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FOUNDATIONS

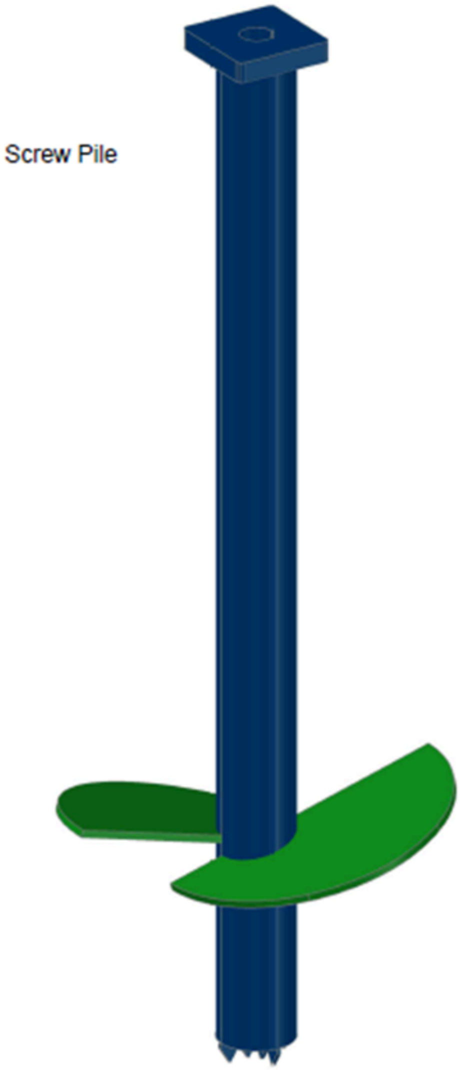
# PRODUCT STATEMENT

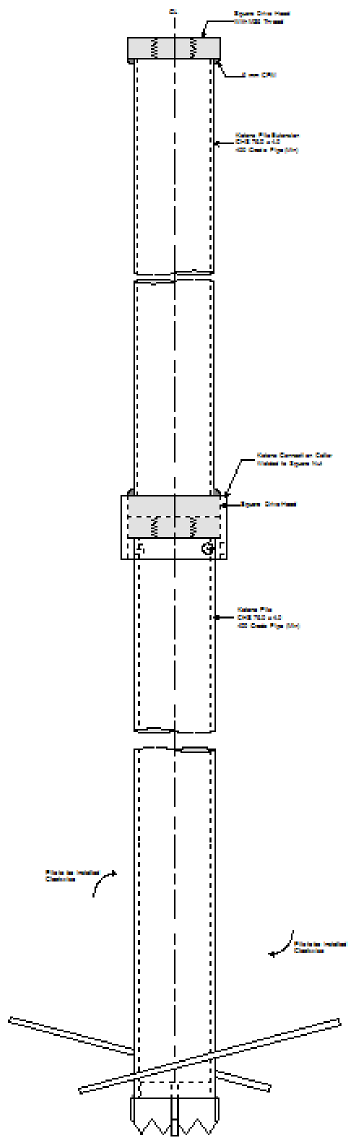
## Katana Twin-Fin Piles:

## 80kN, 100kN & 150kN Series

# Tubular Steel - Katana Piles

**Katana Foundations Pty Ltd has compiled this product statement, outlining the requisite standards and procedures for the supply and installation of the Katana Twin-Fin Pile. The information contained herein aligns with the applicable Australian and New Zealand Standards.**



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# General

## 1.0 Scope

The work to be carried out as per this specification include:

- Supplying steel Katana piles
- Installing steel Katana piles
- Designing and certifying steel Katana pile.

## 2.0 References

### Australian Standards

- ➢ AS 1163 | Cold-formed Steel Hollow Sections
- ➢ AS 1579 | Arc-Welded Steel Pipes and Fittings for Water & Wastewater
- ➢ AS 2159 | Piling Design and Installation
- ➢ AS 2177 | Non-Destructive Testing - Radiography of Welded Butt Joints in Metal
- ➢ AS 2203.1 | Cored Electrodes for Arc Welding
- ➢ AS 2207 | Non-Destructive Testing – Ultrasonic Testing of Fusion Welded Joints in Carbon & Low Alloy Steel
- ➢ AS 4100 | Steel Structures

### Australian/New Zealand Standards

- ➢ AS/NZS 1153.1 | Low Carbon Steel Electrodes for Manual Metal-Arc Welding of Carbon Steels & Carbon-Manganese Steel
- ➢ AS/NZS 1554.1 | Welding of Steel Structures
- ➢ AS/NZS 3678 | Structural Steel - Hot-rolled Plates, Floorplates & Slabs

## Supporting Documentation

- Appendix A | Weld Specification: 80kN Series
- Appendix B | Weld Specification: 150kN Series
- Appendix C | Corrosion Review: 80kN Series
- Appendix D | Corrosion Review: 150kN Series
- Appendix E | Pile Testing
- Appendix F | Bracing Plate
- Appendix G | Lateral Capacities

# Materials

## 3.0 Steel Katana Piles

Requirements for the 80kN, 100kN and 150kN Steel Katana Twin-Fin Pile:

- → The steel shaft of the Katana Pile shall be constructed using 'BlueScope Steel' Circular Hollow Section (CHS) structural steel with a yield strength exceeding 460MPa and a tensile strength of 490MPa or higher, meeting AS 1163 standards and manufactured in accordance with AS/NZS 1554.1.
- → The helix plates of the Katana pile shall be manufactured with a yield strength of 400 or higher, conforming to AS 3678 standards and manufactured following AS/NZS 1554.1.
- → Material Certification: Test certificates for the steel utilized in the production of the Katana piles must be provided, following AS/NZS 3679.1 standards, confirming compliance with the standard through manufacturer-conducted tests.
- → Dimensions & Tolerances: The steel hollow sections must adhere to manufacturing tolerances as outlined in AS/NZS 1163: 2016.
- → Weld Specifications must adhere to the report by e3K Global, a division of Gilmore Engineers; refer to Appendix A & B.
- → The use of unidentified or second-hand steel is strictly prohibited. All steel must comply with AS 4100.
- → Following manufacturing, Katana piles must undergo visual inspection and receive approval.

Corrosion protection for Steel Katana Twin-Fin Pile:

- → Katana Piles' steel components shall be designed in accordance with AS 2159 Section 6.3, considering sectional loss based on the site's corrosion classification and design life; refer to Appendix C & D for e3K Global's Katana pile corrosion review.

# Design

## 4.0 Design of Steel Katana Twin-Fin Piles

- Incorporating the Katana pile into a foundation system requires the involvement of a practicing professional structural engineer with experience in the utilization and design of steel Twin-Fin Piles.
- The steel Katana piles must be engineered in compliance with AS 4100 and AS 2159 standards to accommodate safe working loads (SWL) of 80kN, 100kN, or 150kN, inclusive of any supplementary loads resulting from installation misalignment, soil movement, or pile settlement, if applicable.
- Design calculations for Katana piles should incorporate a load eccentricity of 25mm and a realistic estimation of effective length tailored to specific soil conditions.
- The maximum settlement of Katana piles under the designated working load should adhere to the specifications detailed in AS 2159 Table 8.2, unless otherwise indicated in the engineering drawings.
- The connection of Katana pile to the footing or superstructure must be a component of the design process undertaken by the designated engineer.

# Installation

## 5.0 Katana Pile Installation

Installation Requirements for the Steel Katana Twin-Fin Pile:

- Installation of the Katana piles must be conducted using specialised equipment that is properly calibrated to allow for the monitoring and recoding of torque readings during the installation process.
- The installation of Katana piles must be carried out by a 'Certified Katana Installer/Contractor.'
  - Note: Installers/contractors must obtain approval from an authorised Katana Representative to be eligible to carry out future installations on behalf of Katana.
  - An installation manual is available upon request.
- Proposed equipment for Katana pile installation and the proficiency of operators must be submitted to project engineers for approval.
- During storage, transportation, lifting, and installation, Katana piles must be adequately supported. Any steel Katana piles that are damaged or distorted beyond the specified tolerances outlined in AS 1163-2016 must be replaced at the contractor's sole expense.
- Should testing be necessary, the piling contractor must provide a record of the initial 'Rapid Load Test' verification, including installation torques and achieved piled depths, for approval. The engineer must endorse the installation before the concrete foundation is completed.

Installation Tolerances for the Steel Katana Twin-Fin Pile:

- The maximum variation from the plan position, as indicated in the drawings, should not exceed ± 25mm.
- The installation of the Katana pile shaft must adhere to verticality standards, with a variation not exceeding 4% from the vertical.
- The maximum allowable variation of the cut-off level shall be ± 25mm from that shown on the drawings.

# Certification

## 6.0 Katana Pile Certification

Upon completion of the Katana piling works, the piling contractor is required to provide the following certification to the project engineer or principal contractor.

- ➢ Confirmation that Katana piles have been engineered to support the designated loads specified in the drawings.
- ➢ Assurance that Katana piles have been installed in accordance with the engineered design.
- ➢ Affirmation that Katana piles meet all requirements outlined in AS 4100 and AS 2159.

The design certification must be issued by a practicing professional structural/geotechnical engineer, as defined by the Building Code of Australia/New Zealand Building Code, who possesses the necessary competency and experience in Katana pile design.

# Appendix A

**Weld Specifications: 80kN Series**

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* A division of Gilmore Engineers Pty Ltd Research and Development

Our Ref: RLH:P213304

Your Ref: JW

2nd April 2013

Mr Justin J Williamson
Patented Foundation Systems Pty Ltd ACN 156 530 497
c/- STA Consulting Engineers
241 Milton Road
Milton, QLD 4064

By Email: justin.williamson@staconsulting.com.au

Dear Mr Williamson,

**RE: SCREW PILE WELD SPECIFICATION**

e3k have performed Finite Element analysis (FEA) on the Stoddart Screw Pile and a review of the weld specification for the connection of the blades to the pipe. Three dimensional models were produced in Solidworks 2013 based on the two dimensional drawings supplied in the supplied document "Stoddarts Final Drawings 26-2-2013.pdf". The material for the CHS 76.0 x 4.0 pipe was assumed to be that specified on the supplied test certificate no. TC_138973 from Orrcon Steel. This shows a yield strength of 463 MPa, and tensile strength of 490 MPa.

