# Temporary Works in a Marine Environment

# New Zealand Best Practice Guidance

## 1.0 INTRODUCTION

Temporary works designed and constructed within a marine environment often involves high risk work coupled with complex loading situations.

Currently in New Zealand there is no definitive guidance for the design or construction of temporary works in a marine environment and this can lead to misinterpretation or omission of potential loading or stability situations.

### 1.1 Purpose

The purpose of this Technical Guidance Note (TGN) is to provide the reader with an overview of existing NZ regulatory requirements and current best practice guidance with regards to the design, construction and use of temporary works in a marine environment. Typical situations may include (but are not limited to) construction work involving barges, cranes, and drill rigs on temporary staging, and work off existing wharves and seawalls.

This TGN will not detail how to derive loads or actions on temporary structures but instead will make the reader aware of available literature and existing best practices as well as assist with risk identification and management in line with the TWf(NZ) GPG01:19 Temporary Works: Procedural Control Good Practice Guideline.

## 2.0 CURRENT REGULATORY REQUIREMENTS

### 2.1 Maritime Transport Act and Maritime NZ Rules

The maritime and marine protection rules are statutory instruments made by the Minister of Transport under the Maritime Transport Act 1994. While the Maritime Transport Act stipulates broad principles of maritime law, the Maritime New Zealand rules contain detailed technical standards and procedures. Compliance with the rules is required because they form part of New Zealand maritime law.

Furthermore, Maritime NZ implements safety management systems to ensure that commercial vessels are maintained and operated safely to prevent maritime accidents and protect the marine environment. Safety Management systems include MOSS, SOP, ISM (SOLAS), Safety Case, and Specified Limits Permit.

Construction work that involves commercial or floating vessels (e.g. flat top construction barges or Jack-up barges) should comply with any applicable Maritime Rules and safety management systems.

For more information on the Maritime NZ Rules, refer to https://www.maritimenz.govt.nz

### 2.2 Resource Management Act

The design and installation of temporary works within a marine environment will often require compliance with project specific resource consent conditions. It is important to review and understand these consent conditions before designing and installing temporary works, particularly where interaction with the seabed or riverbed is involved (e.g. installation of temporary piles to support staging).

### 2.3 Building Act and Building Code

The design of temporary works within a marine environment should comply with the applicable clauses of the Building Code (i.e. B1 Structure, F4 Safety from Falling and F5 Construction and Demolition Hazards, and amenity clauses where relevant for site offices).

There is no clear and distinct answer as to whether a building consent is required or not for individual items of temporary works. Regardless of the length of time an item of temporary works is in place, a competent judgement decision must be made by the Designer and/or Temporary Works Coordinator as to whether the consenting authority (council) should be asked if a building consent is needed or not.

# 3.0 EXISTING AND INTERNATIONAL STANTARDS AND GUIDANCE

## 3.1 Existing NZ / Australian Standards and Guidance

- AS/NZS 1170 Structural Design Actions.
- AS 3962 Guidelines for the Design of Marinas.
- AS 4997 Guidelines for the Design of Marine Structures.
- AS 2159 Piling – Design and Installation.
- Maritime New Zealand Rules.
- Maritime New Zealand Barge Stability Guidelines.
- AS 5100 Bridge Design
- NZTA Waka Kotahi Bridge Manual (SM061)
- TWf(NZ) GPG01:19 Temporary Works: Procedural Control GPG

## 3.2 International Guidelines and Recommended Practices

- BS 6349-1-2 Maritime Works – General: Code of Practice for Assessment of Actions
- BS 6349-6 Maritime Structures – Design of inshore Moorings and Floating Structures
- PIANC WG33 Guidelines for the Design of Fender Systems
- PIANC WG34 Seismic Design Guidelines for Port Structures
- US Army Corps Coastal Engineering Manual
- SNAME – 5-5a Guidelines for Site Specific Assessment of Mobile Jack-up Units
- ISO 19905.1 Site Specific Assessment of Offshore Units – Part 1: Jack-ups
- DNV GL Rules for Classification, Ships
- Lloyd's Register Rules and Regulations for the Classification of Ships
- ASCE 7-05 Minimum Design Loads for Buildings and Other Structures

# 4.0 TIDE LEVELS

## 4.1 The NZ Tidal Cycle and Definition of Tidal Terms

All around the New Zealand coastline the tidal regime is semi-diurnal. This means that on most days two high and two low tides will occur at any given location. Maximum tidal ranges exceeding 3.5m occur at Onehunga, Port Taranaki, Nelson, Westport, and Auckland. The smallest tidal ranges (2m or less) are experienced at Gisborne, Napier, Wellington and Picton.

