	7.60	0.274	0.549	0.671	0.792	0.884	1.006	69.20
East	2.316	0.030	5.700	8.00	0.305	0.579	0.701	0.853	0.975	1.097	69.20
South East	2.316	0.671	7.620	8.90	0.335	0.640	0.792	0.914	1.067	1.189	69.20
South	2.316	0.518	9.144	9.60	0.305	0.610	0.732	0.884	1.006	1.128	69.20
South West	2.316	0.610	11.125	10.60	0.274	0.549	0.671	0.792	0.914	1.036	80.47
West	2.316	0.579	10.638	10.50	0.305	0.610	0.762	0.884	1.036	1.158	77.25
North West	2.316	0.701	7.285	8.60	0.366	0.671	0.823	0.945	1.097	1.219	69.20

Environmental Parameters for Installation Condition

Tide (m)	Maximum wave Height (m)	Period (sec)	Current (m/s)		Wind (km/hr)
			Bottom	Surface	1 Minute Sustained
4.36	4.00	7.8	0.701	1.46	48.27

Environmental Parameters for Fatigue Analysis

Deterministic Fatigue

Recommended Wave Period for Specified Wave Height Categories

Wave Height (m)		Wave Period in Sec (Direction from)							
		N-Dir	NE-Dir	E- Dir	SE-Dir	S-Dir	SW-Dir	W-Dir	NW-Dir
0.00	0.60	5	5	5	5.6	6	6.4	6.4	5.6
0.61	1.21	5.4	5.4	5.4	5.9	6.3	6.7	6.7	5.9
1.22	1.82	5.8	5.8	5.8	6.2	6.6	7.1	7.1	6.2
1.83	2.43	6.2	6.2	6.2	6.5	6.9	7.4	7.4	6.5
2.44	3.04	6.5	6.5	6.5	6.8	7.2	7.7	7.7	6.8
3.05	3.65	6.8	6.8	6.8	7.1	7.5	8.1	8.1	7.1
3.66	4.26	7.1	7.1	7.1	7.4	7.9	8.5	8.5	7.4
4.27	4.87	7.4	7.4	7.4	7.7	8.3	8.8	8.8	7.7
4.88	5.48	7.7	7.6	7.7	8	8.6	9.1	9.1	8
5.49	6.09	8		8	8.3	8.9	9.4	9.4	8.3
6.10	7.61	8.3			8.6	9.2	9.6	9.6	8.5
7.62	9.13				8.9	9.5	9.9	9.8	
9.14	10.66						10.1	10.1	
10.67	12.18						10.5		

Number of Waves in 1 Year in Selected wave height categories

Wave Height (m)		N-Dir	NE-Dir	E- Dir	SE-Dir	S-Dir	SW-Dir	W-Dir	NW-Dir
0.00	0.60	445859	272795	82132	43999	61599	489861	730388	806653
0.61	1.21	198315	121338	36532	19571	27399	217883	324871	358793
1.22	1.82	84973	51990	15653	8385	11740	93359	139199	153734
1.83	2.43	36409	22276	6707	3593	5030	40001	59644	65872
2.44	3.04	15600	9545	2874	1540	2155	17140	25556	28224

3.05	3.65	6685	4090	1231	659	924	7344	10950	12093
3.66	4.26	2826	1967	527	283	390	3106	4630	5114
4.27	4.87	1183	936	294	121	164	1298	1937	2140
4.88	5.48	898	163	92	52	66	529	789	871
5.49	6.09	102	0	10	22	29	232	345	742
6.10	7.61	2	0	0	15	34	289	437	200
7.62	9.13	0	0	0	2	8	42	66	0
9.14	10.66	0	0	0	0	1	8	5	0
10.67	12.18	0	0	0	0	0	2	0	0

Spectral Fatigue

Average Annual Occurrence of Mean Wave Period in Significant Wave Height for All Directions

Mean wave period (sec)	Significant Wave Height (m)							
	0.00–0.60	0.61–1.21	1.22–1.82	1.83–2.43	2.44–3.04	3.05–4.56	4.57 plus	Total
0.0-2.4	2	0	0	0	0	0	0	2
2.5-3.4	14	7	2	0	0	0	0	23
3.5-4.4	53	28	9	3	1	0	0	94
4.5-5.4	67	72	35	12	4	3	0	193
5.5-6.4	65	72	41	24	12	10	0	224
6.5-7.4	32	62	41	24	15	20	2	196
7.5-8.4	11	18	19	18	15	20	2	103
8.5-9.4	6	9	9	8	7	15	2	56
9.5-10.4	5	7	5	4	4	3	2	30
10.5-11.4	4	5	4	3	3	2	1	22
11.5-12.4	3	5	3	3	2	2	0	18
12.5-13.4	2	4	3	2	2	1	0	14
13.5-14.4	2	3	2	2	1	1	0	11
14.5-15.4	3	2	1	1	1	1	0	9
15.5 Plus	1	1	1	1	1	0	0	5
Total	270	295	175	105	68	78	9	1000

Average percentage occurrence of Significant wave height: Annual

Direction	Significant Wave Height (m)							
	0.00–0.60	0.61–1.21	1.22–1.82	1.83–2.43	2.44–3.04	3.05–4.56	4.57 plus	Total
N	4.3	3.8	1.5	0.3	0.1	0	0	10
NE	5.3	3.7	1	0.1	0	0	0	10.1
E	1.2	1	0.4	0.1	0	0	0	2.7
SE	0.5	0.5	0.2	0.1	0.1	0	0	1.4

S	0.4	0.8	0.7	0.6	0.3	0.3	0	3.1
SW	1.1	3.5	4.8	5	4.4	5.2	0.6	24.6
W	2.7	6.5	6.3	5.2	3.8	4	0.4	28.9
NW	5.8	6.8	4	1.7	0.6	0.3	0	19.2
Total	21.3	26.6	18.9	13.1	9.3	9.8	1	100

Direction	**Percentage Occurrence**
N	15.2
NE	9.3
E	2.8
SE	1.5
S	2.1
SW	16.7
W	24.9
NW	27.5
Total	100

Notes for Extreme & Operating conditions:

1. Lowest Astronomical Tide (LAT) :

Mumbai High, B&S , Neelam & Heera Fields	(-) 0.183 m
Tapti, Ratna, GK, MB-OSN Fields	(-) 0.091 m
Daman Field	(-) 0.122 m
D1/NBP, Saurashtra Field	(-) 0.061 m

2. Wave Kinematics Factor =0.880 (For In-place Analysis)

   The Contractor shall determine the significant wave heights and apparent wave Periods if required for the work.

3. The above table contains the design environmental conditions for the maximum operating storm, the 100 years extreme storm. The wind speeds are at a reference elevation of + 10.00 M above Mean Sea Level (MSL)

4. Tidal parameter & Environmental Parameters indicated are based on Indian Spring Low Water (ISLW).

5. During Pre-Engineering Survey, Chart Datum (CD) as per international practice shall be established.

6. "Direction from/Direction" in the Tables – Indicates the Direction from which wind blows, current blows & wave approach.

Notes for Installation conditions:

1. Contractor shall select barge which is stable to work at the stated environmental parameters so as to minimize waiting on weather.

2. Wave kinematics factor equal to 1.0 and current blockage factor equal to 1.0 shall be applied in all directions for the installation conditions.

3. All members shall be considered as smooth and effect of conductor shielding shall be ignored for installation condition.

4. Contractor shall obtain Installation Environmental Parameter / Data for Installation of Topside by Float Over method

General Notes for all Environmental loads:

1. Wave directions are directions from which wave approaches the platform.

2. In case the selected wave / wind/current approach direction is within +10 Degrees of the standard approach directions for which the environmental data has been furnished, such data shall be directly used for the selected wave approach direction. For other Cases, the data shall be linearly interpolated between the two adjacent directions for which data shall be furnished.

3. Still water depth shall be taken as CD + (LAT) + SS + (50% of Astronomical Tide) for storm environment. For Earthquake condition still water level shall be considered as CD + (LAT) + (50%of Astronomical Tide).

4. Wave Kinematics Factor = 1.00 (for Fatigue)

STRUCTURAL

DESIGN CRITERIA

(PART - II)

FOR

(REPLACEMENT /REFURBISHMENT OF BRIDGES IN MH ASSET)

OIL AND NATURAL GAS CORPORATION LIMITED
INDIA

NK	PDD	RM	6	22.12.2025	0
Prepared	Reviewed	Approved	No of Pages	Date	Revision

CONTENTS

PROJECT SPECIFIC REQUIREMENT

1. **Design Life:** New bridges shall be designed for 25-year design life.

2. **Platform Location (Released) and Indicative Water Depth: NA**

3. **Geotechnical Data: NA**

4. **Jack-up Rig Penetration: NA**

5. **List & details of Pile Driving Hammers proposed to be mobilized: NA**

6. **List of Lifts/Estimated weight as envisaged by the bidder.**

(Information to be furnished by the bidder in their bid for each platform)

Sl. No	Component to be lifted	Estimated Weight		Proposed Crane vessel name & De- rated Capacity
		Structural (MT)	Gross (MT)	
1.	*Jacket/Substructure			
2.	Deck			
3.	Helideck			
4.	Boat landing			
5.	Bridges			
6.	Building Module			
7.	Conductors			
8.	Piles			

* Jacket to be lifted/launched to be indicated.