Initial FEA was performed with a torque of 9,000 Nm applied to the blades of the screw pile. Figure 1 shows the predicted von Mises stress in the area around the welds. The peak stresses in the weld area are predicted to be well above the yield stress of the pipe (463 MPa). Thus it is not expected that the welds will handle a torque of 9,000 Nm applied to the blades. In practice, some of the torque produced when screwing the pile into the ground will be taken directly by the pipe, through friction between it and the surrounding material, thus the exact torque limit of the welds on the blades is difficult to predict.

It is recommended that the weld material be of equal or higher yield strength than the pipe material, i.e. 463 MPa or greater.

A review of the weld Interface, for the connection of the blades to the pipe, based on the supplied drawings, shows that the gap between the plate and the pipe is inconsistent around the pipe. The semicircular cut out in the blades, when placed on an angle against the pipe, results in the blade edge being angled to the pipe at the leading edge of the pipe, then transitioning to perpendicular to, but further away from, the pipe at the mid blade section, then transitioning to being angled the other way to the pipe at the trailing edge of the pipe. This creates a non-standard weld interface and is expected to make it difficult to create a consistent quality weld around the blades.

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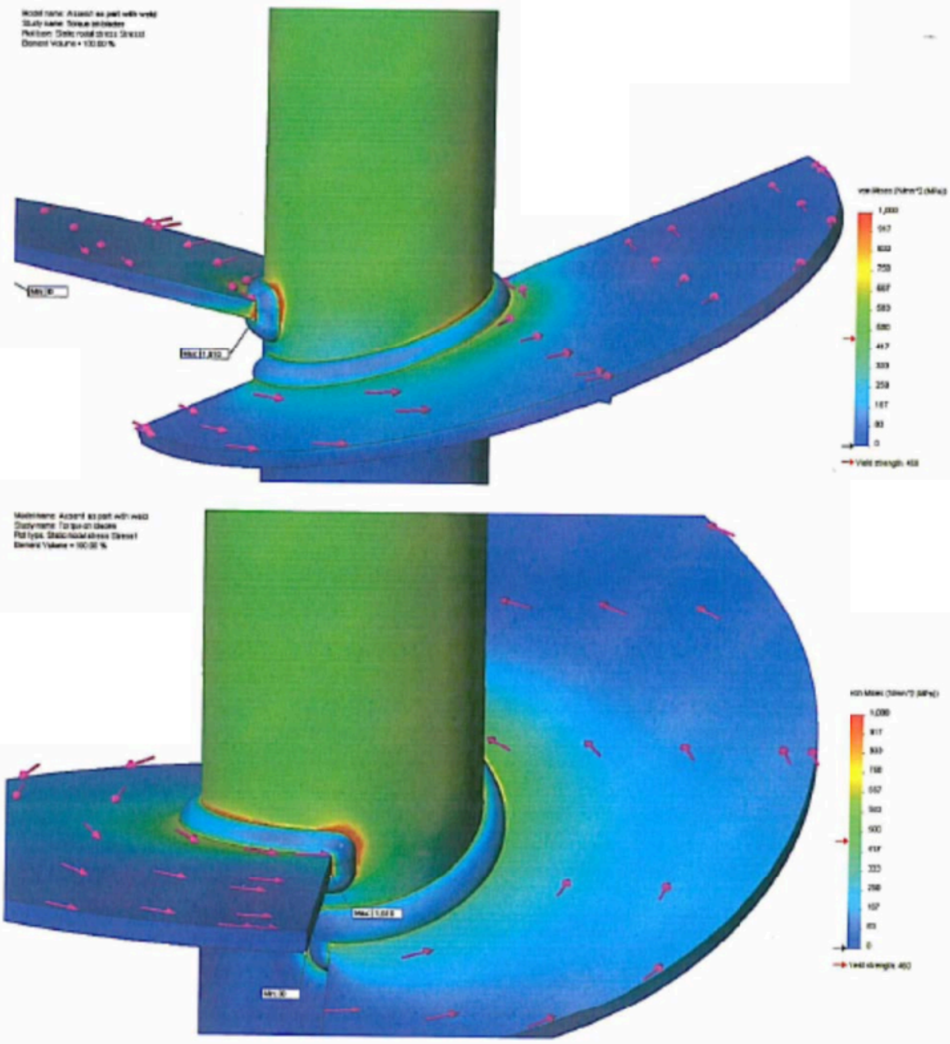

Figure 1. Predicted von Mises stress with a torque of 9000 Nm applied to the blades of the screw pile.

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To maintain an equal distance between the blades and the pipe, it is recommended that the semicircular cut out in the blades be changed to an elliptical cut out, to match the angle the blade is to be placed on the pipe. Figure 2 shows dimensions for an elliptical cut to match a 15° angle on the pipe with a one millimetre clearance around the pipe.

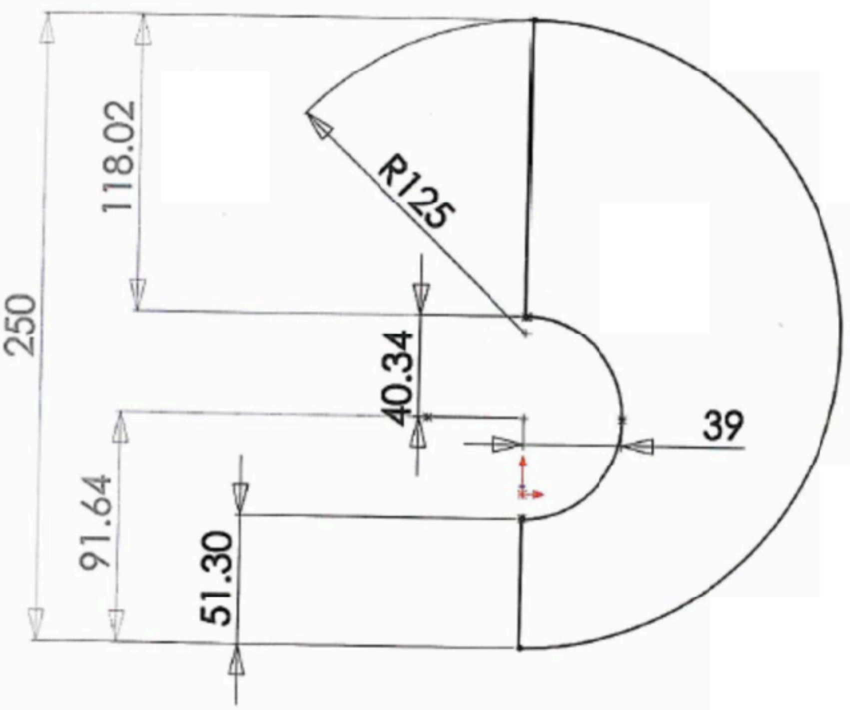


Figure 2. Dimensions for an elliptical cut to match a 15° angle on the pipe, with a one millimetre clearance around the pipe.

To provide a more consistent weld interface around the blade it is recommended that the edges of the elliptical cut out be ground back at 45° on each side (see Figure 3).

The recommended weld is "equal 6mm fillet welds superimposed on complete penetration bevel welds" as shown in Figure 3.

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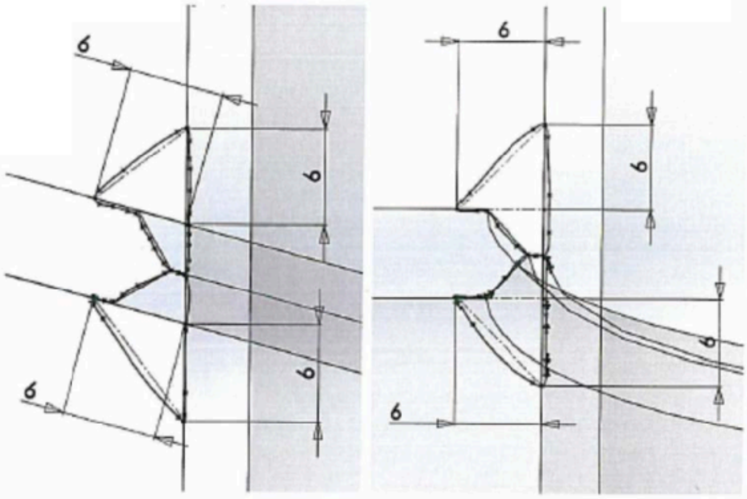


Figure 3. Equal 6mm fillet welds superimposed on complete penetration bevel welds.
The left figure shows the weld interface at the leading edge of the blades,
and the right figure shows the weld interface at the mid blade section.

Yours sincerely,
e3k

Dr Raymond L Hope
Vice President e3k Global

# Appendix B

**Weld Specifications: 150kN Series**

*A division of Gilmore Engineers Pty Ltd
Research and Development

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Our Ref: RLH:VLK:P213324 Your Ref: JW

19th December 2013

ByEmail: justin.williamson@staconsulting.com.au

Mr Justin J Williamson
Patented Foundation Systems Pty Ltd ACN 156 530 497
c/- STA Consulting Engineers
241 Milton Road
Milton, QLD 4064

Dear Mr Williamson,

**RE: 15 TONNE SCREW PILE WELD SPECIFICATION**

e3k have performed Finite Element Analysis (FEA) on the 15 Tonne Stoddart Screw Pile and a review of the weld specification for the connection of the fins to the pipe. Three dimensional models were produced in Solidworks 2013 based on the two dimensional drawings supplied in the document "15 ton Pile Drawing.pdf" dated 17 December 2013.

The material for the CHS 88.9 x 5.5 pipe was assumed to be that specified on the supplied test certificate no. IV13090446 from Alpine Pipe Manufacturing. This shows a yield strength of 419 MPa, and tensile strength of 475 MPa. The material for the 12mm plate from which the fins are manufactured was assumed to be that specified on the supplied test certificate no. 000997 from Ji Kang Dimensi SDN BHD. This shows a yield strength of 436 to 446 MPa, and tensile strength of 573 to 580 MPa.

e3k were asked to assume the torque required to install the 15 Tonne screw pile is on average 10,000 Nm and a maximum of 15,000 Nm. Engineering calculation shows that the von Mises stress in the CHS 88.9 x 5.5 pipe will be 306 MPa under a torque of 10,000 Nm and 459 MPa (note this is above the yield strength of the pipe, but below the tensile strength) under a torque of 15,000 Nm.