The classic fortnightly spring/neap cycle is not seen at Napier, Wellington and Lyttelton. At these sites the solar tides are dominated by the lunar ones and the result is known as a perigean tide.

### 4.1.1 Mean Sea Level (MSL)

The average level of the sea surface over a long period or the average level which would exist in the absence of tides.

### 4.1.2 Mean High Water Springs (MHWS) and Mean Low Water Springs (MLWS)

The average of the levels of each pair of successive high waters, and of each pair of successive low waters, during that period of about 24 hours in each semi-lunation (approximately every 14 days), when the range of this tide is the greatest (Spring Range).


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### 4.1.3 Mean High Water Neaps (MHWN) and Mean Low Water Neaps (MLWN)

The average of the levels of each pair of successive high waters and of each pair of successive low waters during that period of about 24 hours in each semi-lunation (approximately every 14 days), when the range of the tide is least (Neap Range)

### 4.1.4 Chart Datum (CD)

A water level so low that the tide will but seldom fall below it. Chart Datum is the commonly preferred survey height datum for maritime work. The Chart Datum is unique to the location of work and varies across standard ports in New Zealand. It is often derived from a historical LAT and is a legacy level specific to each port authority and used as a consistent level against changing tidal ranges and sea levels.

### 4.1.5 Highest and Lowest Astronomical Tide (HAT and LAT)

The highest and lowest tidal levels which can be predicted to occur under average meteorological conditions over 18 years. Modern chart datums are set at the approximate level of Lowest Astronomical Tide (LAT) and Tide Tables list the predicted height of tide above Chart Datum.

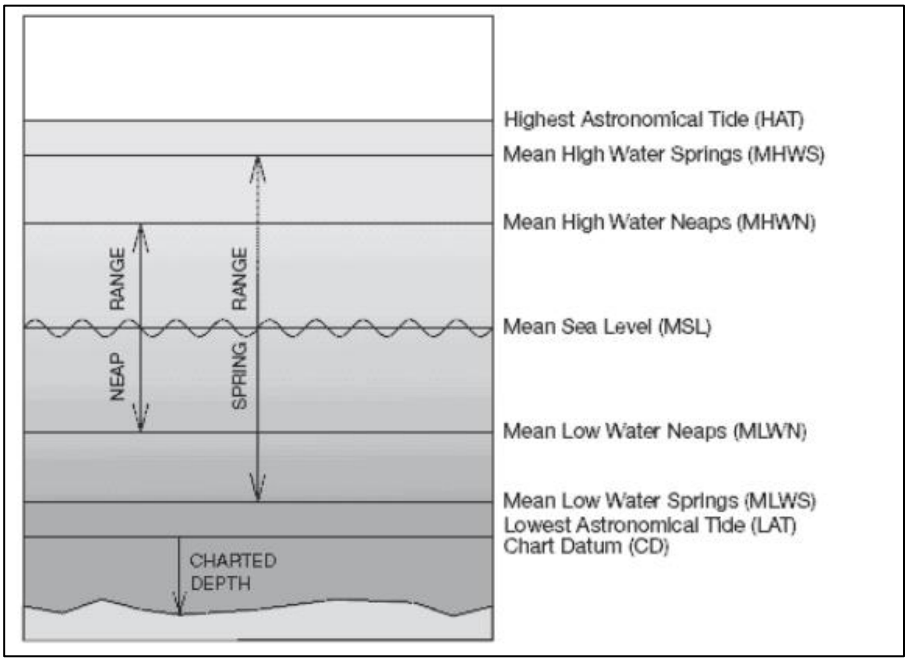


*Figure 1: Diagram Illustrating Tidal Terms (Land Information NZ)*

## 5.0 WAVES

Temporary works designed and constructed within a marine environment will need to consider the wave climate that could reasonably be expected to act on temporary structures that are located within or close to the tidal range.