7. TIDE, WAVE, CURRENT & WIND PARAMETERS FOR DESIGN

S.No.	Platform/Asset	Applicable Field	Reference in DC 3.4 Part-I
1	MH Asset	Mumbai High Field	Annexure- 13A

8. Project Specific Design requirement:

Following project specific requirements shall be met by the conceptual design/scheme proposed by the Contractor/Bidder in bid:

a) **Contractor Concept / Design:**

- **Jacket Pile Configuration: NA**
- **Jackets - Installation by Lift / Launch Method: NA**
- **Topsides- Installation by Lift / Float-over Method: NA**
- **Bridges- Installation by Lift:** As per scope of works.

b) Revamping / Modification at existing Platforms:

As per scope of works.

c) Deck Extension/ Modification/ Strengthening of Topside Members:

As per scope of works.

d) Helideck for Platform: NA

9. Geometric Constraints: NA

10. Coil Tubing Unit (CTU) Operation : NA

11. Modular Rig Operation: NA

12. Conductor orientation: NA

13. List of drawings / Sketch Enclosed as separate enclosure.

Structural drawings available with the Company are being attached along with the Bid Document. Refer Vol-IV of the Bid document for the same. Contractor shall collect all structural and other related details for the purpose of designing deck extension and modification of platform topside during pre-engineering survey. These Drawings / Sketches need to be updated based on pre-Engineering Survey and revised Drawing shall be prepared.

14. Annexures (if any):

STRUCTURAL

DESIGN CRITERIAL FOR UNDER WATER REPAIR
Section-3.4 (Part III)

GG	AKS	RKJ	Issued For Bid	12	19.11.2018	2
DSR	SKJ	RKJ	Issued For Bid	9	11.05.2016	1
SK/KKD	SKJ	RMK	Issued For Bid	11	31.01.2015	0
Prepared by	Reviewed by	Approved by	Remarks	No of Pages	Date	Rev

DESIGN CRITERIA FOR UNDER WATER REPAIR OF JACKET STRUCTURAL MEMBERS AND JOINTS

CONTENTS UNDER DESIGN CRITERIA **–PART III**

DESIGN CRITERIA FOR UNDER WATER REPAIR OF JACKET STRUCTURAL MEMBERS AND JOINTS

1.0 GENERAL REQUIREMENT FOR UNDER WATER REPAIR

Underwater repair of Jacket Structural member(s) & Joint(s) shall be carried out at Platforms specified in the Scope of Work (Section – 2 of Bid Document) to strengthen the Structural member(s) and joint(s). This Document shall be read along with Scope of Work (Section – 2 of Bid Document), Structural Design Criteria Part – I, Part – II, and Material Spec. 6001F.

LSTK Contractor's scope of work includes pre engineering Survey, detail engineering & design & drawings, procurement of various material, supply of manpower (skilled & unskilled) at various stages of work, fabrication, NDT, load-out, transportation, suitable marine spread, Tools & plants, Diving Equipment/ Spreads with skilled divers and installation of clamps on member(s) & Joint(s) & grouting proposed for Under water repair as described in following Clauses & sub-clauses. The Contractor's scope of work shall include but not be limited to the following:

a) Design, procurement, manpower, equipment, steel and non-steel material, fabrication, Load Out, Transportation and underwater repair at offshore site.

b) Contractor shall mobilise suitable marine spread for carrying out the scope of work including mobilization, demobilization, obtaining required clearances from Statutory Authority, Government Authority, Third Party Inspection Agency, Marine Warranty Surveyor & approvals from Company.

c) Envisaged under water repair methodology is by using grouted clamp having multiple segments, which are placed around the existing tubular(s) / joint(s). These segments are closed by pre-tightened bolts (with designed pre-tension value) prior to injection of a suitable cementitious material into the annular space between clamp & existing tubular. Xylan/Teflon/PTFE coated bolts, nuts & washers shall be used.
Contractor shall submit under water repair methodology other than grouting of clamps for approval of company.

d) Contractor shall carry out under water pre-engineering survey with his equipment & Tools, marine spread, skilled & unskilled manpower, Diving Spread & divers, surveyors, etc. to obtain the as-built details of member(s) & Joint(s) proposed for repair. As-built data provided in the bid, shall be updated, wherever required, to enable the successful execution of the job. Contractor need to collect all necessary field data for design, fabrication & installation of the proposed strengthening.

e) Submission of marked up drawings / reports based on data of pre-engineering survey shall be submitted to the Company for review/approval.

f) Detail Design of member(s) & Joint(s) proposed for repair shall be carried out as per standards/codes specified under clause 2.0.

g) Grouted clamp design and execution / Installation procedure to be submitted by the Contractor and shall be approved by Company.

h) All necessary engineering, design Basis /criteria and specifications shall be prepared by contractor and shall be submitted for approval of Company. AFC drawings and relevant analysis/ design calculations, specifications shall be submitted to the Company for their review and approval.

i) Company's comments on Design Calculation & Analysis Reports & Drawings shall be incorporated and revised documents shall be submitted for Company approval.

j) Contractor shall finalise requirement of sacrificial anodes based on additional steel area due to addition of grouted clamp. Engineering, procurement, fabrication & installation of anodes are in contractor's scope. Anode connectivity to the Jacket shall be provided.

k) Based on AFC (drawings approved for Construction), contractor shall prepare fabrication/shop drawings and shall procure all the materials required for fabrication.

l) Pre-Construction survey and submission of the survey report to Company for review.

m) Members & Joints under repair shall be cleaned by removing marine growth, removal of anodes and other non-structural items obstructions prior to taking up for repair.

n) Fabrication of grouted clamps, adding fixtures for grouting and all other Installation aid including mobilization of all necessary grouting equipment, Diving Spread on suitable marine spread & material required for the same for successful completion of the job is in contractor scope with demobilization.

o) Repair of Member(s) & Joint(s) repair is in contractor's scope. Contractor shall take utmost precaution not to damage any existing structure / facilities during execution. In case of any damage, contractor shall rectify the same to the satisfaction of the company without any time & cost.

p) Contractor and his representative, workers shall follow ONGC safety norms and requirements as per the instruction of company representative to execute the job safely and without any operational hazards. The contractor shall provide personnel protection equipment necessary for the safety of workers and supervisory personnel necessary for the safe execution of work at platform site.

q) Contractor shall obtain work permits from Company prior to taking up of any hot work and other works to be carried out on the platform as per the rules and requirement of the Company.

r) Any other activity, not mentioned above, if required for successful completion of the job shall be carried out by the Contractor without any cost and time implication to company.

s) All existing facilities shall be restored back to their original state & cleaning of work area from all debris, tools & tackles, temporary supports etc. after completion of work.

t) Removal & relocation of anodes. Removal & disposal of Riser / I/ J-Tube clamps if any.

u) Post Installation/ repair removing of all temporary work shall be carried out with cleaning the Jacket surrounding area. As-built video survey for the executed work (including cleaning & removal of temporary items) shall be carried out and submitted to Company for their review/record. These video surveys, design documents, reports etc. shall be submitted as As-Built Record through OPMAC.

v) SACS, SESAM, FEM Analysis Software and other proven software (used for analysis) shall be provided to ONGC Engineer at design Centre & ONGC Office for review. All analysis Report with software input file shall be submitted for review.

w) Scope of works for repairing and strengthening of Jacket members and joints are detailed elsewhere in Bid document.

x) Repair by infill grout (inside of Member) can be acceptable only when the members are in compression. Members in tension with low UC Ratio value (UC ratio up to 0.4) can be acceptable for repair by grout filling.

2.0 Codes & Standards :

Ref.	Document	Revision	Title
1	API RP 2A- WSD	21ST Edition	Recommended Practice for Planning, Designing and Construction of fixed Offshore Platforms – WSD, 21st Edition with Erratas and Supplements 3:October 2007.
2	AISC- ASD	13th Edition	American Institute of Steel Construction, Specification for Structural Steel Buildings, Allowable Stress

			Design and Plastic Design
3	API RP 2A- LRFD	1st Edition	Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms – Load Resistance and Factor Design, 1st Edition.
4	AISC 360-10	June 22,2010	Specification for Structural Steel Buildings
5	AISC, RCSC	June 30, 2004	Specification for Structural Joints using ASTM A325 or A490 Bolts
6	NORSOK Standard N-004	Rev.2	Design of Steel Structures
7	DNV-RP-C203	October 2011	Fatigue Strength Analysis of Offshore Steel Structures
8	BS EN 1992-1-1 :2004	2004	Eurocode 2: Design of Concrete Structures, Part 1-1, General rules and rules for buildings
9	ASTM A193/A193M	Rev. 01b	Standard Specification for Alloy- Steel and Stainless Steel Bolting Materials for High-Temperature Service
10	HSE OTR 2001/16	-----	Pile/sleeve connections

All other relevant and related Codes concerning the specific job under consideration and/or referred in the above-mentioned Codes shall be followed wherever applicable. Any conflict between the applicable codes and the Design criteria shall be referred to the Company for resolution. Company's decision in this regard shall be final and binding on the Contractor.

3.0 STRUCTURAL ANALYSIS FOR UNDER WATER JACKET REPAIR FOR MEMBER(S) & JOINT(S):

Contractor shall carryout In-place Analysis (Working Stress design method) & Pushover Analysis before repair (for as supplied SACS /SESAM Model) and after repair.

On obtaining Member(s) & Joint(s) Design forces, clamp length design calculation shall be carried out using HSE OTR 2001/016 pile-sleeve connection / NORSOK 004/ DNV rules for classifications of fixed offshore installation to meet its intended purposes and shall satisfy minimum requirement of API RP 2A Chapter 17. FEM Analysis shall be carried out to workout Bolt design forces, clamp shell & flange stress and Stress Concentration Factor (SCF).

3.1 INPLACE, & PUSHOVER ANALYSIS TO WORK OUT DESIGN FORCES:

Contractor shall update the SACS /SESAM Model (global inplace analysis) with Modified stiffness (Modulus of Elasticity and Moment of Inertia) with revised / modified Cd & Cm override for clamp / repair / strengthened member(s) & Joint(s) and obtain forces, deflections for the members & Joints proposed for repair.