FEA of material stress was performed on the screw pile using a torque of 15,000 Nm applied to the fins of the screw pile. Figure 1 shows the predicted von Mises stress in the area around the welds. The stress shown in the bulk of the pipe is consistent with the Engineering calculations. The peak stresses in the weld area are predicted to be well above the tensile strength of the pipe (475 MPa). Thus it is not expected that the welds will handle a torque of 15,000 Nm applied to the fins. In practice, some of the torque produced when screwing the pile into the ground will be taken directly by the pipe, through friction between it and the surrounding soil, and thus the exact torque limit before the welds on the fins fail is difficult to predict.

It is recommended that the weld material be of equal or higher yield strength than the pipe material, i.e. 419 MPa or greater.

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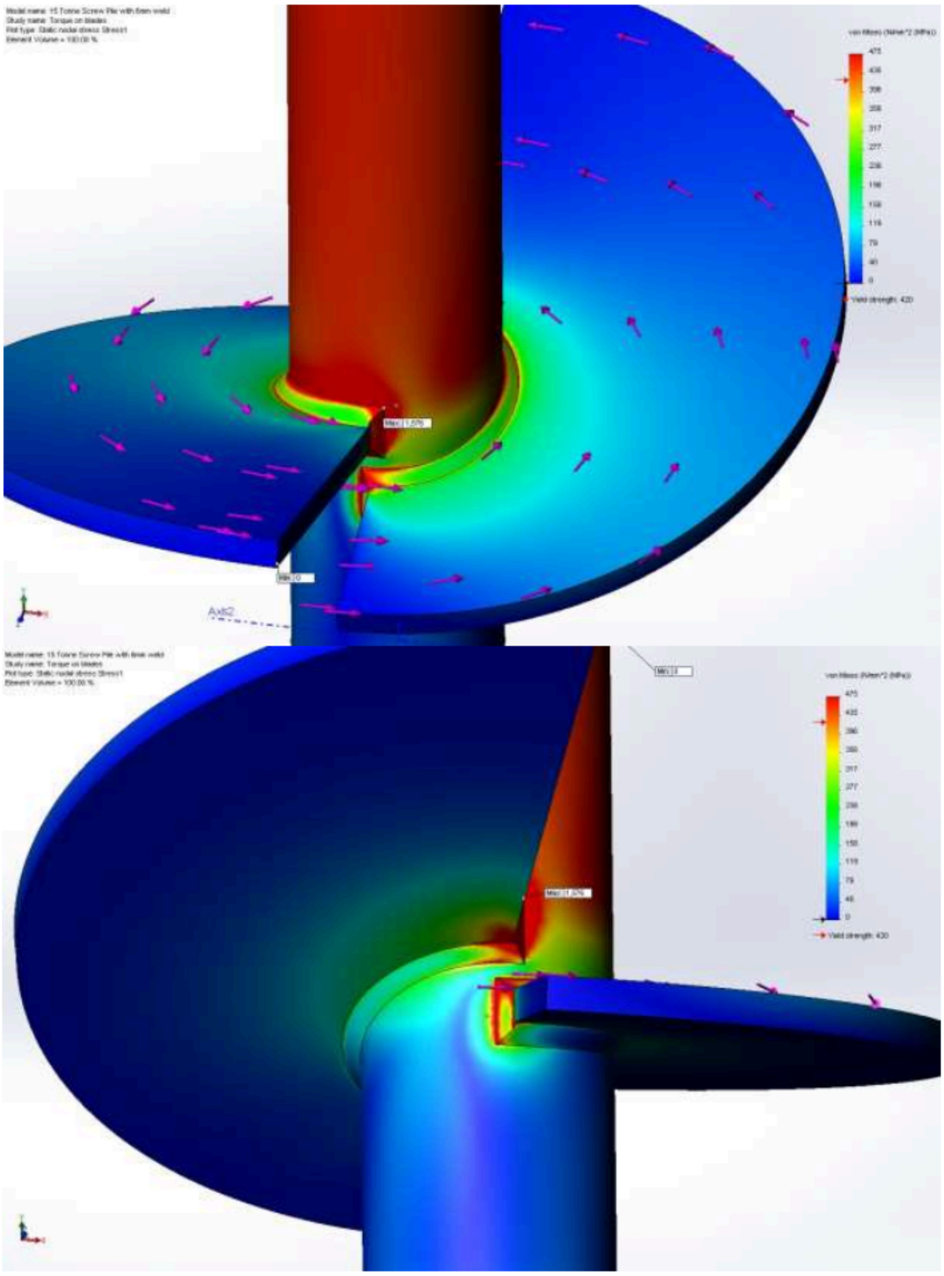

Figure 1. Predicted von Mises stress from a torque of 15000 Nm applied to the fins of the screw pile.

A review of the weld interface, for the connection of the fins to the pipe, based on the supplied drawings, shows that the gap between the plate and the pipe is inconsistent around the pipe. The semicircular cut out in the fins, when placed on an angle against the pipe, results in the fin edge being angled to the pipe at the leading edge of the fin, then transitioning to perpendicular to, but further away from, the pipe at the mid fin section, then transitioning to being angled the other way to the pipe at the trailing edge of the fin. This creates a non-standard weld interface and is expected to make it difficult to create a consistent quality weld around the fins. To maintain an equal distance between the fins and the pipe, it is recommended that the semicircular cut out in the fins be changed to an elliptical cut out, to match the angle the fin is to be placed on the pipe. Figure 2 shows dimensions of an elliptical cut to match a 15° angle on the pipe with one millimetre clearance around the pipe.

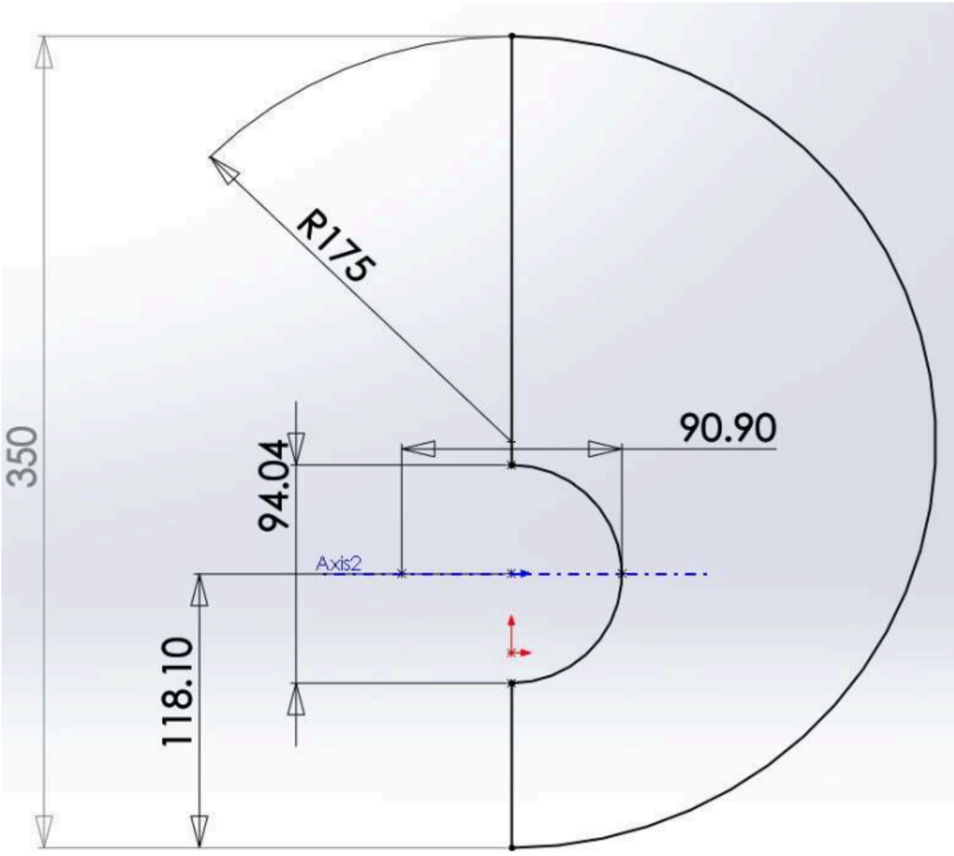


Figure 2. Dimensions of an elliptical cut to match a 15° angle on the pipe with one millimetre clearance around the pipe.

To provide a more consistent weld interface around the fin it is recommended that the edges of the elliptical cut out be ground back at 45° on each side (see Figure 3).

The recommended weld is "equal 6mm fillet welds superimposed on complete penetration bevel welds" as shown in Figure 3.

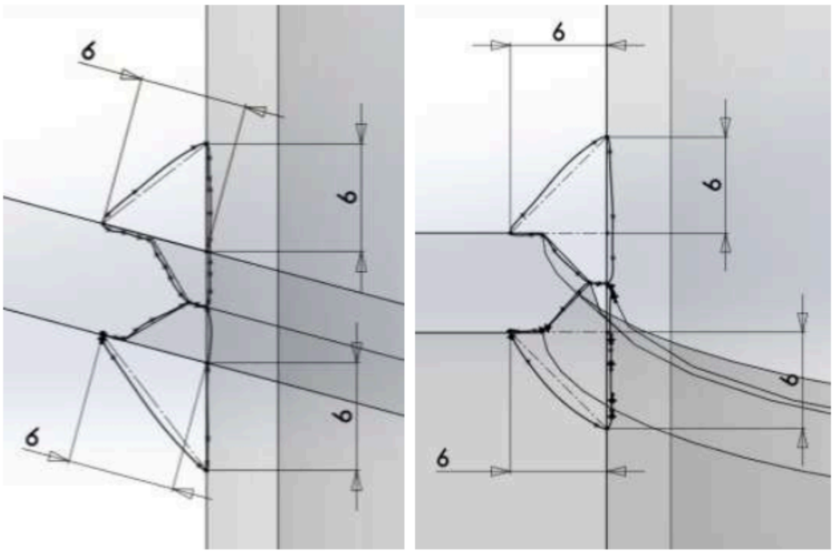


Figure 3. Equal 6mm fillet welds superimposed on complete penetration bevel welds. The left figure shows the weld interface at the leading edge of the fins, and the right figure shows the weld interface at the mid fin section.