The incident wave climate at the site may comprise wind waves, ocean swells and vessel wash. The assessment of wave climate at a site requires knowledge of:

- Wind climate including regional winds and local topographic winds.
- Water areas and fetch lengths in all directions.
- Water depths, not only at the site but average depths along each of the major fetch directions.


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## 5.1 Statistical Wave Forecasting

The determination of wave parameters used to derive the design wave height, wave period and wave direction should be assessed using site-specific wave records where records of adequate duration, to determine an appropriate long-term record, are available. If such records are not available, wave heights and periods may be determined from available wind data.

For further information on wave theory and statistical wave forecasting we recommend the reader refers to the US Army Corps Coastal Engineering Manual.

# 6.0 DESIGN ACTIONS

The design of temporary works for ultimate strength, serviceability, stability, and other relevant limit states should consider the appropriate design actions arising from those given in NZS1170 and other actions applicable to maritime structures, as follows:

- Permanent actions (dead loads)
- Imposed actions (live loads)
- Seismic actions (fixed structures only and excluding Jack-up Barges)
- Vessel berthing and mooring actions
- Wind actions
- Current and debris actions
- Scour
- Hydrostatic actions
- Wave actions
- Storm surge actions
- Propeller Wash

For further information and detailed guidance on design actions, including appropriate load combinations and load factors, we recommend the reader refers to AS 4997-2005 Guidelines for the design of maritime structures.

## 6.1 Permanent and Imposed Actions

Permanent and imposed loads should be factored and combined with the principles and intent of:

- AS/NZS 1170
- AS 4997 Guidelines for the Design of Marine Structures
- AS 2159 Piling – Design and Construction
- AS 3610 Formwork for Concrete
- NZTA Bridge Manual

Where an appropriate load factor or load combination is not directly obtainable from the above documents or is deemed inappropriate for the given circumstances, the factored loads should be combined as appropriate to produce the most adverse effects using competent engineering judgement.

It should also be noted that load factors and combinations that have the most adverse effect on structure strength, may not necessarily be the same as those that have the most adverse effect on structure stability (particularly when assessing floating plant).

### 6.1.1 Plant and Equipment Loading on Temporary Staging and Wharfs

For cranes and drill rigs sitting on temporary staging or an existing wharf structure, resultant track or outrigger loading should be determined assuming hard ground conditions (i.e. triangular load distribution for tracked plant), not equivalent UDL conditions that are typically applied for granular working platforms.



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When assessing minimum lateral loads for temporary staging or wharf structures holding plant and equipment it is recommended that a minimum of 10% of the static vertical load is considered (this is higher than the nominal 2.5% as specified in NZS1170). The static vertical load should include plant and equipment loading arrangements that could reasonably be foreseen to be working on the temporary staging or wharf structure at any one time.

## 6.2 Design Vessel Berthing and Mooring Loads

### 6.2.1 Vessel Berthing Loads

The berthing impact force should be derived from the energy impacted to the structure and restraining system from the design vessel striking the structure. Vessel berthing energies can be calculated using the methods set out in either AS4997, BS6349 or the PIANC WG33 Report.

Berthing velocity guidance provided in BS6349 or the PIANC WG33 report are for vessels with displacements greater than 1000t. The table below provides guidance on berthing velocities for vessels with displacements less than 1000t, which has been taken from AS 4997-2005 Appendix B.

| Vessel Class | Vessel Displacement (tonnes) | Exposure Conditions | Normal Berthing Velocity Range (m/s) |
|---|---|---|---|
| Private | Up to 10t | Mild<br>Moderate<br>Severe | 0.2 m/s<br>0.25 m/s<br>0.3 m/s |
| Private | Over 10t | Mild<br>Moderate<br>Severe | 0.15 m/s<br>0.2 m/s<br>0.25 m/s |
| Commercial Charter / Cruise vessel | Up to 1000t | Mild<br>Moderate<br>Severe | 0.2 m/s<br>0.25 m/s<br>0.3 m/s |
| Ferries | Up to 100t | Mild<br>Moderate<br>Severe | 0.3 m/s<br>0.35 m/s<br>0.4 m/s |
| Ferries | Over 100t | Mild<br>Moderate<br>Severe | 0.25 m/s<br>0.3 m/s<br>0.35 m/s |

*Table 1: Berthing velocities for vessels<1000t (AS4997)*

Typical design vessel parameters, such as beam, draft, displacement and windage areas can be found in AS 3962. However, care should be taken with the application of 'typical' parameters to represent specific construction vessels, such as flat top barges, split hopper barges and tugboats. Where these vessels and vessels that require tug assistance need to be considered, the process for determining a more accurate design berthing velocity can be found in the BS36349 or WG33 guidelines. Furthermore, we also recommend speaking to skippers who typically operate similar vessels in the area and are familiar with the site location.