Structural Model:

Three dimensional SACS In-place model provided by ONGC shall be modified as per as built details collected during under water pre engineering survey in each of the Structural Analyses.
For infill grouted member, section thickness, elastic modulus and density shall be modelled with equivalent section properties of steel- grout composite. For Grouted clamp, it shall be modelled as concentric tubular in Global SACS analysis.

Foundation Model:

The through leg and Piles shall be represented as concentric tubular members with grouted annulus, with appropriate modelling of the load transfer between the leg and pile.

The foundation model below mudline shall be represented by data describing the non-linear relationship between the soil and the pile. It shall take the form of P-Y (lateral stiffness), Q-Z (bearing) and T-Z (axial stiffness) curves as per the PSI Input file.

3.1.1 IN-PLACE ANALYSIS

Detailed analysis using SACS software shall be carried out by the contractor considering 100% environmental loading along with operating loads to ascertain design forces for damaged members and joints. Updated In-place SACS Model, to ascertain the actual design forces in the members / joints due to proposed strengthening / stiffening. Based on these design forces clamp shall be designed with required Factor of Safety. Contractor shall update the SACS model (global in-place analysis) with Modified stiffness (Modulus of Elasticity and Moment of Inertia) with revised / modified Cd & Cm override for clamp / repair / strengthened member(s) & Joint(s) and obtain forces, deflections for the members & Joints proposed for repair.

Members and Joints check:

Member strength shall be checked at the ends of members and throughout their span in accordance with API RP-2A WSD recommendations and AISC Specifications. Repaired member stress shall be shown through Finite element analysis (FEA). In addition, infill grout members shall be code checked against NORSOK N-004.

Tubular Joint check shall be in accordance with API RP-2A WSD. Joint stress at repaired member shall be shown through FEA. Strengthened joints shall be checked to ensure that it is within elastic limit.

3.1.2 PUSHOVER ANALYSIS:

The objective of the Non-linear Pushover analysis is to check the adequacy of the Jacket against maximum environmental load level that can be sustained by the “intact” substructure and foundation before Global Collapse, and ultimately determine the “intact” reserve stress ratio (RSR) of the Platform. Further Pushover Analysis for all required directions shall be carried out before repair of Structure and reported. Post Repair Pushover Analysis for all required directions shall be carried out with reporting of RSR Value. For the reliability study RSR is defined as the base shear at which the Substructure’s structural system is deemed to collapse divided by the base shear calculated by the reference load. The reference load is taken as 100 year storm loading. The minimum Reserve Strength Ratio (RSR) of the Platform in all eight (8) wave directions shall be reported.

Repaired member(s) & Joint(s) UC ratio should be kept less than one such that the repaired member(s) & Joint(s) does not get failed to achieve RSR of 1.60 at any direction. In case RSR Value of 1.6 is not achieved than Structure shall be investigated to achieve RSR Value of 1.6 for all required directions and shall identify requirement of strengthening of other Member(s), joint(s) & Pile(s) and reported.

Maximum Design force for Member(s) & Joint(s) shall be obtained from Pushover Analysis (to achieve RSR value of 1.6), Inplace Analysis before repair and Inplace analysis after repair. Post repair of Member(s) & Joint(s) UC Ratio shall comply with the above provision.

3.2 FATIGUE ANALYSIS

Fatigue Analysis shall be carried out before repair and after repair using the SACS / SESAM Model and as per Structural Design Criteria Part – I & II.
Stress Concentration Factor for the repair Joint shall be compared before & after repair.

3.3 LOCAL DESIGN:

Finite element analysis (FEA) shall be carried out for the local design of joint(s), member(s) & Bolts (for clamp) where repair work to be carried out based on forces obtained from Inplace Analysis. Repaired member(s) & Joint(s) UC Ratio shall be brought down such level that the Member(s) & Joint(s) does not get fail to achieve RSR of 1.60.
SCF (Stress concentration factor) Values for the repaired Joints / Clamps / Clamp Flanges, etc. shall be obtained using Finite Element Analysis with simulation.
Coefficient of Friction between Concrete & Steel shall be considered as 0.40 for all design calculation & FEA Analysis.

3.4 CLAMP BOLT, FLANGE, AND STIFFENER DESIGN:

Bolt force shall be obtained using FEA Analysis. Bolt forces shall be added with 10% bolt relaxation value for bolt tightening in one go of installation. Bolt UC ratio (total) shall be kept below 0.7 to sustain the cyclic loading (under this Bolt UC Ratio, bolt fatigue analysis is not included in the scope) from wave forces. Clamp flange plate shall be designed for full capacity of Bolt Forces (irrespective of actual bolt force). Welding between Flange Plate to Clamp shell shall be full penetration weld from both sides. Welding between Stiffeners to Flange plate shall be full penetration weld. Welding between Stiffeners to clamp shell shall be fillet weld.

4.0 REPAIR METHOD:

Repair methodology by using doubler plates/mechanical clamps/grouted clamp having multiple segments, which are placed around an existing damaged tubular/joint and grouting of damaged structural members shall be as follows.

4.1 DOUBLER PLATES

The doubler plates / sleeves shall be designed as per latest edition of API-RP-2A. Modified stiffness shall be considered in the global analysis.

4.2 MECHANICAL CLAMPS

The mechanical clamps shall be designed in accordance with API-RP-2A. All bolts / stiffeners of clamp connections shall be designed in accordance with AISC 13th edition. All clamps, nuts & bolts shall be fluoro-polymer coated (xylan type).

4.3 GROUTED CLAMP DESIGN

The grouted clamp shall be designed with high strength grout properties of minimum 28 day characteristic strength of 16000 psi (110Mpa) and appropriate radial stiffness factor. The grout annulus is to be of width minimum 38 mm. The interface bond strength shall be as per formula given below. Grout material shall possess properties such as rapid strength development & high elastic modulus. Grout shall have non shrinkage, high sulphate resistance (HSR) properties and no shrinkage in sealed condition. At least 40% of the design compressive strength and 75% of elastic modulus of the grout should be achieved within 24 hours, this should also provide better fatigue strength compared to conventional grout. However Bond strength shall be calculated without considering the shear keys/weld beads.

5.0 STRENGTH FORMULATION FOR GROUTED CONNECTION (HSE PILE/SLEEVE CONNECTIONS)

The characteristic bond strength of a grouted connection, with or without mechanical shear connectors satisfying the requirements of Section 2.2, HSE Offshore Technology Report 2001/016 on Pile/Sleeve Connection, is given by:

$$fbuc = K.CL(9Cs + 1100\ h/s)\ (fcu)^{1/2}$$

Where,
fbuc = is the characteristic bond strength of grout (in N/mm2)
fcu = is the characteristic grout compressive strength (in N/mm2)
K = is the stiffness factor defined below
CL = is the coefficient for grouted length to member diameter ratio
Cs = is the surface condition factor
h = is the minimum shear connector outstand (in mm)
s = is the nominal shear connector spacing (in mm)

$$K = [m\ (D/t)g]^{-1} + [(D/t)p + (D/t)s]^{-1}$$

Where,
m = is the modular ratio of steel to grout
D = is the outside diameter
t = is the wall thickness and subscripts g, p and s relate to grout, member and sleeve respectively.

In the absence of other data the modular ratio m may conservatively be taken as 18 for the long term (i.e. 28 days or more).

The available data on the parameter CL are limited. In the absence of data relating to a specific tubular and shear connector geometry, the following values of CL should be assumed:

L/Dp	CL
2	1
4	0.90
8	0.80
≥ 12	0.70

Where,
L = is the nominal grouted connection length.

Intermediate values for L/Dp < 12 should be calculated by linear interpolation.

The surface condition factor Cs should be taken according to the following:

i) If shear connectors are present and satisfy the requirement $h/s \geq 0.005$ then Cs may be taken as 1.0.

ii) For plain pipe connections and for connections with shear connectors but with $h/s < 0.005$, then, in the absence of test data, Cs should be taken as 0.6.

The values in i) and ii) above refer to shot-blasted or lightly rusted surface conditions. Other conditions (e.g. painted surfaces) should receive special consideration.

6.0 SAFETY FACTORS

In determining the permissible working bond stresses from the characteristic bond strength calculated using the above formulation, the following safety factors given below should be applied.

Loading Condition	Safety Factor
Extreme	4.5
Operating	6.0

7.0 MATERIAL FOR GROUTING

7.1 GROUT (**CEMENTITIOUS**) MATERIAL

Ultra High Performance Cementious (UHPC) material of proven track record as per API 10A shall be selected to achieve minimum 28 day compressive grout strength of 16000 psi.

Simulation Test (after production of material and before actual use) shall be carried out for the proposed UHPC Material (for actual use for the project) like Water Cement Ratio, Grout fluidity, duration of Grout fluidity, initial setting time, final setting time, Cube Crushing Strength, Grout Density, Bond Strength between Grout & Steel, Coefficient of Friction of Concrete & Steel, Modulus of Elasticity of Grout. Simulation Test shall be physically witnessed by Company Certifying Agency and or Company appointed inspector and record their views / acceptance.

7.2 GENERAL REQUIREMENTS OF CEMENTITIOUS MATERIAL

Contractor shall mobilize extra quantities of Cementitious material for smooth Installation. The specimens taken from the field should be subjected, until test, to a curing regime representative of the situ curing conditions, i.e., underwater and with appropriate seawater salinity and temperature. (As per #8.4.1 of API RP2A).