Yours sincerely,
e3k

Ray Hope

Dr Raymond L Hope
Vice President e3k Global

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# Appendix C

**Corrosion Review: 80kN Series**

*A division of Gilmore Engineers Pty Ltd
Research and Development

Our Ref: RLH:VLK:213306 Your Ref: JW

***8 May 2013***

REPORT

TO

Patented Foundation Systems Pty Ltd
ACN 156 530 497
c/- STA Consulting Engineers
241 Milton Road
Milton, QLD 4064

Attention: Mr Justin Williamson
Senior Geotechnical Engineer

RE: KATANA SCREW PILE CORROSION REVIEW

ON

**VOID SLAB SYSTEM**

Prepared by:

Dr Ray Hope
B.E.(Mech-Hons), Ph.D., MIEAust, CPEng, RPEQ
Vice President, Engineering

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## 1 INTRODUCTION

Patented Foundation Systems Pty Ltd have requested e3k review appropriate Australian Standards, or other Standards relevant to corrosion of steel screw piles, to determine the potential effects and limitations of use of the Katana pile in soils of varying pH, up to a depth of 500 mm, for an expected lifetime of 50 years. Patented Foundation Systems Pty Ltd have also requested e3k investigate measures to protect the Katana pile against corrosion in soils of varying pH, up to a depth of 500 mm, for an expected lifetime of 50 years.

I understand that the "Void slab system" is primarily intended for use in areas with expansive clay foundation soils.

In the preparation of this report, I have read and used the following information:

a) Katana Pile Product Guide, including drawings, from STA Consulting Engineers, dated 7th May (see Appendix 1).

b) Void Slab System, preliminary edition, from STA Consulting Engineers, dated 16th March 2013.

c) Australian Standard AS 2159-2009 Piling – Design and installation (incorporating amendment No.1).

d) Australian / New Zealand Standard AS/NZS 2312:2002 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings (incorporating amendment No.1).

e) Australian Standard AS 2832.2-2003 Cathodic protection of metals Part 2: Compact buried structures.

f) Australian Standard AS 2832.3-2005 Cathodic protection of metals Part 3: Fixed immersed structures.

g) Data sheet for Denso PVC SA tape (see Appendix 2).

h) Data sheet for Denso Rigspray Micro (see Appendix 3).

This report details our review of the relevant Standards and our recommendations.

## 2 AS 2159-2009 PILING – DESIGN AND INSTALLATION

Australian Standard AS 2159-2009 Piling – Design and installation, contains specific information on the durability design of piling. Section 6.5, of AS 2159-2009, "Design for durability of steel piles", contains exposure classifications for steel piles in different environments.

The exposure classification of the surface of a steel pile is to be determined from Tables 6.5.2 (A), (B) & (C) from AS 2159-2009. For the range of chemical conditions of piles in soil, the condition leading to the most severe aggressive conditions shall be allowed for and consideration shall be given to possible changes in groundwater levels.

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## TABLE 6.5.2(A)

### EXPOSURE CLASSIFICATION FOR STEEL PILES—PILES IN WATER

| Exposure conditions | Exposure classification |
| --- | --- |
| Sea water—submerged | Severe |
| Sea water—tidal/splash zone—<br>Cold water (south of 30°S) | Severe |
| Sea water—tidal splash zone—<br>Tropical/Subtropical water (North of 30°S) | Very severe |
| Fresh water—soft running water | Moderate |

## TABLE 6.5.2(B)

### EXPOSURE CLASSIFICATION FOR STEEL PILES—PILES IN REFUSE FILL

| Exposure conditions | Exposure classification |
| --- | --- |
| Domestic waste | See Note 2 |
| Industrial waste | See Note 2 |

## TABLE 6.5.2(C)

### EXPOSURE CLASSIFICATION FOR STEEL PILES—PILES IN SOIL

| Exposure conditions | | | | Exposure classification | |
| --- | --- | --- | --- | --- | --- |
| pH | Chlorides Cl | | Resistivity ohm.cm | Soil condition A* | Soil condition B† |
| | In soil ppm | In groundwater ppm | | | |
| >5 | <5000 | <1 000 | >5 000 | Non-aggressive | Non-aggressive |
| 4–5 | 5000–20,000 | 1 000–10 000 | 2 000–5 000 | Mild | Non-aggressive |
| 3–4 | 20,000–50,000 | 10 000–20 000 | 1 000–2 000 | Moderate | Mild |
| <3 | >50,000 | >20 000 | <1 000 | Severe | Moderate |

* Soil conditions A—high permeability soils (e.g., sands and gravels) that are in groundwater

† Soil conditions B—low permeability soils (e.g., silts and clays) or all soils above groundwater

NOTES TO TABLES 6.5.2 (A), 6.5.2 (B) AND 6.5.2 (C):

1 Where high levels of sulfates exist (>1000 ppm), sulfate-reducing bacteria may be present and active, sometimes leading to microbiologically induced corrosion. In such cases, classify as 'mild' for low permeability soils and 'moderate' for high permeability soils.

2 Contamination by the tipping of mineral and domestic waste or by spillage from mining, processing or manufacturing industries presents special durability risks due to the presence of certain aggressive acids (both organic and inorganic), salts and solvents, which can chemically attack steel. In the absence of site-specific chemical information, the exposure condition should be assessed as 'severe' for domestic refuse tips and 'very severe' for industrial/mining waste tips. Chemical and microbiological analysis of the latter may, however, lead to lower risk classification.

3 For piles in disturbed soil, consider the assumption of soil A conditions where accelerated corrosion is possible.

Based on table 6.5.2 (C) from AS 2159-2009, it is recommended to test the chloride level and resistivity at each installation site, as well as measuring the pH. Measuring of the sulphate level in clay is not required as even high levels above 1000 ppm will only result in a "mild" classification for low permeability soils.

Table 6.5.3, from AS 2159-2009, gives uniform corrosion allowances for loss of section under the five exposure classifications. Section 6.5.3 of AS 2159-2009 states "corrosion on the internal faces of a fully sealed closed-form pile may be assumed to be negligible".

**TABLE 6.5.3**

**CORROSION ALLOWANCES FOR STEEL PILES**

| Exposure classification | Uniform corrosion allowance (mm/year) |
|---|---|
| Non-aggressive | <0.01 |
| Mild | 0.01–0.02 |
| Moderate | 0.02–0.04 |
| Severe | 0.04–0.1 |
| Very severe[3] | >0.1 |

NOTES:

1 The allowances in Table 6.5.3 may be reduced, as appropriate, where adequate corrosion protection systems (coatings or cathodic protection) are to be used. Coatings will reduce corrosion allowance while they remain in good condition. Coating damage, deterioration and breakdown will result in the corrosion rate increasing and, in such circumstances, the corrosion allowances in Table 6.5.3 shall apply.

2 To allow the implementation of cathodic protection after construction it is good practice to provide electrical continuity throughout the piled system at the time of construction. In providing electrical continuity, consideration shall be given to the likelihood of stray current corrosion, especially if the completed structure is of significant length and adjacent to a cathodically protected system or within close proximity to direct current electrified traction or power supply systems.

3 For very severe conditions a site-specific assessment should be sought.

The Katana pile drawings are shown in Appendix 1 of this report. The main tube of the pile is a 350 Grade 76 x 4.0 Circular Hollow Section (CHS). I understand that the minimum required wall thickness for an 80 kN Safe Working Load (SWL) is 2.0 mm. Thus the 4.0 mm wall thickness CHS has a steel corrosion allowance of 2.0 mm.

It can be seen from the drawings in Appendix 1 of this report that the top of the piles can be sealed with the threaded edge beam connector. However, this will not provide an air tight seal. The bottom ends of the piles are open, and as the pile screws into the ground, the pile will fill with soil, which may seal the bottom end of the pile. However, this seal will most likely not be water tight. Thus in my opinion, the provided design would not be considered a fully sealed closed-form pile.

## 3 RECOMMENDATIONS

Table 1 of this report shows the estimated design life and recommendations for the Australian Standard exposure classifications.

I understand that the "Void slab system" is primarily intended for use in areas with expansive clay foundation soils. I note that Table 6.5.2 (C) from AS 2159-2009 indicates for use in clays, soil condition B is used, and that it has a maximum exposure classification of "Moderate". The only exception is if the site has been contaminated by domestic or industrial waste. Thus most sites where the "Void slab system" will be used will be classified as "Non-aggressive", "Mild" or "Moderate".

### 3.1 Non-Aggressive and Mild Environments

To be conservative, it is assumed that for the basic design the uniform corrosion allowance acts on both the inside and outside of the CHS. With this assumption, the basic design is expected to have a design life of 50 years or more in environments classified as "Non-aggressive" and "Mild".

### 3.2 Moderate Environments

To achieve a design life of 50 years or more in environments classified as "Moderate", it is recommended that the inside of the CHS be fully sealed air tight by welding, thus limiting corrosion to the outside surface.

### 3.3 Severe Environments

To achieve a design life of 50 years or more in environments classified as "Severe", it is recommended that the inside of the CHS be fully sealed air tight by welding. Additionally the wall thickness will need to be increased to at least 7.0 mm or extra corrosion protection will be required. AS 2159-2009 allows for either coating protection systems or cathodic protection.

#### *3.3.1 Coating Protection Systems*

Section 6.5.4 of AS 2159-2009 states "Coating systems should comply with the requirements of AS/NZS 2312". Appendix C of AS/NZS 2312:2002 deals with coating systems for non-atmospheric and hot environments. Table C1 in AS/NZS 2312:2002 recommends three different coating systems for soil environments. These are: ultra-high build two-pack epoxy, fusion bonded epoxy, or wrapping tapes.

Appendix 2 and 3 of this report show typical examples of coating protection systems available on the market. Other systems from other manufacturers are also available and may be more suitable.

Appendix 2 of this report contains a data sheet for Denso PVC SA tape. This is an example of a possible coating protection system.

Appendix 3 of this report contains a data sheet for Denso Rigspray Micro, a 2-component isophalic Polyester resin reinforced with micro glass flakes. This was recommended by Denso as a possible coating protection system for the screw piles.

For any coating protection system, it is recommended that the manufacturer's advice on suitability for the environment, surface preparation and application, be followed.