With regards to ULS design checks, the WG33 guidelines recommend that an abnormal berthing energy of 1.5-2.0x the normal berthing energy is considered, the energy resulting from abnormal berthing need not be further factored when determining the design load.

### 6.2.2 Vessel Mooring Loads

Where vessels are moored against a temporary structure, the structure should be designed to resist mooring loads, which includes the actions from wind, currents and waves acting on the vessel in both the beam-to and bow/stern-to directions. Where applicable, loads from tensioning spring lines or dynamic mooring systems should also be considered

### 6.2.3 Anchoring/Bollard Loads

A typical procedure for the selection of an appropriate mooring line break load requires the selection of a design vessel and the calculation of its associated Equipment Number. This method is outlined in detail within documents such as the Lloyd's Register Rules and Regulations for the Classification of Ships or DNV GL Rules for Classification, Ships.

For convenience, AS 4997-2005 Appendix C provides a table of vessel displacement ranges and required minimum bollard rated capacity for use in structural design assessments. Most classification societies (such as Lloyd's, DNV, GL, BV etc) require bollards or similar anchoring points on vessels to be designed to a minimum capacity of 1.25 x the mooring line break load. Therefore, it is also recommended that bollards or similar anchoring points mounted on temporary works structures are designed to a similar capacity.

### 6.2.4 Snap Back Zones

A snap-back is the sudden recoil of a mooring line as a result of its failure under tension. A snap-back zone on a mooring deck or wharf is the space where it is anticipated that the failed mooring line could recoil with great speed, possibly resulting in serious harm to people within this zone.

The potential for snap-back zones to be present within the construction area should be identified during the construction planning stage and avoided where possible. Where work close to snap-back zones is un-avoidable, the risks and mitigation measures should be identified as part of the safety-in-design process as well as in the daily safe-work-method statements (SWMS) or job safety and environmental assessments (JSEA's).

## 6.3 Environmental Loads

### 6.3.1 Design Return Periods

The design return periods for wind and seismic actions should be calculated in accordance with AS/NZS1170. With regards to design wave events, AS4997 provides the following guidance:

| **Function Category** | **Category Description** | **Design Working Life:**<br>**5 years or less – Temporary Works** |
|---|---|---|
| 1 | Structures presenting a low degree of hazard to life or property | 1/20 |
| 2 | Normal Structures | 1/50 |
| 3 | High property value or high risk to people | 1/100 |

*Table 2: Return Periods for design wave effects (AS4997)*

### 6.3.2 Wind Loading

Wind actions on fixed structures should be calculated in accordance with AS/NZS1170.2.

Guidance provided in AS4997 and AS3962 recommends that wind actions on moored vessels and floating structures can be designed using a wind pressure based on 30 second steady state wind speed, rather than basic wind speeds due to 3 second gusts. This is because floating structures have a delayed response to wind loads. The 30-second wind speed may be taken as 0.87 times the relevant basic wind speed as specified in AS/NZS1170.2.

Terrain Category 2 is generally appropriate for wind over exposed fetches, due to surface roughness of the water at design wind speeds.



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Appropriate drag coefficients for vessels, piles and rectangular members are provided in AS4997 or AS 3962. Drag coefficients for a wider range of structural forms and components can be found in AS 1170.2.

### 6.3.3 Current and Debris Loads

The design strength of temporary works within the marine environment should allow for the combined effects of tidal and/or river/estuarine flood currents.

- Current design velocities for structures constructed within in an estuary or river should be a minimum of 1.0 m/s (refer to AS4997 for further information). Where the estuary or river is prone to significant flood events, a site-specific study should be undertaken to determine the design velocity.
- Tidal currents can typically be found within the relevant harbour charts.