7.2.1 EX-STOCK CEMENTITIOUS MATERIAL

Cement supplied ex-stock shall not be accepted without proper identification and without manufacturer's certificates with identification on bag/container as required in 8.2.2 hereinafter. Cement manufactured over six months prior to actual use shall not be used for construction

7.2.2 MANUFACTURER'S CERTIFICATE OF CEMENTITIOUS MATERIAL

i) The Contractor shall submit Original manufacturers' test certificates to the Company for physical variation for all cements the contractor intends to use for the works whether procured freshly or being supplied ex-stock. The certificate shall indicate the manufacturer's name, trade mark or other means of identification, the batch number and date of manufacture and test results covering fineness, chemical composition, compressive strength at 1 day, 3 days and 28 days, initial and final setting time, shrinkage/expansion and soundness. All tests shall be carried out as specified below. Company appointed Inspector shall physically verify the Cementitious Material with respect to Original Mill test Certificate and accept same before use. Any Cementitious material rejected shall be disposed-off without cost & time implication to the Company.

ii) All tests for the cement shall be carried out as specified in ASTM C- 109 and or other relevant ASTM Codes.

iii) Shrinkage/expansion test shall be carried out as specified in ASTM designation C-806-87 "Restrained Expansive Cement Mortar" or by similar acceptable method.

iv) Identification of the cement intended to be used for the works shall be co-relatable with the identification on the manufacturer's test certificate.

v) Cement Grout Mix Design shall be carried out for the supplied Cement batch, which shall comply with the Parameters considered for Design calculation. This Mix design shall be witnessed by the Certifying Agency. The mix design report shall be made available at site so the mixing parameter (Water Cement Ratio, type of water, other components) can be witnessed by Inspecting Authority & Certifying Agent at Site of Works.

7.2.3 TESTING REQUIREMENTS OF CEMENTITIOUS MATERIAL FOR GROUTING:

On site sampling shall be performed and test cubes will be cast for 28 day strength verification. The cubes will be tested in an independent accredited onshore testing laboratory.

Test cubes (cube of 75 mm side) shall be cast at various stages during the grouting operations and will include samples taken from the start, middle and end of grouting of each clamp. The sample will be taken from the mixer during the operation. A minimum number of 3 (three) cubes will be cast at each stage. Test cubes will be de-moulded after 24 hours, stored and cured in water bath prior to testing. If the test results do not satisfy the minimum compressive strength requirements, LSTK Contractor shall be responsible for making suitable rectification measures to ensure adequacy of the strengthening arrangement.

8.0 BOLT MATERIAL:

All bolts, nuts & washers for use in the submerged and splash zones shall be flouro-polymer coated (XYLAN type) or equivalent. Coating color for all bolts and nuts shall be "Red". All bolts & nuts shall be of ASTM A-193 Grade B7 and nuts of ASTM A-194, grade 2H and shall be designed as per AISC.

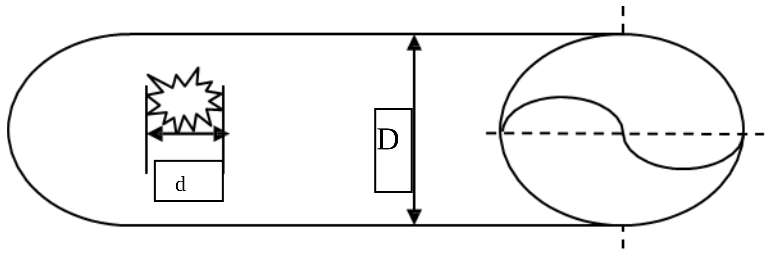
All bolts, nuts and washers fixed to external surfaces and internal surfaces exposed to natural ventilation shall be of stainless steel ASTM A-193 Grade B8M and nuts of ASTM A-194, grade 8M.

Sr. no.	Properties	Requirement
i	Corrosion resistance	salt spray test up to 3000 hours (nuts not frozen) (ASTM B117)
ii	Adhesion	5B (ASTM D3359)
iii	Pencil Hardness	5H-6H (ASTM D3363)
iv	Kinetic friction coefficient	0.06-0.08
v	Elongation	35%-50%
vi	Tensile strength	27.6 Mpa (4000 psi)
vii	Operating pressure	upto 690Mpa (100,000 psi)
viii	Coating Thickness	25 µm to 40µm
ix	Impact	18.43 Nm (160 in.lb) (ASTM D2794)
x	Thread fit	Over tapping of nuts 0.25mm (0.010'')
xi	Dielectric strength	500 volts per 25 µm
xii	Operating temperature	-100°C to +260°C

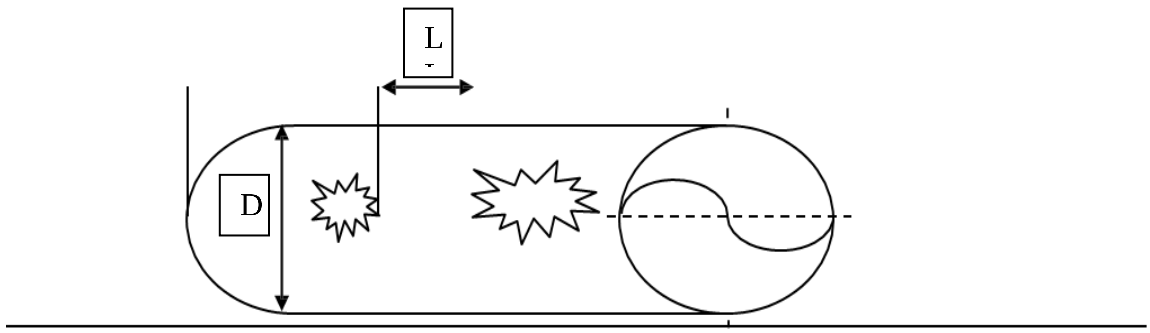
PTFE coating on fasteners will have a uniform thickness of 20 ± 5 microns to 45± 5 microns thick.

9.0 GUIDELINES FOR REPAIR OF JACKET WALKWAY MEMBERS:

Contractor shall follow while carrying out repair work pertaining to jacket walkway members having holes on them.



If d>D/5 then the complete segment of the member needs to be replaced. However, if d<D/5, then the member can be strengthened using doubler plates.
Where d is the largest dimension of observed hole on the member.



If L<914mm or D (whichever is less), the complete segment containing the two holes as a combination needs to be replaced. If however, L>914 mm or D (whichever is more), the member can be strengthened using separate doubler plates subject to meeting requirements of 1) above.

Where L is the Clear Spacing between two holes on a particular member

3) All strengthening work shall be in accordance with API RP 2A and API spec 2B. Final joint configuration and arrangement shall also meet requirements of API RP 2A.

Note: For both clauses 1) and 2) above, the segment is defined as a length on either side of the hole until original thickness of member is achieved. The LSTK Contractor shall carry out UT survey for checking the thicknesses of the members. In case the above necessitates complete dismantling and replacement of entire member, the same is also in scope of the LSTK Contract.

10.0 INSTALLATION/REPAIR PROCEDURE:

LSTK Contractor shall furnish the detailed installation procedure for the repair method adopted for approval by Company 60 days prior to installation incorporation all design aspects. Design consultant shall review & certify the Installation Procedure regarding incorporation of all Design Parameters. Vetting of MWS shall be obtained and submitted.

11.0 AS-BUILT DOCUMENTATION:

Installation process shall be video recorded and after installation As-Built Video survey shall be carried out. All videos shall be submitted under As-built Documentation.

Post Installation, As-Built Drawings shall be prepared by Design Consultant and shall be approved by ONGC. As-Built Drawings, Analysis Reports and Input files of respective Analysis in respective software format shall be submitted under As-Built Documentation.

Documents for fabrication shall contain Material Inspection Report with MTC, Material traceability with inspection report, Dimension control Report, Welding Inspection Reports, UT & RT Records, Loadout Report, etc. and shall be document progressively during Fabrication & Installation.

- **END** -

EXECUTION METHODOLOGY (STRUCTURAL)

PROJECT : ENGINEERING / TECHNICAL CONSULTANCY SERVICES FOR PREPERATION OF EXECUTION METHODOLOGY, SOW AND COST ESTIMATES FOR REPLACEMENT /REFURBISHMENT OF BRIDGES IN MH ASSET

LOCATION: MH ASSET (NORTH AND SOUTH FIELD)

OWNER : ONGC, MUMBAI

JOB NO : B774

Rev. No	Date	Purpose	Prepared by	Reviewed by	Approved by
C	11.11.2025	Re-ISSUED FOR TENDER (ICP-ICD bridge deleted)	RS	DP	CS
B	12.09.2025	ISSUED FOR TENDER	RS	DP	CS
A	23.08.2025	ISSUED AS STUDY	RS	DP	CS

CONTENTS

Table of Figures

No table of figures entries found.

List of Tables

No table of figures entries found.

Symbols and Abbreviations

Organisations – India

IS	Indian Standard
ONGC	Oil and Natural Gas Corporation
EIL	Engineers India Limited

Other abbreviations

CD	Chart Datum
g	Acceleration due to Gravity
H	Unsupported Length of pile
HAT	Highest Astronomical Tide
Hmax	Maximum Wave Height
Hs	Significant Wave Height
l	Length of a Structural Member
LAT	Lowest Astronomical Tide
MHWN	Mean High Water Neap
MHWS	Mean High Water Spring
MLWN	Mean Low Water Neap
MLWS	Mean Low Water Spring
HAT	Highest Astronomical Tide
LAT	Lowest Astronomical Tide
SS	Storm Surge

1.0 INTRODUCTION

M/S Oil & Natural Gas Corporation Ltd. (ONGC) owns and operates number of offshore platforms located on west coast of India. The platforms are operating in the Mumbai high field. With the ageing of field, condition of existing platform, bridges has deteriorated.