If a coating protection system is used, it is recommended that any coating protection system be tested to ensure it remains adhered to the piles after screwing into the ground. At least five tests are recommended where the piles are coated, screwed into the ground and then removed from the ground to check for damage to the coating protection system.

#### *3.3.2 Cathodic Protection*

Section 6.5.5 of AS 2159-2009 requires cathodic protection systems to conform with AS 2832.2 or AS 2832.3. After reviewing both AS 2832.2 and AS 2832.3 it is my opinion that cathodic protection systems will not be reliable in the clay environment and are not suitable for the "Void Slab System".

### 3.4 Very Severe Environments

For environments classified as "Very severe", it is not recommended that the metal Katana pile be used.

### 3.5 Recommendations Summary

| Exposure Classification | Uniform corrosion allowance (mm/year) | Uniform corrosion over 50 year life (mm) | Recommendation | Estimated Life (Years) |
|---|---|---|---|---|
| **Non-aggressive** | <0.01 | <0.5 | Basic design ok | 100 + (Corrosion inside & outside) |
| **Mild** | 0.01 – 0.02 | 0.5 – 1.0 | Basic design ok | 50 – 100 (Corrosion inside & outside) |
| **Moderate** | 0.02 – 0.04 | 1.0 – 2.0 | Fully Seal | 50 – 100 (Corrosion outside only) |
| **Severe** | 0.04 – 0.1 | 2.0 – 5.0 | Fully Seal + increase wall thickness to 7mm or + Coat | 50 – 125 (7mm wall thickness) 20 – 50 (4mm wall thickness) + Coating allowance (Corrosion outside only) |
| **Very severe** | > 0.1 | > 5.0 | Not Recommended | < 20 (Corrosion outside only) |

Table 1. Estimated design life and recommendations for the Australian Standard exposure classifications for a 350 Grade 76 x 4.0 CHS Katana plie (with 2.0 mm steel corrosion allowance).

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## 4 CONCLUSIONS

Based on my review of the documents listed in Section 1, I am able to provide the following conclusions:

a) It is recommended that the pH, chloride level, and resistivity at each installation site be measured to determine the exposure classification of the site as per table 6.5.2 (C) from AS 2159-2009.

b) I understand that the "Void slab system" is primarily intended for use in areas with expansive clay foundation soils. I note that Table 6.5.2 (C) from AS 2159-2009 indicates for use in clays, soil condition B is used, and that it has a maximum exposure classification of 'Moderate'. The only exception is if the site has been contaminated by domestic or industrial waste. Thus most sites where the "Void slab system" will be used will be classified as "Non-aggressive", "Mild" or "Moderate".

c) The basic Katana pile design, shown in Appendix 1, is expected to have a design life of 50 years or more in environments classified as "Non-aggressive" and "Mild".

d) To achieve a design life of 50 years or more in environments classified as 'Moderate', it is recommended that the inside of the CHS of the Katana pile be fully sealed air tight by welding, thus limiting corrosion to the outside surface.

e) To achieve a design life of 50 years or more in environments classified as "Severe", it is recommended that the inside of the CHS of the Katana pile be fully sealed air tight by welding. Additionally the wall thickness will need to be increased to at least 7.0 mm or extra corrosion protection will be required (see Section 3.3.1 of this report).

f) For environments classified as "Very severe", it is not recommended that the metal Katana pile be used.

**APPENDIX 1**

# Katana Pile Product Guide :

## Standard Katana Pile Product :

| Product Code | Item Description | Pile Length (m) |
|---|---|---|
| SP-010 | 80 kN Pile, CHS 76 x 4.0 wall, 250 x 6 Helix - 350 Grade | 1.0 |
| SP-015 | 80 kN Pile, CHS 76 x 4.0 wall, 250 x 6 Helix - 350 Grade | 1.5 |
| SP-020 | 80 kN Pile, CHS 76 x 4.0 wall, 250 x 6 Helix - 350 Grade | 2.0 |
| SP-025 | 80 kN Pile, CHS 76 x 4.0 wall, 250 x 6 Helix - 350 Grade | 2.5 |
| SP-030 | 80 kN Pile, CHS 76 x 4.0 wall, 250 x 6 Helix - 350 Grade | 3.0 |
| SP-040 | 80 kN Pile, CHS 76 x 4.0 wall, 250 x 6 Helix - 350 Grade | 4.0 |

## Katana Attack Pile Product :

| Product Code | Item Description | Pile Length (m) |
|---|---|---|
| AP-010 | 80 kN Pile, CHS 76 x 4.0 wall, 200 x 6 Helix - 350 Grade | 1.0 |
| AP-015 | 80 kN Pile, CHS 76 x 4.0 wall, 200 x 6 Helix - 350 Grade | 1.5 |
| AP-020 | 80 kN Pile, CHS 76 x 4.0 wall, 200 x 6 Helix - 350 Grade | 2.0 |
| AP-025 | 80 kN Pile, CHS 76 x 4.0 wall, 200 x 6 Helix - 350 Grade | 2.5 |
| AP-030 | 80 kN Pile, CHS 76 x 4.0 wall, 200 x 6 Helix - 350 Grade | 3.0 |
| AP-040 | 80 kN Pile, CHS 76 x 4.0 wall, 200 x 6 Helix - 350 Grade | 4.0 |

## Katana Pile Extension Product :

| Product Code | Item Description | Pile Length (m) |
|---|---|---|
| EXT-010 | 80 kN Pile Extension, CHS 76 x 4.0 wall - 350 Grade | 1.0 |
| EXT-015 | 80 kN Pile Extension, CHS 76 x 4.0 wall, 350 Grade | 1.5 |

## Katana Pile Connector Product :

| Product Code | Item Description |
|---|---|
| EC-250 | Edge Beam Connector, 250 N12 Bar 500 Grade, M36 Thread |
| TP-200 | Load Transfer Plate 200 x 200 x 4 350 grade, M36 Thread |

## Katana Pile Adaptor Product :

| Product Code | Item Description |
|---|---|
| PT-010 | Pile Adaptor to suite - 80 kN Pile, CHS 76 x 4.0 wall - 350 Grade |

## APPENDIX 2

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Approved Quality Management System AS/NZS ISO 9001:2008 Lloyds Register-Certificate No. MEL 0927759

**Technical Data Sheet**

# DENSO PVC SA TAPE

*(Formerly "Denso MP/HD PVC Overwrap Tape")*

| | |
|---|---|
| **Description:** | A tough, multi-purpose, heavy duty, conformable, pressure sensitive adhesive PVC tape. |
| **Composition:** | Plasticised Poly Vinyl Chloride incorporating natural and synthetic rubber based adhesives and fungal inhibitor. |
| **Characteristics:** | • highly impermeable to water moisture and air<br>• stable in composition and plasticity<br>• non hardening and non cracking<br>• accommodates vibration and movement of substrate<br>• resistant to mineral acids, alkalis and salts<br>• exhibits limited resistance to ultraviolet radiation (black only) |
| **Uses:** | For mechanical protection, sealing and water proofing of metal above and below ground as part of the Denso Petrolatum Tape system.<br>Protection of pipelines, joints, fittings, cables, tensioning members. |
| **Surface Preparation & Application:** | Prepare substrate to be protected as per the Denso Petrolatum Tape System.<br>Clean metal surfaces with wire brush.<br>Firmly adherent rust and scale need not be removed.<br>Apply a thin film of Denso MP Primer, where needed use mastic to prepare profiles then apply tape.<br>Wrap tape without overstretching. Apply heavily coated side of the tape to the metal surface.<br>Smooth down and mould by hand especially all overlapped edges.<br>A 55 % overlap of tape should be applied to provide a double layer of tape.<br>Finally apply Denso PVC SA Tape ensuring a 55% overlap is maintained. |
| **Recommended Temperatures:** | Application: 0 to + 60 °C<br>Service: - 20 to + 60 °C<br>Peak: + 75 °C |
| **Storage:** | In cool, dry, ambient conditions, in original cartons away from heat and direct sunlight. |
| **Available Dimensions:** | Colours: Available in Black or Yellow<br>Widths: 25, 50, 100, 150 mm.<br>Length: 30 metre roll, minimum.<br>Other sizes available by special arrangement. |

**Physical Properties:**

| Test | Test Method | Units | Value |
|---|---|---|---|
| Thickness | ASTM D751 | mm | 0.19 ± 0.02 |
| Weight | ASTM D751 | g/m² | 245 ± 25 |
| Breaking Strength | ASTM D1000 | N/mm | 3.0 ± 0.6 |
| Elongation at Break | ASTM D1000 | % | 180 ± 40 |
| Breakdown Voltage - double layer | ASTM D149 | kV | ≥ 16 |
| Adhesion Strength -to steel<br>-to self | ASTM D1000 | g/mm | 18<br>14 |

**APPENDIX 3**

## Description

**Archco-Rigidon Rigspray Micro** is a 2-component medium duty brush, roller or spray applied lining. It is formulated from an isopthalic Polyester resin reinforced with micro glassflakes. The lining dry film thickness is normally 0.6mm. More than one coat can be applied if required.

## Principal Characteristics

* Excellent corrosion resistance
* Very good abrasion resistance
* Very good erosion resistance
* Very low permeability
* Good chemical resistance
* Excellent application properties
* Single coat application 300 to 600 micrometres
* Excellent undercutting resistance
* Lower styrene emissions
* Rapidity of cure
* Excellent UV resistance

## Corrosion and Temperature Resistance

**Archco-Rigidon Rigspray Micro** is suitable for use in aggressive marine environments and resists some mildly aggressive chemicals at temperatures up to 65°C under immersion conditions.

## Suggested Uses

**Archco-Rigidon Rigspray Micro** is used primarily to protect steel structures from corrosive attack.

Rigspray Micro is widely used for the protection of steel structures subject to the most aggressive marine environments, where abrasion and erosion are also a problem, i.e. splash zones, underdeck areas, helidecks and main deck surfaces.