For structures where a debris mat could form against the structure (most river estuarine situations) AS4997 recommends that the structure should be designed for a mat of thickness not less than 1.2m and not greater than 3m. It further recommends that all structures subject to flood debris should be designed for a minimum load of 10kN/m of structure, applying to both fixed and floating structures.

Detailed guidance on debris rafts and associated loading is also provided in the NZTA Bridge Manual and AS5100-2017 Bridge Design.

Lastly, for floating structures in waterways subjected to flood currents. A phenomenon known as negative lift should be considered. This occurs due to currents passing under the floating structure and causing a downward load on the leading edge of the structure. Further guidance on this is provided in AS4997.

### 6.3.4 Wave Loads

Wave loads can be determined using one of the following three methods:

- Analytical methods
- Advanced numerical modelling procedures
- Laboratory test procedures (physical modelling)

For the purpose of determining wave loads on typical elements of temporary works (e.g. piles, headstocks, beams and vessels or barges moored against structures) analytical methods that estimate a combination of viscous drag and lift (velocity related) forces and inertial (acceleration related) forces are usually appropriate.

It is also important to determine whether the design wave is expected to be breaking or non-breaking, as the force application on the temporary structure can vary significantly.

Various literature provides guidance on the calculation of wave loads such as the API Recommended Practice (American Petroleum Institute 2000), ASCE 7-05 Minimum Design Loads for Buildings and Other Structures, or the US Army Corps Coastal Engineering Manual.

In the absence of specific analysis, it is recommended that temporary structures are designed for a minimum horizontal force due to wave loading of 2kN/m (AS3962:2020). However, caution is always advised when applying generic/minimum design loads and if in doubt - we recommend engaging a suitably qualified Coastal Engineer to provide anticipated wave loads on the temporary structure.

For temporary structures where waves can travel under the soffit of the structure (staging or temporary working platforms under extreme wave conditions) consideration should be given to dynamic uplift loads. AS4997 provides guidance where the uplift load may be approximated as the head of water corresponding to the wave crest as if the structure were not present, factored by 2.0. In addition to this


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slowly varying dynamic pressure, structures containing re-entrant corners or a sharp change in direction can experience very high wave impact loads, with pressures several times the slowly varying pressure. Further information on designing for dynamic uplift loads is provided in AS4997 and the above-mentioned literature.

Furthermore, we recommend that temporary structures suspended above the water are designed with a sufficient 'air-gap' to avoid dynamic uplift loads from the waves passing underneath during the design storm event.

### 6.3.5 Scour

Scour can occur around piles or structures extending from the seabed or riverbed in areas located close to vessel prop wash or in high tidal or river flow zones. The effects of scour can cause a significant and localised loss of sediment around the pile or structure resulting in potential instability or a reduction in capacity.

Guidance on scour design is provided in the NZTA Bridge Manual and AS5100-2017 Bridge Design.

# 7.0 FLOATING CONSTRUCTION BARGES

Floating barges are susceptible to overturing whilst in use and while loading and unloading – in particular when driving machinery (trucks, trailers, excavators, cranes, drill rigs) on and off the sides and ends of the barge.

Competent advice from a suitably qualified Engineer or Naval Architect should be sought on the loading, use and unloading of all barges, and on the theoretical engineering design required to ensure both structural integrity and overturing stability is not compromised. Refer to the Maritime NZ Barge Stability Guidelines for guidance on the theoretical stability of barges.

## 7.1 Cranes and Drill Rigs on Floating Barges

Note that some barges have light weight decks that may require strengthening before taking on crane, plant, or material loads.

### 7.1.1 Cranes

Cranes used on barges while in floating mode should work off appropriate barge charts. Where barge charts are not available, the crane manufacturer should be consulted to determine appropriate operational limits and reductions in the rated capacities. In general, most crane manufactures will require the following limits be imposed on lattice jib crawler cranes operating on barges:

- Max barge trim angle of 3deg when lifting, slewing, and placing.
- Max list/heel angle of 1.5deg when lifting, slewing, and placing.
- De-rated lift capacities typically in the range of 66%-75% of the rated capacity for normal operations.
- A limit on the maximum allowable boom length.