M/S Oil & Natural Gas Corporation Ltd. (ONGC) intends to carry out the refurbishment / replacement of existing bridges in offshore location at its MH asset.
For this purpose, the existing condition of the existing structural items such as tubular members, girders, rolled sections, plate girders, plating of the existing offshore platform, bridges are assessed by conducting laser scanning and Non-Destructive Test (UT Survey, Radiography survey of Joints) for each of these items.
The replacement / refurbishment requirements for existing bridges are assessed. The following document describes the execution methodology for the EPC contractor to perform the replacement / refurbishment of bridges.

2.0 GENERAL

The existing condition of the existing structural items such as tubular members, girders, rolled sections, plate girders, plating of the existing offshore platform, bridges are assessed by conducting Non- Destructive Test (Ultrasonic thickness Survey, dye penetration testing for welds, Ultrasonic testing of fillet welds and alternating current field measurements for welds) for each of these items.

Further, the Laser scanning of the bridge and landing area platform are also performed for assessing the piping, cables, other facilities, etc. The details of NDT and Laser scanning works are attached as reference for the contractor. However, Contractor shall perform all required data collection, NDT and laser scanning works to collect all necessary data.

i) Contractor shall carry out extensive site surveys and familiarize himself with the total work scope to be carried out on the existing platforms. Their scope of work shall include verification of data/ drawings of existing facilities (provided with bid) before proceeding with detailed engineering/ procurement based on bidding documents. It shall be Contractor's responsibility to assess the total quantum of work to be carried out on the existing platforms.

i) To verify as-built documents (like elevations, sizes/ wall thickness of relevant structural as well as non-structural members, etc.) and fill the missing data.

ii) To collect data such as member size, corroded size & thickness (using ultrasound method) of plating's, equipment supports/ skids, primary/ secondary/tertiary structural members for replacement of corroded members/ strengthening of existing members/ providing additional members.

The preliminary execution methodology for replacement / refurbishment of existing bridges (supply and providing new bridges (including piping, cables, lighting, monorails, etc) and revamping, modifications and strengthening works of existing bridges) are provided in this document. The final execution methodology shall be developed by EPC contractor.

Following is the list of bridges envisaged in the scope of work.

IC Complex:

1. ICP-ICG Lower Deck bridge (New)
2. ICW-ICG Lower Deck bridge (New)
3. ICP-ICG Upper Deck bridge
4. ICW-ICG Upper Deck bridge

BHS Complex:

5. BHS-SLQ Lower Deck bridge (Replacement)
6. SLQ-WIS Lower Deck bridge

NQO Complex:

7. NQO-NQD bridge

WIN Complex:

8. WIN-NC bridge

SCA Complex:

9. SCA-SC1 bridge
10. SCA-SCF bridge

Total of 10 bridges (2 nos. of new bridges, 1 no. of replacement of existing bridge & 7 bridges for strengthening) are included in the scope of work of LSTK contractor.

The scope of work is covered in two parts.

Part A – Strengthening of existing bridges

Part B – New bridges / Replacement of existing bridges

3.0 EXECUTION METHODOLOGY FOR PART-A & B

The preliminary execution methodology for strengthening of existing bridges and replacement / providing new bridges is provided herewith in clause 3.0, 4.0 and 5.0 below.

PART A: STRENGTHENING OF BRIDGES / LANDING AREAS ON PLATFORMS:

1. The strengthening of the existing bridge shall be performed by using construction barges. Handling of all man, materials, marine spread shall be through construction barges, supply vessels.
2. No accommodation / space shall be provided for contractor's men and material in platform during construction. Temporary scaffolding, supports, installation aids, etc shall be provided by the contractor.
3. All materials shall be brought in through supply vessels from construction barge through crane mounted on the barge. Company shall not provide facility of deck crane due to its operational requirements.
4. All tools and tackles required for performing the works, including all marine spread, etc shall be arranged from Construction barges.
5. Permits for all works including hot works shall be obtained from Company before execution.
6. Contractor shall note that there are live cables, piping (carrying hydrocarbon) are available at the bridge and landing locations. Contractor shall ensure complete safety by providing safety wraps, scaffoldings, etc

PART B: REPLACEMENT / NEW BRIDGES & NEW DECK EXTENSIONS:

1. There are three new bridges, 6 new deck extensions are envisaged in the project. The supply, transportation and installation of these bridges, extensions shall be performed by DP vessels with crane. Hence it is recommended to provide the Part B works to EPC contractor with sufficient experience in handling
2. The DP vessel with sufficient crane capacity and transportation barge carrying the bridges, extensions shall be deployed for carrying the works.
3. No accommodation / space shall be provided for contractor's men and material in platform during construction. Temporary scaffolding, supports, installation aids, etc shall be provided by the contractor.

4. All materials shall be brought in through supply vessels from construction barge through crane mounted on the barge. Company shall not provide facility of deck crane due to its operational requirements.
5. All tools and tackles required for performing the works, including all marine spread, etc shall be arranged from Construction barges.
6. Permits for all works including hot works shall be obtained from Company before execution.
7. Contractor shall note that there are live cables, piping (carrying hydrocarbon) at the bridge and landing locations. Contractor shall ensure complete safety by providing safety wraps, scaffoldings, etc.

a) Pre-engineering survey of Jacket walkway, bridge landing, Sub-cellar deck, cellar deck, middle deck and main deck for collection of all necessary information, as built information required for detailed engineering and preparation of the AFC drawings.

b) The bid drawings are based on visual inspection, NDT works, Laser scanning works, preliminary analysis and design performed by company and the same are provided to bidder for the understanding of EPC Contractor's scope of work. All data, corroded/damaged members etc as shown in bid drawings shall be verified by the successful EPC Contractor during pre-engineering survey to collect the actual extent of damage/corrosion and other as-built data. Contractor shall perform NDT and Laser scanning works for the platforms and bridges to collect all data required for performing the works.

c) It is mandatory that UT survey shall be carried out during pre-engineering survey for all structural members of the proposed modifications, revamp and strengthening and any new members as instructed by the Engineer-in-charge at site, to ascertain the extent of corrosion/ damage and its remedial measures. EPC Contractor shall also collect relevant data for preparation of installation scheme for various facilities.

d) Submission of pre-engineering survey report including marked-up sketches / drawing's installation schemes, fouling of structural members, damaged members etc to Company for review and approval.

e) Pre-construction survey for verification of the feasibility of the approved installation scheme for providing new facilities as per AFC drawings. EPC Contractor shall make necessary modifications in AFC drawings to facilitate the installation and matching with as-built site conditions after review and approval by Company.

f) Demolition / Dismantling of structural scrap items including damaged and corroded structural items needing repair & replacements as per the detailed platform wise scope. Contractor's scope with respect to scrap material is demolition / removal, safe handling, loading on cargo barges / supply vessels, sea fastening, transportation from offshore sites to Nhava yard and handing over to ONGC at Nhava yard. Providing of cargo barges / supply boats is within the Contractor's scope of work. Loading on cargo barges, sea fastening, transporting and disposal of all scrap material, serviceable/ non-serviceable materials dismantled from offshore platform is in EPC Contractor's scope. All marine spread for dismantling/ transportation of material shall be in EPC Contractor scope. All taxes and duties w.r.t. above scrap material while taking away to Contractor's storage location shall be borne by the EPC Contractor.

g) Modification / dismantling / cutting/ rerouting/ etc of any existing facilities, structures, piping, cabling, cable trays, instruments as necessary to overcome obstruction and to facilitate installation of new items and to make it good after installation, shall be carried out by the EPC Contractor.

h) Installation and erection of all structural modifications, strengthening, deck extensions etc including Hook up and commissioning with existing platform facilities. Plates and tubular members used in the strengthening / replacement shall be as per FS 6001F.

i) EPC Contractor shall make necessary protective arrangement above/ below deck for safety of the neighboring structures, equipment etc.

j) All necessary approvals/ permit for commencement of the work shall be taken in advance from company and/ or appropriate authority for proper execution of the job. EPC Contractor and his representative, workmen shall follow ONGC safety norms and requirements as per the instruction of Engineer-in-charge to execute the job safely and without any operational hazards. The EPC Contractor shall provide personnel protection equipment's necessary for the safety of workmen and supervisory personnel necessary for the execution of work at platform.

k) EPC Contractor will not be provided any space at platform for storage, fit-up, fabrication etc and all such activities shall be pre-planned by EPC Contractor at his own resources.

l) EPC Contractor shall be fully responsible for any damage caused both direct and consequential to the existing facilities during installation, hook-up & commissioning and removal of existing items / components and shall repair/ replace at his own cost. All such works shall be carried out as per the instruction and within the schedule decided by Engineer-in-charge at platform.

m) Repair and Touch-up painting of all surfaces/ structural members etc affected during execution of work. All existing facilities shall be restored back to their original state & cleaning of work area from all debris, tools & tackles, temporary supports etc after completion of work.

n) Arrangement of the scaffolding shall be made for proper access during pre-engineering survey, Pre-construction, installation & inspection related works.

o) Post installation survey to verify the installation as per the AFC drawings.

p) Preparation and submission of as-built documentation.

q) The complete bridge (Strengthened, New and replacement bridges), landing areas (All extensions and strengthened landings) including replaced plating, grating, handrail, monorails, Sheeting's, cladding shall be painted as per company painting specifications FS-2009. (Specifications for Protective Coating)

4.0 BRIDGE / PLATFORMWISE DETAILED EXECUTION METHODOLOGY FOR PART A (STRENGTHENING OF EXISTING BRIDGES)

The work shall be performed in sequential manner by following the below. The strengthening of landing areas shall be performed prior to the strengthening of bridges.