## How to Order

A full material system may be ordered by simply specifying **Archco-Rigidon Rigspray Micro (System 457).**

Contact **Archco-Rigidon** engineers for further information.

| Rigspray | Isopthalic Polyester |
|---|---|
| Operating Temperature Range | Min -50°C Max +65°C |
| Application Method | Spray, roller or brush |
| Surface Preparation | Gritblast to Sa2½ min |
| Colour | To specification |
| Catalyst Type | Archco-Rigidon C2 |
| Volume Solids | 98%-99% |
| Dry Film Thickness | 300-600 Mic. |
| Min Substrate Temperature | 10°C |
| Max Humidity during Application | 90% Rh |
| Min Dewpoint/Substrate Differential (steel) | Dewpoint +3°C |
| Flash Point | 31°C |
| Overcoating Times | Min 2 hrs - Max 36hrs @ 25°C |
| Tool Cleaning Solvent | T2 Cleaner |
| Storage Temperature Limits | 10°C - 20°C |
| Specific Gravity | 1.2 |
| Shelf Life | 6 Months |

| Estimated Coverages are as follows: | Theoretical Material Requirement | Practical Material Requirement |
|---|---|---|
| **Component** | **Quantity m²/0.6mm DFT** | **Quantity m²/0.6mm DFT** |
| 457/04 Rigspray Micro Resin Mix | 0.72 kg | 1.0 kg |
| 457/11 C2 Catalyst | 0.01 kg | 0.02 kg |
| 457/16 T2 Cleaner | 0.50 litres | 0.50 litres |

| Rigspray Test Data | | |
|---|---|---|
| **Characteristic** | **Standard** | **Result** |
| Abrasion Resistance | ASTM D 4060 | 0.035gm (smooth) |
| Adhesion Properties | ASTM D 952 | 8 Mpa |
| Cathodic Disbondment | BS 3900F11 | Compatible |

# Appendix D

**Corrosion Review: 150kN Series**

TM*

*A division of Gilmore Engineers Pty Ltd
Research and Development

engineering3000
new product design & development

Our Ref: RLH:VLK:213324 Your Ref: JW

***19 December 2013***

REPORT

TO

Patented Foundation Systems Pty Ltd
ACN 156 530 497
c/- STA Consulting Engineers
241 Milton Road
Milton, QLD 4064

Attention: Mr Justin Williamson
Senior Geotechnical Engineer

RE: 15 TONNE KATANA SCREW PILE CORROSION REVIEW

ON

**VOID SLAB SYSTEM**

Prepared by:

Dr Ray Hope
B.E.(Mech-Hons), Ph.D., MIEAust, CPEng, RPEQ
Vice President, Engineering

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ABN : 12 060 559 480

## 1 INTRODUCTION

Patented Foundation Systems Pty Ltd have requested e3k review appropriate Australian Standards, or other Standards relevant to corrosion of steel screw piles, to determine the potential effects and limitations of use of the 15 tonne Katana pile in soils of varying pH, up to a depth of 500 mm, for an expected lifetime of 50 years. Patented Foundation Systems Pty Ltd have also requested e3k investigate measures to protect the 15 tonne Katana pile against corrosion in soils of varying pH, up to a depth of 500 mm, for an expected lifetime of 50 years.

I understand that the "Void Slab System" is primarily intended for use in areas with expansive clay foundation soils.

In the preparation of this report, I have read and used the following information:

a) Drawing No. STAC 007, 15 Ton Katana Pile Specifications, from STA Consulting Engineers, dated 17th December 2013 (see Appendix 1).

b) Void Slab System, from Katana Foundations, dated 3rd October 2013.

c) Australian Standard AS 2159-2009 Piling – Design and installation (incorporating amendment No.1).

d) Australian / New Zealand Standard AS/NZS 2312:2002 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings (incorporating amendment No.1).

e) Australian Standard AS 2832.2-2003 Cathodic protection of metals Part 2: Compact buried structures.

f) Australian Standard AS 2832.3-2005 Cathodic protection of metals Part 3: Fixed immersed structures.

g) Data sheet for Denso PVC SA tape (see Appendix 2).

h) Data sheet for Denso Rigspray Micro (see Appendix 3).

This report details our review of the relevant Standards and our recommendations.

## 2 AS 2159-2009 PILING – DESIGN AND INSTALLATION

Australian Standard AS 2159-2009 Piling – Design and installation, contains specific information on the durability design of piling. Section 6.5, of AS 2159-2009, "Design for durability of steel piles", contains exposure classifications for steel piles in different environments.

The exposure classification of the surface of a steel pile is to be determined from Tables 6.5.2 (A), (B) & (C) from AS 2159-2009. For the range of chemical conditions of piles in soil, the condition leading to the most severe aggressive conditions shall be allowed for and consideration shall be given to possible changes in groundwater levels.

## TABLE 6.5.2(A)

## EXPOSURE CLASSIFICATION FOR STEEL PILES—PILES IN WATER

| Exposure conditions | Exposure classification |
|---|---|
| Sea water—submerged | Severe |
| Sea water—tidal/splash zone—Cold water (south of 30°S) | Severe |
| Sea water—tidal splash zone—Tropical/Subtropical water (North of 30°S) | Very severe |
| Fresh water—soft running water | Moderate |

## TABLE 6.5.2(B)

## EXPOSURE CLASSIFICATION FOR STEEL PILES—PILES IN REFUSE FILL

| Exposure conditions | Exposure classification |
|---|---|
| Domestic waste | See Note 2 |
| Industrial waste | See Note 2 |

## TABLE 6.5.2(C)

## EXPOSURE CLASSIFICATION FOR STEEL PILES—PILES IN SOIL

| Exposure conditions | | | | Exposure classification | |
|---|---|---|---|---|---|
| pH | Chlorides Cl | | Resistivity ohm.cm | Soil condition A* | Soil condition B† |
| | In soil ppm | In groundwater ppm | | | |
| >5 | <5000 | <1 000 | >5 000 | Non-aggressive | Non-aggressive |
| 4–5 | 5000–20,000 | 1 000–10 000 | 2 000–5 000 | Mild | Non-aggressive |
| 3–4 | 20,000–50,000 | 10 000–20 000 | 1 000–2 000 | Moderate | Mild |
| <3 | >50,000 | >20 000 | <1 000 | Severe | Moderate |

* Soil conditions A—high permeability soils (e.g., sands and gravels) that are in groundwater

† Soil conditions B—low permeability soils (e.g., silts and clays) or all soils above groundwater

NOTES TO TABLES 6.5.2 (A), 6.5.2 (B) AND 6.5.2 (C):

1 Where high levels of sulfates exist (>1000 ppm), sulfate-reducing bacteria may be present and active, sometimes leading to microbiologically induced corrosion. In such cases, classify as 'mild' for low permeability soils and 'moderate' for high permeability soils.

2 Contamination by the tipping of mineral and domestic waste or by spillage from mining, processing or manufacturing industries presents special durability risks due to the presence of certain aggressive acids (both organic and inorganic), salts and solvents, which can chemically attack steel. In the absence of site-specific chemical information, the exposure condition should be assessed as 'severe' for domestic refuse tips and 'very severe' for industrial/mining waste tips. Chemical and microbiological analysis of the latter may, however, lead to lower risk classification.

3 For piles in disturbed soil, consider the assumption of soil A conditions where accelerated corrosion is possible.

Based on Table 6.5.2 (C) from AS 2159-2009, it is recommended to test the chloride level and resistivity at each installation site, as well as measuring the pH. Measuring of the sulphate level in clay is not required as even high levels above 1000 ppm will only result in a "mild" classification for low permeability soils.

Table 6.5.3, from AS 2159-2009, gives uniform corrosion allowances for loss of section under the five exposure classifications. Section 6.5.3 of AS 2159-2009 states "corrosion on the internal faces of a fully sealed closed-form pile may be assumed to be negligible".

**TABLE 6.5.3**

**CORROSION ALLOWANCES FOR STEEL PILES**

| Exposure classification | Uniform corrosion allowance (mm/year) |
|---|---|
| Non-aggressive | <0.01 |
| Mild | 0.01–0.02 |
| Moderate | 0.02–0.04 |
| Severe | 0.04–0.1 |
| Very severe[3] | >0.1 |

NOTES:

1 The allowances in Table 6.5.3 may be reduced, as appropriate, where adequate corrosion protection systems (coatings or cathodic protection) are to be used. Coatings will reduce corrosion allowance while they remain in good condition. Coating damage, deterioration and breakdown will result in the corrosion rate increasing and, in such circumstances, the corrosion allowances in Table 6.5.3 shall apply.

2 To allow the implementation of cathodic protection after construction it is good practice to provide electrical continuity throughout the piled system at the time of construction. In providing electrical continuity, consideration shall be given to the likelihood of stray current corrosion, especially if the completed structure is of significant length and adjacent to a cathodically protected system or within close proximity to direct current electrified traction or power supply systems.

3 For very severe conditions a site-specific assessment should be sought.

The 15 Tonne version of the Katana pile drawings are shown in Appendix 1 of this report. The main tube of the pile is a 450 Grade 88.9 x 5.5 Circular Hollow Section (CHS). I understand that the minimum required wall thickness for a 15 Tonne Safe Working Load (SWL) is 3.0 mm. Thus the 5.5 mm wall thickness CHS has a steel corrosion allowance of 2.5 mm.

It can be seen from the drawings in Appendix 1 of this report that the top of the piles can be sealed with the threaded edge beam connector. However, this will not provide an air tight seal. The bottom ends of the piles are open, and as the pile screws into the ground, the pile will fill with soil, which may seal the bottom end of the pile. However, this seal will most likely not be water tight. Thus in my opinion, the provided design would not be considered a fully sealed closed-form pile.

# 3 RECOMMENDATIONS

Table 1 of this report shows the estimated design life and recommendations for the Australian Standard exposure classifications.

I understand that the "Void Slab System" is primarily intended for use in areas with expansive clay foundation soils. I note that Table 6.5.2 (C) from AS 2159-2009 indicates for use in clays, soil condition B is used, and that it has a maximum exposure classification of "Moderate". The only exception is if the site has been contaminated by domestic or industrial waste. Thus most sites where the "Void Slab System" will be used will be classified as "Non-aggressive", "Mild" or "Moderate".

## 3.1 Non-Aggressive and Mild Environments

To be conservative, it is assumed that for the basic design the uniform corrosion allowance acts on both the inside and outside of the CHS. With this assumption, the basic design is expected to have a design life of more than 50 years in environments classified as "Non-aggressive" or "Mild".