Under certain conditions, cranes may not need to be de-rated however, for these instances significant risk mitigation measures should be put in place such as test lifts, naval architect assessments and appropriate monitoring of the barge inclination (heel/trim), weather and sea state.

The key risks affecting the crane capacities working on barges, which should be considered during lift planning are:

- Dynamic effects of load lifting and slewing while operating in a sea state.
- Trim and heel of the barge affecting the cranes centre of gravity.
- Side loading of the crane boom.

Design considerations when planning crane lifts or the movement of plant and equipment onto and off floating barges should include:

- Dimensions, weight, draft, and freeboard of the barge.
- Will the barge be beached at the water's edge during equipment transfer? If so, consideration needs to be given to protection of the underside of the barge, securing of the barge to the shore, temporary fill against the side of the barge (which also adds load to the mooring system) and the use of ramps to reduce the slop under the equipment.
- As plant and equipment moves on and off the barge, how much will the level changes of the barge and adjacent support system affect the slope/level of the equipment being transferred? Does the barge have ballasting ability to help counteract the slope/level change?
- If the outer end of a loading ramp is supported by a pontoon system, how much will it rise / fall during the equipment transfer?
- How does the weight and centre of gravity of the load and its location on the barge affect the barges static and dynamic stability?
- Will the load on the barge change position during use? Static and dynamic stability should be checked for the full range of load movement on the barge.
- Is the deck of the barge strong enough? Or will timber mats or structural strengthening be required.
- What handling power and manoeuvrability is required of the tug?
- What tow rope strength is required? Is a bridal system required?
- If the crane on the barge is lifting an item either off the deck of the barge, off land or off another floating barge, dynamic loading effects should be considered. If under wave action the barge suddenly drops away, the weight of the lifted item may be 'violently' transferred to the crane if it is hooked up at the time. This may also happen if the crane is on land, lifting a load of the barge. We recommend that the design lift weight of the load be increased by 25% when operating in a calm – smooth sea state.

### 7.1.2 Drill Rigs

Similar consideration also needs to be given to drill rigs operating on floating barges. The drill rig does not typically have 'barge-charts' available in a similar style to a crane. Therefore, it is recommended that detailed stability assessments (of both the rig and barge) are undertaken by either a competent Engineer or Naval Architect to ensure that the drill rig remains stable during drilling, extracting, slewing, and lifting with the auxiliary line.

When assessing allowable extraction and slewing loads on a floating barge the calculated heel and trim of the barge should be within the allowable operating limits of the drill rig. It is recommended that a suitable factor of safety is applied to the allowable heel and trim of the barge when operating a drill rig to ensure the drill rig or barge does not suddenly loose stability if subjected to the maximum extraction or slewing loads.

It is recommended that drill rigs are sat on timber or rubber mats while operating to reduce the risk of sliding.

Communication of drill rig operating limits (including deck limit lines, maximum extraction forces and limits on trim/heel) can be documented in the Barge Specification, provided all possible operational positions and load cases have been considered.

## 8.0 JACK-UP BARGES

A Jack-Up Barge (JUB) consists of a buoyant hull which is fitted with three or four movable spud legs, capable of raising the hull over the surface of the sea (or 'jacking' the barge up). This is different to a floating Flat Top Barge (FTB) which relies on buoyancy alone to remain stable during use (spud legs in a FTB are only used to laterally restrain the barge and are not designed to take vertical load).

*Figure 2: Floating Flat Top Barge (FTB)*

*Figure 3: Jack Up Barge (JUB)*

The operation of a JUB need to consider the strength and stability of the barge hull as well as the ability the spud legs to resist the applied deck and environmental loading when the barge is in 'Jack-up' mode.

The advantages of JUB's are that they provide a stable (non-floating) platform to work from and are especially useful for delicate lifting operations. Furthermore, when the JUB is in 'jack-up' mode they can stay on location during more adverse weather conditions than an equivalent floating barge.

JUB's are not designed for a particular location or site setting and therefore the stability of the JUB when jacked up needs to be assessed for each location.

### 8.1 Spud Leg Penetration and Stability

Spud legs need to resist vertical, horizontal, and moment loads that result from elevated operational loads (elevated barge weight, working equipment on the barge deck etc) and environmental loads (such as wind and wave). A critical requirement of the JUB performance is that the spud legs remain stable during all possible loading scenarios and do not settle.