4.1 ICW-ICG Upper Deck Bridge (Strengthening)

4.1.1 ICW side Landing Area

a. Step 1: Repair of existing corroded beams and corresponding joints consisting of stiffeners, flange extension plates, half cut tubulars, etc wherever corroded at cellar deck level and main deck level including trusses, deck legs by providing strengthening/modification. Extent of corrosion / strengthening requirement are marked in NDT drawings for contractors understanding only.

b. Step 2: Repair of existing tubular joints, I section joints with stiffeners, plates, etc by strengthening / modification as per analysis requirements.

c. Step 3: Dismantling of existing corroded CS grating and providing new grating

d. Step 4: Dismantling of existing corroded handrail and providing new handrail

e. Step 5: Preparation of surface for receiving the bridge sliding / Fixed support including construction equipment's such as hydraulic jack-ups, strengthening of supports.

f. Step 6: Dismantling of existing bridge supports (fallen) and making surface clean.

g. Step 7: Relocating the existing scramble net to nearby safe area

4.1.2 ICG side landing area:

a. Step 1: Repair of existing corroded beams and corresponding joints consisting of stiffeners, flange extension plates, half cut tubulars, etc wherever corroded at cellar deck level and main deck level including trusses, deck legs by providing strengthening/modification. Extent of corrosion / strengthening requirement are marked in NDT drawings for contractors understanding only.

b. Step 2: Repair of existing tubular joints, I section joints with stiffeners, plates, etc by strengthening / modification as per analysis requirements.

c. Step 3: Dismantling of existing corroded CS grating and providing new grating

d. Step 4: Dismantling of existing corroded handrail and providing new handrail

e. Step 5: Preparation of surface for receiving the bridge sliding / Fixed support including construction equipment's such as hydraulic jack-ups, strengthening of supports.

f. Step 6: Dismantling of existing bridge supports (fallen) and making surface clean.

4.1.3 ICW-ICG Upper deck Bridge:

a. Step 1: Strengthening of bottom chord members and top chord members with half cut tubulars / channels, including strengthening of joints with stiffeners, etc.

b. Step 2: Strengthening of bracing members, providing additional bracing members, etc at ICW side and ICG side with half cut tubulars, / channels, etc including strengthening of joints with stiffeners, etc.

c. Step 3: Strengthening of the fixed support (at support location) provided at ICG side & Sliding support at ICW side.

d. Step 4: Replacement of walkway support members with new members (after completion of other strengthening) sequentially after completing each of the member.

e. Step 5: Replacement of all walkway members, monorails, grating and handrail with new walkway members, grating and handrail.

f. Step 6: Replacement of existing cable tray support with new cable tray supports.

g. Step 7: Replacement of existing cladding, roofing (sheeting, j clamps, screw, etc, all inclusive), supporting members, with new members, roofing, cladding sheets.

h. Contractor shall perform safety study for bridge and provide sufficient lifebuoys and other safety items as required.

4.2 ICP-ICG Upper Deck Bridge (Strengthening)

4.2.1 ICP side Landing Area

a. Step 1: Repair of existing corroded beams and corresponding joints consisting of stiffeners, flange extension plates, half cut tubulars, etc wherever corroded at cellar deck level and main deck level including trusses, deck legs by providing strengthening/modification. Extent of corrosion / strengthening requirement are marked in NDT drawings for contractors understanding only.

b. Step 2: Repair of existing tubular joints, I section joints with stiffeners, plates, etc by strengthening / modification as per analysis requirements.

c. Step 3: Dismantling of existing corroded CS grating and providing new grating

d. Step 4: Dismantling of existing corroded handrail and providing new handrail

e. Step 5: Preparation of surface for receiving the bridge sliding / Fixed support including construction equipment's such as hydraulic jack-ups, strengthening of supports.

f. Step 6: Dismantling of existing bridge supports (fallen) and making surface clean.

4.2.2 ICG side landing area:

a. Step 1: Repair of existing corroded beams and corresponding joints consisting of stiffeners, flange extension plates, half cut tubulars, etc wherever corroded at cellar deck level and main deck level including trusses, deck legs by providing strengthening/modification. Extent of corrosion / strengthening requirement are marked in NDT drawings for contractors understanding only.

b. Step 2: Repair of existing tubular joints, I section joints with stiffeners, plates, etc by strengthening / modification as per analysis requirements.

c. Step 3: Dismantling of existing corroded CS grating and providing new grating

d. Step 4: Dismantling of existing corroded handrail and providing new handrail

e. Step 5: Preparation of surface for receiving the bridge sliding / Fixed support including construction equipment's such as hydraulic jack-ups, strengthening of supports.

f. Step 6: Dismantling of existing bridge supports (fallen) and making surface clean.

4.2.3 ICP-ICG Upper deck Bridge:

a. Step 1: Strengthening of bottom chord members and top chord members with half cut tubulars / channels, including strengthening of joints with stiffeners, etc.

b. Strengthening of bottom tier of bridge (cable tray supporting) by providing new members, half cut tubulars, etc.

c. Step 2: Strengthening of bracing members, providing additional bracing members, etc with half cut tubulars, / channels, etc including strengthening of joints with stiffeners, etc.

d. Step 3: Strengthening of the fixed support (at support location) provided at ICG side & Sliding support at ICP side.

e. Step 4: Replacement of walkway support members with new members (after completion of other strengthening) sequentially after completing each of the member.

f. Step 5: Replacement of all walkway members, monorails, grating and handrail with new walkway members, grating and handrail.

g. Step 6: Replacement of existing cable tray support with new cable tray supports.

h. Step 7: Replacement of existing cladding, roofing (sheeting, j clamps, screw, etc, all inclusive), supporting members, with new members, roofing, cladding sheets.

i. Step 8: Strengthening of pipe supports, cable tray supports.

j. Contractor shall perform safety study for bridge and provide sufficient lifebuoys and other safety items as required.

4.3 SLQ-WIS Bridge (Strengthening)

4.3.1 SLQ side Landing Area

a. Step 1: Repair of existing corroded beams and corresponding joints consisting of stiffeners, flange extension plates, half cut tubulars, etc wherever corroded at cellar deck level and main deck level including trusses, deck legs by providing strengthening/modification. Extent of corrosion / strengthening requirement are marked in NDT drawings for contractors understanding only.

b. Step 2: Repair of existing tubular joints, I section joints with stiffeners, plates, etc by strengthening / modification as per analysis requirements.

c. Step 3: Dismantling of existing corroded CS grating and providing new grating

d. Step 4: Dismantling of existing corroded handrail and providing new handrail

e. Step 5: Preparation of surface for receiving the bridge sliding / Fixed support including construction equipment's such as hydraulic jack-ups, strengthening of supports.

f. Step 6: Dismantling of existing bridge supports and making surface clean.

4.3.2 WIS side landing area:

a. Step 1: Repair of existing corroded beams and corresponding joints consisting of stiffeners, flange extension plates, half cut tubulars, etc wherever corroded at cellar deck level and main deck level including trusses, deck legs by providing strengthening/modification. Extent of corrosion / strengthening requirement are marked in NDT drawings for contractors understanding only.

b. Step 2: Repair of existing tubular joints, I section joints with stiffeners, plates, etc by strengthening / modification as per analysis requirements.

c. Step 3: Dismantling of existing corroded CS grating and providing new grating

d. Step 4: Dismantling of existing corroded handrail and providing new handrail

e. Step 5: Preparation of surface for receiving the bridge sliding / Fixed support including construction equipment's such as hydraulic jack-ups, strengthening of supports.

f. Step 6: Dismantling of existing bridge supports and making surface clean.

4.3.3 SLQ-WIS Bridge:

a. Step 1: Strengthening of bottom chord members and top chord members with half cut tubulars / channels, including strengthening of joints with stiffeners, etc.

b. Strengthening of bottom tier of bridge (cable tray supporting) by providing new members, half cut tubulars, etc.

c. Step 2: Strengthening of bracing members, providing additional bracing members, etc with half cut tubulars, / channels, etc including strengthening of joints with stiffeners, etc.

d. Step 3: Strengthening of the fixed support (at support location) provided at SLQ side & Sliding support at WIS side.

e. Step 4: Replacement of walkway support members with new members (after completion of other strengthening) sequentially after completing each of the member.

f. Step 5: Replacement of all walkway members, monorails, grating and handrail with new walkway members, grating and handrail.

g. Step 6: Replacement of existing cable tray support with new cable tray supports.

h. Step 7: Strengthening of pipe supports, cable tray supports.

i. Contractor shall perform safety study for bridge and provide sufficient lifebuoys and other safety items as required.

4.4 NOQ-NQD Bridge (Strengthening)

4.4.1 NQO side Landing Area

a. Step 1: Repair of existing corroded beams and corresponding joints consisting of stiffeners, flange extension plates, half cut tubulars, etc wherever corroded at cellar deck level and main deck level including trusses, deck legs by providing strengthening/modification. Extent of corrosion / strengthening requirement are marked in NDT drawings for contractors understanding only.

b. Step 2: Repair of existing tubular joints, I section joints with stiffeners, plates, etc by strengthening / modification as per analysis requirements.

c. Step 3: Dismantling of existing corroded CS grating and providing new grating

d. Step 4: Dismantling of existing corroded handrail and providing new handrail

e. Step 5: Preparation of surface for receiving the bridge sliding / Fixed support including construction equipment's such as hydraulic jack-ups, strengthening of supports.

f. Step 6: Dismantling of existing bridge supports and making surface clean.

4.4.2 NQD side landing area:

a. Step 1: Repair of existing corroded beams and corresponding joints consisting of stiffeners, flange extension plates, half cut tubulars, etc wherever corroded at cellar deck level and main deck level including trusses, deck legs by providing strengthening/modification. Extent of corrosion / strengthening requirement are marked in NDT drawings for contractors understanding only.

b. Step 2: Repair of existing tubular joints, I section joints with stiffeners, plates, etc by strengthening / modification as per analysis requirements.

c. Step 3: Dismantling of existing corroded CS grating and providing new grating

d. Step 4: Dismantling of existing corroded handrail and providing new handrail

e. Step 5: Preparation of surface for receiving the bridge sliding / Fixed support including construction equipment's such as hydraulic jack-ups, strengthening of supports.

f. Step 6: Dismantling of existing bridge supports and making surface clean.