## 3.2 Moderate Environments

To achieve a design life of 50 years or more in environments classified as "Moderate", it is recommended that the inside of the CHS be fully sealed air tight by welding, thus limiting corrosion to the outside surface.

## 3.3 Severe Environments

To achieve a design life of 50 years or more in environments classified as "Severe", it is recommended that the inside of the CHS be fully sealed air tight by welding. Additionally the wall thickness will need to be increased to at least 8.0 mm or extra corrosion protection will be required. AS 2159-2009 allows for either coating protection systems or cathodic protection.

### *3.3.1 Coating Protection Systems*

Section 6.5.4 of AS 2159-2009 states "Coating systems should comply with the requirements of AS/NZS 2312". Appendix C of AS/NZS 2312:2002 deals with coating systems for non-atmospheric and hot environments. Table C1 in AS/NZS 2312:2002 recommends three different coating systems for soil environments. These are: ultra-high build two-pack epoxy, fusion bonded epoxy, or wrapping tapes.

Appendix 2 and 3 of this report show typical examples of coating protection systems available on the market. Other systems from other manufacturers are also available and may be more suitable.

Appendix 2 of this report contains a data sheet for Denso PVC SA tape. This is an example of a possible coating protection system.

Appendix 3 of this report contains a data sheet for Denso Rigspray Micro, a 2-component isophalic Polyester resin reinforced with micro glass flakes. This was recommended by Denso as a possible coating protection system for the screw piles.

For any coating protection system, it is recommended that the manufacturer's advice on suitability for the environment, surface preparation and application, be followed.

If a coating protection system is used, it is recommended that any coating protection system be tested to ensure it remains adhered to the piles after screwing into the ground. At least five tests are recommended where the piles are coated, screwed into the ground and then removed from the ground to check for damage to the coating protection system.

*3.3.2 Cathodic Protection*

Section 6.5.5 of AS 2159-2009 requires cathodic protection systems to conform with AS 2832.2 or AS 2832.3. After reviewing both AS 2832.2 and AS 2832.3 it is my opinion that cathodic protection systems will not be reliable in the clay environment and are not suitable for the "Void Slab System".

### 3.4 Very Severe Environments

For environments classified as "Very severe", it is not recommended that the metal Katana pile be used.

### 3.5 Recommendations Summary

| Exposure Classification | Uniform corrosion allowance (mm/year) | Uniform corrosion over 50 year life (mm) | Recommendation | Estimated Life (Years) |
|---|---|---|---|---|
| **Non-aggressive** | <0.01 | <0.5 | Basic design ok | 125 +<br>(Corrosion inside & outside) |
| **Mild** | 0.01 – 0.02 | 0.5 – 1.0 | Basic design ok | 62.5 – 125<br>(Corrosion inside & outside) |
| **Moderate** | 0.02 – 0.04 | 1.0 – 2.0 | Fully Seal | 62.5 – 125<br>(Corrosion outside only) |
| **Severe** | 0.04 – 0.1 | 2.0 – 5.0 | Fully Seal<br>+ increase wall thickness to 8mm<br>or + Coat | 50 – 125 (8mm wall thickness)<br>25 – 62.5 (5.5mm wall thickness)<br>+ Coating allowance<br>(Corrosion outside only) |
| **Very severe** | > 0.1 | > 5.0 | Not Recommended | < 25<br>(Corrosion outside only) |

Table 1. Estimated design life and recommendations for the Australian Standard exposure classifications for a 450 Grade 88.9 x 5.5 CHS Katana pile (with 2.5 mm steel corrosion allowance).

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## 4 CONCLUSIONS

Based on my review of the documents listed in Section 1, I am able to provide the following conclusions:

a) It is recommended that the pH, chloride level, and resistivity at each installation site be measured to determine the exposure classification of the site as per table 6.5.2 (C) from AS 2159-2009.

b) I understand that the "Void Slab System" is primarily intended for use in areas with expansive clay foundation soils. I note that Table 6.5.2 (C) from AS 2159-2009 indicates for use in clays, soil condition B is used, and that it has a maximum exposure classification of "Moderate". The only exception is if the site has been contaminated by domestic or industrial waste. Thus most sites where the "Void Slab System" will be used will be classified as "Non-aggressive", "Mild" or "Moderate".

c) The basic 15 tonne Katana pile design, shown in Appendix 1, is expected to have a design life of more than 50 years in environments classified as "Non-aggressive" and "Mild".

d) To achieve a design life of 50 years or more in environments classified as "Moderate", it is recommended that the inside of the CHS of the 15 tonne Katana pile be fully sealed air tight by welding, thus limiting corrosion to the outside surface.

e) To achieve a design life of 50 years or more in environments classified as "Severe", it is recommended that the inside of the CHS of the 15 tonne Katana pile be fully sealed air tight by welding. Additionally the wall thickness will need to be increased to at least 8.0 mm or extra corrosion protection will be required (see Section 3.3.1 of this report).

f) For environments classified as "Very severe", it is not recommended that the metal 15 tonne Katana pile be used.

# APPENDIX 1

## APPENDIX 2

Approved Quality Management System
AS/NZS ISO 9001:2008
Lloyds Register-Certificate No. MEL 0927759

# Technical Data Sheet

## DENSO PVC SA TAPE

*(Formerly "Denso MP/HD PVC Overwrap Tape")*

| | |
|---|---|
| **Description:** | A tough, multi-purpose, heavy duty, conformable, pressure sensitive adhesive PVC tape. |
| **Composition:** | Plasticised Poly Vinyl Chloride incorporating natural and synthetic rubber based adhesives and fungal inhibitor. |
| **Characteristics:** | • highly impermeable to water moisture and air<br>• stable in composition and plasticity<br>• non hardening and non cracking<br>• accommodates vibration and movement of substrate<br>• resistant to mineral acids, alkalis and salts<br>• exhibits limited resistance to ultraviolet radiation (black only) |
| **Uses:** | For mechanical protection, sealing and water proofing of metal above and below ground as part of the Denso Petrolatum Tape system.<br>Protection of pipelines, joints, fittings, cables, tensioning members. |
| **Surface Preparation & Application:** | Prepare substrate to be protected as per the Denso Petrolatum Tape System.<br>Clean metal surfaces with wire brush.<br>Firmly adherent rust and scale need not be removed.<br>Apply a thin film of Denso MP Primer, where needed use mastic to prepare profiles then apply tape.<br>Wrap tape without overstretching. Apply heavily coated side of the tape to the metal surface.<br>Smooth down and mould by hand especially all overlapped edges.<br>A 55 % overlap of tape should be applied to provide a double layer of tape.<br>Finally apply Denso PVC SA Tape ensuring a 55% overlap is maintained. |
| **Recommended Temperatures:** | Application: 0 to + 60 °C<br>Service: - 20 to + 60 °C<br>Peak: + 75 °C |
| **Storage:** | In cool, dry, ambient conditions, in original cartons away from heat and direct sunlight. |
| **Available Dimensions:** | Colours: Available in Black or Yellow<br>Widths: 25, 50, 100, 150 mm.<br>Length: 30 metre roll, minimum.<br>Other sizes available by special arrangement. |

**Physical Properties:**

| Test | Test Method | Units | Value |
|---|---|---|---|
| Thickness | ASTM D751 | mm | 0.19 ± 0.02 |
| Weight | ASTM D751 | g/m² | 245 ± 25 |
| Breaking Strength | ASTM D1000 | N/mm | 3.0 ± 0.6 |
| Elongation at Break | ASTM D1000 | % | 180 ± 40 |
| Breakdown Voltage - double layer | ASTM D149 | kV | ≥ 16 |
| Adhesion Strength -to steel<br>-to self | ASTM D1000 | g/mm | 18<br>14 |

**APPENDIX 3**

## Description

**Archco-Rigidon Rigspray Micro** is a 2-component medium duty brush, roller or spray applied lining. It is formulated from an isopthalic Polyester resin reinforced with micro glassflakes. The lining dry film thickness is normally 0.6mm. More than one coat can be applied if required.

## Principal Characteristics

* Excellent corrosion resistance
* Very good abrasion resistance
* Very good erosion resistance
* Very low permeability
* Good chemical resistance
* Excellent application properties
* Single coat application 300 to 600 micrometres
* Excellent undercutting resistance
* Lower styrene emissions
* Rapidity of cure
* Excellent UV resistance

## Corrosion and Temperature Resistance

**Archco-Rigidon Rigspray Micro** is suitable for use in aggressive marine environments and resists some mildly aggressive chemicals at temperatures up to 65°C under immersion conditions.

## Suggested Uses

**Archco-Rigidon Rigspray Micro** is used primarily to protect steel structures from corrosive attack.

Rigspray Micro is widely used for the protection of steel structures subject to the most aggressive marine environments, where abrasion and erosion are also a problem, i.e. splash zones, underdeck areas, helidecks and main deck surfaces.

## How to Order

A full material system may be ordered by simply specifying **Archco-Rigidon Rigspray Micro (System 457).**

Contact **Archco-Rigidon** engineers for further information.

| Rigspray | Isopthalic Polyester |
|---|---|
| Operating Temperature Range | Min -50°C Max +65°C |
| Application Method | Spray, roller or brush |
| Surface Preparation | Gritblast to Sa2½ min |
| Colour | To specification |
| Catalyst Type | Archco-Rigidon C2 |
| Volume Solids | 98%-99% |
| Dry Film Thickness | 300-600 Mic. |
| Min Substrate Temperature | 10°C |
| Max Humidity during Application | 90% Rh |
| Min Dewpoint/Substrate Differential (steel) | Dewpoint +3°C |
| Flash Point | 31°C |
| Overcoating Times | Min 2 hrs - Max 36hrs @ 25°C |
| Tool Cleaning Solvent | T2 Cleaner |
| Storage Temperature Limits | 10°C - 20°C |
| Specific Gravity | 1.2 |
| Shelf Life | 6 Months |

| Estimated Coverages are as follows: | Theoretical Material Requirement | Practical Material Requirement |
|---|---|---|
| **Component** | **Quantity m²/0.6mm DFT** | **Quantity m²/0.6mm DFT** |
| 457/04 Rigspray Micro Resin Mix | 0.72 kg | 1.0 kg |
| 457/11 C2 Catalyst | 0.01 kg | 0.02 kg |
| 457/16 T2 Cleaner | 0.50 litres | 0.50 litres |

| Rigspray Test Data | | |
|---|---|---|
| **Characteristic** | **Standard** | **Result** |
| Abrasion Resistance | ASTM D 4060 | 0.035gm (smooth) |
| Adhesion Properties | ASTM D 952 | 8 Mpa |
| Cathodic Disbondment | BS 3900F11 | Compatible |

# Appendix E

**Pile Testing**

## Introduction

A series of twenty six compressive tests, six lateral tests and ten pull out (tension) tests were undertaken to present a report of results in accordance with static pile load tests, AS 2159-2009 specifications requirements. These tests have three primary objectives:

- To establish load-deflection relationships in the pile-soil system,
- To determine capacity of the pile-soil system, and
- To determine load distribution in the pile-soil system.