SNAME and ISO19905 provide good guidance and flow charts to assist the person assessing the suitability of the JUB setups and spud leg capacity. In general, prior to any JUB spud leg assessment it is recommended that:

- A site-specific geotechnical assessment of the sub-seabed conditions has been completed (this typically forms part of the permanent works designs on most projects however, additional site investigation may need to be completed at the proposed JUB setup locations)
- Operational sea-state conditions have been established (e.g. tidal ranges, design wind pressures and wave heights).
- The barge can be jacked up to a height which allows a sufficient airgap to be present (distance between the sea level and hull of the barge (jacked-up).
- There is sufficient spud leg reserve in the event the spud legs penetrate deeper than expected.

The calculation of spud leg reaction loads is an important factor in determining the expected spud penetration and to check that the structural capacity of the spud leg is not exceeded. The calculation of spud leg reactions should consider all possible loading arrangements that could take place on the barge deck (including crane lifts) as well as environmental loads such as wind, waves and current.

### 8.1.1 Summary of Design Checks to be Completed

Structural Checks

- Overturning Moment of the JUB in jack-up mode
- Pre-load / Pre-drive capacity of the barge structure and spud legs
- Holding system strength
- Spud leg reserve

Geotechnical Checks

- Spud leg bearing capacity check / additional settlements
- Windward leg sliding check
- Sliding capacity / lateral capacity check

### 8.1.2 Spud leg punch through

A key risk that needs to be considered when assessing the jack up locations and expected spud leg penetrations is the risk of seabed punch-through.

Spud leg punch through most commonly occurs in situations where:

1. The spud leg is founded in a strong layer which is underlain by a weaker layer. If the spud leg becomes overloaded, it may exceed the bearing capacity of the underlying layer which can result in rapid spud leg penetration and catastrophic tilting of the JUB.
2. The spud leg is installed very close to a previous spud leg footprint (typically due to multiple movements of a JUB in a close area).
3. The spud leg has not been appropriately preloaded and a sudden increase in load (e.g. from a crane undertaking a lifting close to it) results in sudden settlement.

*Figure 4: Examples of JUB spud leg punch through*

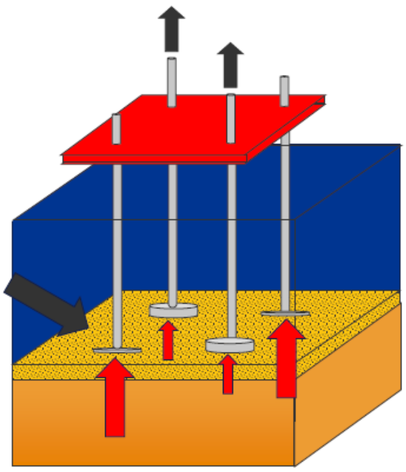
It is the role of the designer, assessing the spud leg penetrations and capacities to ensure this risk has been considered and communicated as part of the design output.

## 8.2 Spud Leg Pre-Loading

An important risk mitigation measure against spud leg punch through or progressive settlement is to pre-load each spud leg once the JUB is initially jacked-up and before the JUB is signed off for use. The general pre-load procedure involves:

- Determining the maximum expected spud leg reaction from operational loads, environmental loads, or a combination of both (called the spud Stillwater reaction)
- The target preload for each leg is usually based on 1.11 times (equivalent to a geotechnical strength reduction factor of 0.9) the maximum expected Stillwater reaction for a single spud leg
- Predict the anticipated penetration of the spud legs based on these loads
- The pre-loading sequence typically involves extracting two diagonally opposite legs, which in turn increases the load on the other two diagonally opposite legs. This load is then held until spud leg penetration stops for a set amount of time (typically 30min-1hour).
- This procedure is then repeated for the other two diagonally opposite legs.
- Legs should be extracted only to a point where the target preload is reached on the opposite two legs. It is important to note that legs should never be fully extracted during this procedure and a minimum load limit of 10% of the original leg load should be always maintained.
- Where the above method is not sufficient to generate sufficient preload, additional load may need to be temporarily added to the barge to meet the required pre-load target. This should be determined and planed for prior to mobilising the JUB into position and commencing pre-load testing.