4.4.3 NQO-NQD Bridge:

a. Step 1: Strengthening of bottom chord members and top chord members with half cut tubulars / channels, including strengthening of joints with stiffeners, etc.

b. Strengthening of bottom tier of bridge (cable tray supporting) by providing new members, half cut tubulars, etc.

c. Step 2: Strengthening of bracing members, providing additional bracing members, etc with half cut tubulars, / channels, etc including strengthening of joints with stiffeners, etc.

d. Step 3: Strengthening of the fixed support (at support location) provided at NQO side & Sliding support at NQD side.

e. Step 4: Replacement of walkway support members with new members (after completion of other strengthening) sequentially after completing each of the member.

f. Step 5: Replacement of all walkway members, monorails, grating and handrail with new walkway members, grating and handrail.

g. Step 6: Replacement of existing cable tray support with new cable tray supports.

h. Step 7: Replacement of existing cladding, roofing (sheeting, j clamps, screw, etc, all inclusive), supporting members, with new members, roofing, cladding sheets.

i. Step 8: Strengthening of pipe supports, cable tray supports.

j. Contractor shall perform safety study for bridge and provide sufficient lifebuoys and other safety items as required.

4.5 WIN-NC Bridge (Strengthening)

4.5.1 WIN side Landing Area

a. Step 1: Repair of existing corroded beams and corresponding joints consisting of stiffeners, flange extension plates, half cut tubulars, etc wherever corroded at cellar deck level and main deck level including trusses, deck legs by providing strengthening/modification. Extent of corrosion / strengthening requirement are marked in NDT drawings for contractors understanding only.

b. Step 2: Repair of existing tubular joints, I section joints with stiffeners, plates, etc by strengthening / modification as per analysis requirements.

c. Step 3: Dismantling / demolition of temporary bridge supporting members at landing area already provided by company as remedial action.

d. Step 3: Dismantling of existing corroded CS grating and providing new grating

e. Step 4: Dismantling of existing corroded handrail and providing new handrail

f. Step 5: Preparation of surface for receiving the bridge sliding / Fixed support including construction equipment's such as hydraulic jack-ups, strengthening of supports.

g. Step 6: Dismantling of existing bridge supports and making surface clean.

4.5.2 NC side landing area:

a. Step 1: Repair of existing corroded beams and corresponding joints consisting of stiffeners, flange extension plates, half cut tubulars, etc wherever corroded at cellar deck level and main deck level including trusses, deck legs by providing strengthening/modification. Extent of corrosion / strengthening requirement are marked in NDT drawings for contractors understanding only.

b. Step 2: Repair of existing tubular joints, I section joints with stiffeners, plates, etc by strengthening / modification as per analysis requirements.

c. Step 3: Dismantling of existing corroded CS grating and providing new grating

d. Step 4: Dismantling of existing corroded handrail and providing new handrail

e. Step 5: Preparation of surface for receiving the bridge sliding / Fixed support including construction equipment's such as hydraulic jack-ups, strengthening of supports.

f. Step 6: Dismantling of existing bridge supports and making surface clean.

4.5.3 WIN-NC Bridge:

a. Step 1: Strengthening of bottom chord members and top chord members with half cut tubulars / channels, including strengthening of joints with stiffeners, etc.

b. Strengthening of bottom tier of bridge (cable tray supporting) by providing new members, half cut tubulars, etc.

c. Step 2: Strengthening of bracing members, providing additional bracing members, etc with half cut tubulars, / channels, etc including strengthening of joints with stiffeners, etc.

d. Step 3: Strengthening of the fixed support (at support location) provided at NQO side & Sliding support at NQD side.

e. Step 4: Replacement of walkway support members with new members (after completion of other strengthening) sequentially after completing each of the member.

f. Step 5: Replacement of all walkway members, monorails, grating and handrail with new walkway members, grating and handrail.

g. Step 6: Replacement of existing cable tray support with new cable tray supports.

h. Step 7: Strengthening of pipe supports, cable tray supports.

i. Contractor shall perform safety study for bridge and provide sufficient lifebuoys and other safety items as required.

4.6 SC1-SCA Bridge (Strengthening)

4.6.1 SC1 side Landing Area

a. Step 1: Repair of existing corroded beams and corresponding joints consisting of stiffeners, flange extension plates, half cut tubulars, etc wherever corroded at cellar deck level and main deck level including trusses, deck legs by providing strengthening/modification. Extent of corrosion / strengthening requirement are marked in NDT drawings for contractors understanding only.

b. Step 2: Repair of existing tubular joints, I section joints with stiffeners, plates, etc by strengthening / modification as per analysis requirements.

c. Step 3: Dismantling of existing corroded CS grating and providing new grating

d. Step 4: Dismantling of existing corroded handrail and providing new handrail

e. Step 5: Preparation of surface for receiving the bridge sliding/fixed support including construction equipment's such as hydraulic jack-ups, strengthening of supports.

f. Step 6: Dismantling of existing bridge supports and making surface clean.

4.6.2 SCA side landing area:

a. Step 1: Repair of existing corroded beams and corresponding joints consisting of stiffeners, flange extension plates, half cut tubulars, etc wherever corroded at cellar deck level and main deck level including trusses, deck legs by providing strengthening/modification. Extent of corrosion / strengthening requirement are marked in NDT drawings for contractors understanding only.

b. Step 2: Repair of existing tubular joints, I section joints with stiffeners, plates, etc by strengthening / modification as per analysis requirements.

c. Step 3: Dismantling of existing corroded CS grating and providing new grating

d. Step 4: Dismantling of existing corroded handrail and providing new handrail

e. Step 5: Preparation of surface for receiving the bridge sliding/fixed support including construction equipment's such as hydraulic jack-ups, strengthening of supports.

f. Step 6: Dismantling of existing bridge supports and making surface clean.

4.6.3 SC1-SCA Bridge:

a. Step 1: Strengthening of bottom chord members and top chord members with half cut tubulars / channels, including strengthening of joints with stiffeners, etc.

b. Strengthening of bottom tier of bridge (piping, cable tray supporting) by providing new members, half cut tubulars, etc.

c. Step 2: Strengthening of bracing members, providing additional bracing members, etc with half cut tubulars, / channels, etc including strengthening of joints with stiffeners, etc.

d. Step 3: Strengthening of the fixed support (at support location) provided at SCA side & Sliding support at SC1 side.

e. Step 4: Replacement of walkway support members with new members (after completion of other strengthening) sequentially after completing each of the member.

f. Step 5: Replacement of all walkway members, monorails, grating and handrail with new walkway members, grating and handrail.

g. Step 6: Replacement of existing cable tray support with new cable tray supports.

h. Step 7: Strengthening of pipe supports, cable tray supports.

i. Contractor shall perform safety study for bridge and provide sufficient lifebuoys and other safety items as required.

4.7 SCA-SCF Bridge (Strengthening)

4.7.1 SCA side Landing Area

a. Step 1: Repair of existing corroded beams and corresponding joints consisting of stiffeners, flange extension plates, half cut tubulars, etc wherever corroded at cellar deck level and main deck level including trusses, deck legs by providing strengthening/modification. Extent of corrosion / strengthening requirement are marked in NDT drawings for contractors understanding only.

b. Step 2: Repair of existing tubular joints, I section joints with stiffeners, plates, etc by strengthening / modification as per analysis requirements.

c. Step 3: Dismantling of existing corroded CS grating and providing new grating

d. Step 4: Dismantling of existing corroded handrail and providing new handrail

e. Step 5: Preparation of surface for receiving the bridge sliding/fixed support including construction equipment's such as hydraulic jack-ups, strengthening of supports.

f. Step 6: Dismantling of existing bridge supports and making surface clean.

4.7.2 SCF side flare boom / Tripod area:

a. Step 1: Repair of existing corroded beams and corresponding joints consisting of stiffeners, flange extension plates, half cut tubulars, etc wherever corroded at tripod level including trusses, deck legs by providing strengthening/modification. Extent of corrosion / strengthening requirement are marked in NDT drawings for contractors understanding only.

b. Step 2: Repair of existing tubular joints, I section joints with stiffeners, plates, etc by strengthening / modification as per analysis requirements.

c. Step 3: Dismantling of existing corroded CS grating and providing new grating

d. Step 4: Dismantling of existing corroded handrail and providing new handrail

e. Step 5: Preparation of surface for receiving the bridge sliding/fixed support including construction equipment's such as hydraulic jack-ups, strengthening of supports.

f. Step 6: Dismantling of existing bridge supports and making surface clean.

4.7.3 SC1-SCA Bridge:

a. Step 1: Strengthening of bottom chord members and top chord members with half cut tubulars / channels, including strengthening of joints with stiffeners, etc.

b. Strengthening of bottom tier of bridge (piping, cable tray supporting) by providing new members, half cut tubulars, etc.

c. Step 2: Strengthening of bracing members, providing additional bracing members, etc with half cut tubulars, / channels, etc including strengthening of joints with stiffeners, etc.

d. Step 3: Strengthening of the fixed support (at support location) provided at SCA side & Sliding support at SC1 side.

e. Step 4: Replacement of walkway support members with new members (after completion of other strengthening) sequentially after completing each of the member.

f. Step 5: Replacement of all walkway members, monorails, grating and handrail with new walkway members, grating and handrail.

g. Step 6: Replacement of existing cable tray support with new cable tray supports.

h. Step 7: Strengthening of pipe supports, cable tray supports.

i. Contractor shall perform safety study for bridge and provide sufficient lifebuoys and other safety items as required.

5.0 BRIDGE / PLATFORMWISE DETAILED SCOPE OF WORK FOR PART B (NEW / REPLACEMENT OF BRIDGES)

5.1 ICW-ICG Lower Deck Bridge (New Bridge)

5.1.1 ICW side Landing Area

a. Step 1: Repair of existing corroded beams and corresponding joints consisting of stiffeners, flange extension plates, half cut tubulars, etc wherever corroded at cellar deck level and main deck level including trusses by providing strengthening/modification.

b. Step 2: Repair of existing tubular joints, I section joints with stiffeners, plates, etc by strengthening / modification as per analysis requirements.

c. Step 3: Dismantling of existing corroded CS grating and providing new grating

d. Step 4: Dismantling of existing corroded handrail and providing new handrail. Preparation of surface for receiving the bridge sliding / Fixed support.

e. Step 5: Supply and Installation of loading / Unloading area (as per design criteria attached elsewhere in the tender) near the existing loading / Unloading area (including fabrication at onshore, transportation, erection with all marine spread and man machinery inclusive)

f. Step 6: Relocating the existing scramble net to nearby safe area including safety study for performing the same.

5.1.2 ICG side Landing Area

a. Step 1: Repair of existing corroded beams and corresponding joints consisting of stiffeners, flange extension plates, half cut tubulars, etc wherever corroded at cellar deck level and main deck level including trusses by providing strengthening/modification.

b. Step 2: Repair of existing tubular joints, I section joints with stiffeners, plates, etc by strengthening / modification as per analysis requirements.

c. Step 3: Dismantling of existing corroded CS grating and providing new grating

a. Step 4: Dismantling of existing corroded handrail and providing new handrail. Preparation of surface for receiving the bridge fixed support.

d. Step 5: Supply and Installation of deck extension (as per design criteria attached elsewhere in the tender) near the existing loading / Unloading area (including fabrication at onshore, transportation, erection with all marine spread and man machinery inclusive)

5.1.3 ICW-ICG Lower deck Bridge:

a. Step 1: Onshore fabrication of New walkway bridge ICW-ICG lower Deck.

b. Step 2: Load-out & transportation including sea fastening, all inclusive.

c. Step3: Lifting and installation of new walkway bridge (as per design criteria attached elsewhere in the tender) including walkway at cellar deck level between platforms ICW and ICG (including fabrication erection with all marine spread and man machinery inclusive) at identified landing locations

d. Step 4: Supply, installation of walkway members, new grating, handrail, on the bridge ICP-ICG Lower Deck Bridge (New Bridge)

e. Contractor shall perform safety study for bridge and provide sufficient lifebuoys and other safety items as required.

5.2 ICP-ICG Lower Deck Bridge (New Bridge)

5.2.1 ICP side Landing Area

g. Step 1: Repair of existing corroded beams and corresponding joints consisting of stiffeners, flange extension plates, half cut tubulars, etc wherever corroded at cellar deck level and main deck level including trusses by providing strengthening/modification.

h. Step 2: Repair of existing tubular joints, I section joints with stiffeners, plates, etc by strengthening / modification as per analysis requirements.

i. Step 3: Dismantling of existing corroded CS grating and providing new grating

j. Step 4: Dismantling of existing corroded handrail and providing new handrail. Preparation of surface for receiving the bridge sliding / Fixed support.

k. Step 5: Supply and Installation of New extension (as per design criteria attached elsewhere in the tender) near the existing loading / Unloading area (including fabrication at onshore, transportation, erection with all marine spread and man machinery inclusive)

5.2.2 ICG side Landing Area

a. Step 1: Repair of existing corroded beams and corresponding joints consisting of stiffeners, flange extension plates, half cut tubulars, etc wherever corroded at cellar deck level and main deck level including trusses by providing strengthening/modification.

b. Step 2: Repair of existing tubular joints, I section joints with stiffeners, plates, etc by strengthening / modification as per analysis requirements.

c. Step 3: Dismantling of existing corroded CS grating and providing new grating

b. Step 4: Dismantling of existing corroded handrail and providing new handrail. Preparation of surface for receiving the bridge fixed support.

d. Step 5: Supply and Installation of deck extension (as per design criteria attached elsewhere in the tender) near the existing loading / Unloading area (including fabrication at onshore, transportation, erection with all marine spread and man machinery inclusive)

e. Step 6: Relocating the existing scramble net to nearby safe area including safety study for performing the same.

5.2.3 ICP-ICG Lower deck Bridge:

a. Step 1: Onshore fabrication of New walkway bridge ICP-ICG lower Deck.

b. Step 2: Load-out & transportation including sea fastening, all inclusive.

c. Step 3: Lifting and installation of new walkway bridge (as per design criteria attached elsewhere in the tender) including walkway at cellar deck level between platforms

ICW and ICG (including fabrication erection with all marine spread and man machinery inclusive) at identified landing locations

d. Step 4: Supply, installation of walkway members, new grating, handrail, on the bridge ICP-ICG Lower Deck Bridge (New Bridge)

e. Contractor shall perform safety study for bridge and provide sufficient lifebuoys and other safety items as required.

5.3 BHS-SLQ Lower Deck Bridge (New Bridge)

5.3.1 BHS side Landing Area

a. Step1: Repair of existing corroded beams and corresponding joints consisting of stiffeners, flange extension plates, half cut tubulars, etc wherever corroded at cellar deck level and main deck level including trusses by providing strengthening/modification. Extent of corrosion / strengthening requirement are marked in NDT drawings for contractors understanding only.

b. Step 2: Repair of existing tubular joints, I section joints with stiffeners, plates, etc by strengthening / modification as per analysis requirements.

c. Step 3: Dismantling of existing corroded CS grating and providing new grating

d. Step 4: Dismantling of existing corroded handrail and providing new handrail

e. Step 5: Supply and installation of new extension for landing area (as per design criteria attached elsewhere in the tender) near Row B along with extensions for new life boat, pipe way, cable tray (including fabrication at onshore, transportation, erection with all marine spread and man machinery inclusive)

f. Step 6: Preparation of surface for receiving the bridge sliding / Fixed support.

Step 7: Demolition of existing lifeboat extension and relocation of existing lifeboat to new life boat location. During the period that the existing life boat is rendered out of service, contractor shall provide alternate lifeboat or life raft till the existing lifeboat is relocated to the new location.

5.3.2 SLQ side Landing Area

a. Step 1: Repair of existing corroded beams and corresponding joints consisting of stiffeners, flange extension plates, half cut tubulars, etc wherever corroded at cellar deck level and main deck level including trusses by providing strengthening/modification. Extent of corrosion / strengthening requirement are marked in NDT drawings for contractors understanding only.

b. Step 2: Repair of existing tubular joints, I section joints with stiffeners, plates, etc by strengthening / modification as per analysis requirements.

c. Step 3: Dismantling of existing corroded CS grating and providing new grating

d. Step 4: Dismantling of existing corroded handrail and providing new handrail

e. Step 5: Supply and installation of new extension for landing area (as per design criteria attached elsewhere in the tender) near Row B along with extensions for pipe way, cable tray (including fabrication at onshore, transportation, erection with all marine spread and man machinery inclusive)

f. Step 6: Preparation of surface for receiving the bridge Fixed support.

5.3.3 BHS-SLQ Lower deck Bridge: (New Bridge)

a. Step 1: Onshore fabrication of New walkway bridge BHS-SLQ lower Deck.

b. Step 2: Load-out & transportation including sea fastening, all inclusive.

c. Step 3: Lifting and installation of new walkway bridge (as per design criteria attached elsewhere in the tender) including walkway at cellar deck level between platforms BHS and SLQ (including fabrication erection with all marine spread and man machinery inclusive) at identified landing locations

d. Step 4: Supply, installation of walkway members, new grating, handrail, on the bridge BHS-SLQ Lower Deck Bridge (New Bridge)

e. Step 5: Supply, erection of electrical items such as cables, cable tray, lighting, etc

f. Step 6: Supply, Erection of cable tray supports, pipe supports, monorails, etc for re-routing of all new piping, cables, etc similar as existing BHS-SLQ bridge, Refer piping, electrical and instrumentation scope of work for further details.

g. Step 7: Supply, installation of cladding, roofing (including sheeting, J clamps, etc,) along with cladding, roofing supporting members.

h. Step 8: Identification of Tie-ins for Piping and cables on either side of existing bridge BHS-SLQ.

i. Step 9: Supply, installation of piping, cables, lighting along the bridge and along platform extensions till the tie-in location for piping and cable.

j. Step 10: Hook-up & commissioning of existing piping, cables with new bridge as detailed elsewhere in the tender.

k. Contractor shall perform safety study for bridge and provide sufficient lifebuoys and other safety items as required.

5.3.4 BHS-SLQ Lower deck bridge (Existing Bridge)

a. Step 1: Strengthening of chord members for demolition, dismantling of existing process bridge BHS-SLQ (as per company design criteria attached elsewhere in the tender)

b. Step 2: Strengthening of bracing members including strengthening of joints with stiffeners, etc to facilitate removal.

c. Step 3: Demolition / Dismantling of all walkway members, grating and handrail.

d. Step 4: Demolition / Dismantling of existing cable tray support.

e. Step 5: Demolition / Dismantling of existing cladding, roofing (sheeting, j clamps, screw, etc, all inclusive), supporting members.

f. Step 6: Demolition / Dismantling of existing pipe supports, hanging supports, cable tray supports below bridge main truss.

g. Step 7: Demolition / Dismantling of the fixed support (at support location) provided at BHS side.

h. Step 8: Demolition / Dismantling of the sliding / Fixed support (at support location) provided at SLQ side.