Once each spud leg is pre-loaded, this gives the JUB operation team confidence that no further spud leg settlement will occur, provided they remain within the operation constraints and load cases of the pre-load assessment.



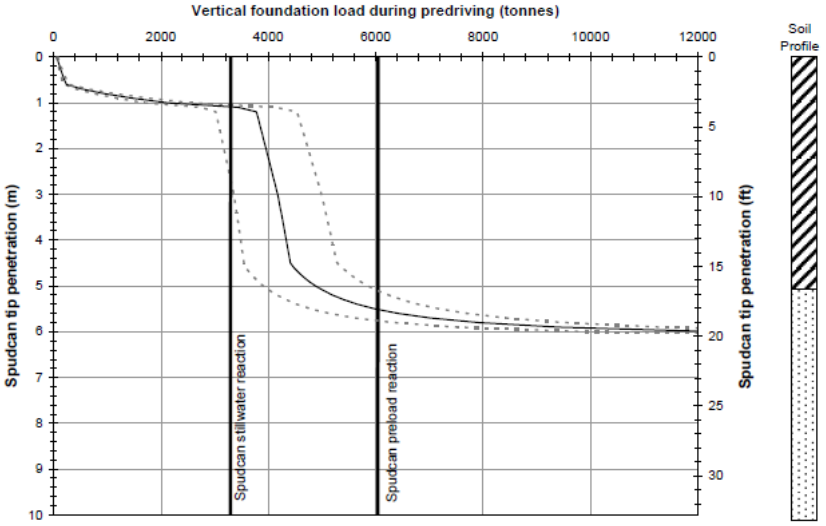



*Figure 5: Example spud leg pre-load sequence (IJUBOA)*

## 9.0 TIE DOWN SUPPORT FOR EQUIPMENT/MATERIALS

There are various rules of thumb which provide guidance for lashing and securing of deck cargoes.

The basic rule-of-thumb for securing cargoes on the weather-deck with a tendency to move during a moderate weather voyage is simply that the sum of the minimum breaking-loads of all the lashings should not be less than 3x the design load of the item of cargo to be secured.

- For example, if the breaking-load of all the lashings is 30 tonnes, then they can safely hold an item with a design load of 10 tonnes – on the assumption that all securing arrangements are deployed in a balanced, efficient, and non-abrasive manner.
- Design load being the weight of the cargo subjected to an acceleration of 0.7g athwartships (laterally), 1.0g vertically, and 0.3g longitudinally.

For voyages outside a port or harbour it is recommended that a Naval Architect be engaged to provide a lashings plan.

## 10.0 MAINTENANCE AND INSPECTIONS

Construction work within a marine environment can be harsh and unforgiving to temporary structures, plant, and vessels. It is recommended that a suitable inspection and maintenance regime is established and maintained, particularly for temporary works and plant that will be exposed to the marine environment for extended periods of time.

Critical items are often the smallest, which is why it is important to include items such as bolted connections, anchor points, base plates, beam / crosshead / pile connections in the inspection and maintenance regime.

## 11.0 EDGE PROTECTION REQUIREMENTS

Where there is a potential for a person to fall from any height, reasonable and practicable steps must be taken to prevent harm. Suitable edge protection or fall prevention measures should be provided in accordance with the NZ Building Code F4 and applicable MBIE guidelines. Where the provision of suitable edge protection or fall prevention measures is not reasonable or practicable when working over water, a suitable risk management procedure should be established and consider the following:

- Where a person could fall into water, suitable life jackets should always be worn.
- Suitable life jackets should also be always worn when working close to an unprotected edge or a risk assessment undertaken to establish additional control measures should this not be practicable.
- A rescue procedure should be in place if people are required to wear life jackets.
- The rescue procedure should be briefed and practiced (emergency drills) at regular intervals.
- Where there is potential for a body of water to be shallow (for example at low tide or where an existing structure is present), and there is a risk that should a person fall - they will hit the seabed or existing structure, suitable edge protection barriers or fall prevention measures should remain in place.
- Where there is potential for a person to fall a significant distance before they hit the water surface, suitable edge protection or fall prevention measures should remain in place.
- Where there is potential for plant and machinery to overturn and fall into water, a risk assessment should be undertaken to establish specific control and contingency measures for operators.