These tests will confirm design assumptions or / and provide information to allow those assumptions and the pile design to be modified. These tests relate, but are not limited to, a load capacity test for the footings of buildings, and more particularly, to the load capacity of screw piles supporting the footings.

## Pile Test Loads & Load Application Systems

### 1) Reaction Frame

- Install two or more reaction piles for the reaction frame after the installation of the test pile. Locate these reaction piles not less than 3.0m from the test pile. These distances are measured between the axis of the test pile and reaction piles.
- Apply the load to the pile by one or more hydraulic jack.
- Design the reaction frame and reaction piles to resist four times the pile design load indicated in the contract documents without undergoing a magnitude of deflection exceeding 75 percent of maximum travel of the jack.

### 2) Load Application System

Apply load with the jack(s), having a capacity of at least four times the pile design load indicated in the contract documents. Use jacks with a minimum travel of 150 mm, but not less than 25 percent of the test pile's maximum cross-section dimension. Equip the jack(s) with spherical bearing plates, to bear firmly and concentrically against the pile load transfer plate. Use an automatic load-maintaining pump with manual supplement to control load application. Use a pressure-gage for the jack so that the pressure reading corresponding to the pile design load indicated in the contract documents is between one-fourth and one-third of maximum gage pressure. Place a load cell (either electric or hydraulic, unless one or the other is specified in the contract documents) to measure strains for load monitoring during the load test. Load cell shall be accurate to within 2% of the indicated load and of stable construction.

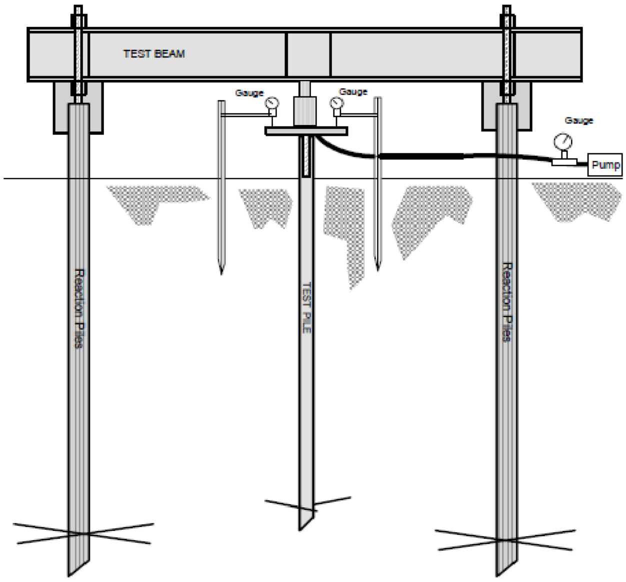
Arrange and construct the elements of the load-application system as follows:

1. Provide a level load transfer plate perpendicular to the pile axis.
2. To distribute load over the pile's entire cross-section, place a solid steel plate of sufficient thickness (16 mm minimum) to prevent bending as a bearing plate between the capped pile and the jack base. The size of the solid steel plate shall be not less than the size of the pile butt or less than the area covered by the jack base.

3. Place the load application system (including hydraulic jack, spherical bearing and load cell) between the bearing plate on the pile and the centre of the underside of the load beam.

4. Construct the system so that all components are centred along the pile's longitudinal axis, to ensure application of a concentric axial load.

5. Immediately before starting a load test, verify that at least 25 mm of clear space exists between the load transfer plate and load beam. The details of the reaction frame, test pile and apparatus for testing the load-bearing capacity of the test screw pile are illustrated in figure 1. below




## Preparation & Maintenance of Test Area

- Clear the area surrounding the test pile,
- Provide a properly designed level platform of sufficient plan dimensions to support the testing equipment safely and with suitable access for operatives,
- Construction plant that may be operating elsewhere on site must be excluded from
- the test area during the course of the pile test so that the test pile's performance can
- be accurately monitored in a safe environment,
- Any excavations within the exclusion zone are prohibited,
- Provide complete protection at all times for the pile supports and reference beam from wind, heavy rains, direct sunlight, frost action, and other disturbances. Also maintain a temperature of not less than 10° C and not more than 40° C throughout the duration of the test and provide a thermometer to monitor temperature,
- Provide adequate lighting for the duration of the test.

## Compression Test

Load and unload the test pile incrementally in two cycles, unless an alternative procedure is specified in the contract documents. Apply each load increment to the pile in as short a period as physically possible. The maximum load applied is at least 150% the pile design load indicated in the contract documents. The required load increments are expressed as a percentage of the pile design load. Magnitude and sequence of load increments for the two loading cycles are as follows:

| Cycle | Percent of Maximum Design Load |
|---|---|
| 1 | 10,20,30,40,50,60,70,80,90,100 |
| 2 | 10,20,30,40,50,60,70,80,90,100,110,120,130,140,150 |

Maintain each load increment until the deflection rate under the applied load, or rate of rebound from the previous load increment, is less than 0.05 mm in 10 minutes. The minimum period for maintaining a load increment, however, is 30 minutes and an increment may be removed after having been maintained for 2 hours, regardless of rate of deflection or rebound. When 150 percent of the design load has been applied during Cycle 2, provided the pile has not failed, leave this load in place for 24 hours. When the pile has rebounded to zero load at the end of Cycle 2, maintain zero load at least 1 hour.

If the pile fails before application of the 150-percent load, rebound it to zero load. The pile designer and the piling contractor should investigate the causes and undertake appropriate remedial action, if any.

## Tension Load Test

This test has been developed to calibrate individual sites soil properties to actual performance load capacity tests. The Katana pile is installed to a set depth, with torque reading obtained. The Katana pile is then tested to determine whether it has maintained the nominated load bearing capacity, as specified by the engineer.

### Methodology

The On-Site Rapid Load Test consisted of a test pile installed at a minimum depth of 2.0 metres below ground surface. The pile top was 100 mm clear of ground surface enabling Rapid Load Test Device to be positioned over the top of the test pile. The threaded pull rod was screwed into the top of the test pile ensuring full embedment of thread then locked off with an M36 locking nut. Load was then applied to the pile in increments using a 20 tonne hydraulic jack. Load was maintained at each loading increment for a minimum of 3 minutes ensuring pressure remained consistent for this period of time. The load was increased on each test until such time load/ pressure could no longer be maintained at which point is considered the failure point of the test.

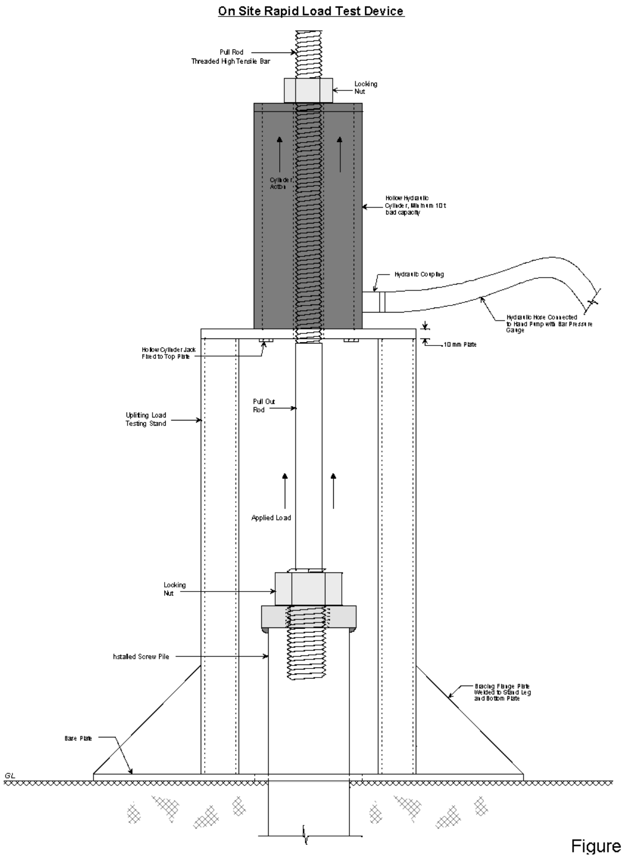



Figure 2.

### Procedure

1. Install the first Katana Pile to the minimum target depth as nominated within the foundation design report.

2. Record the barometric pressure achieved on the machine used for installation when at the required target depth.

3. Place the Rapid Load Testing Device over the Katana Pile, ensuring a level firm base under the test unit.

    a. Note - Test is not suitable on piles installed at least 2.0 metres.

4. Screw in the connecting threaded rod to the full depth of the threaded slug in the top of the pile. Fix in place with locking nut as shown in fig.1 below.

5. Connect the hand pump unit with a calibrated barometric pressure gauge.

6. Hydraulic Ram Jack, pre-loading the test device allowing for potential settlement at base of the testing unit. This may vary depending on the extent of soils beneath test unit. All persons should be located a minimum of 3 metres clear of the testing unit prior to jacking.

7. Once pre-loading is completed, that is no further settlement can be observed within testing unit. Continue jacking ram until such time the required pier capacity as nominated by the engineer has been achieved. Typically, the measured uplifting load is ~ 100 % of the calculated load-bearing capacity of the pile.

8. Maintain minimum constant pressure on pile at load capacity requirement for a minimum of 5 minutes ensuring pile does not displace.

9. Record barometric pressures achieved on the supplied record sheets and document using photographs and video evidence.

10. Where the tested pile continues to hold the required load capacity with no displacement for the minimum time specified, it can be confirmed the screw has passed the load requirements nominated.

### Acceptance Criteria

The "Rapid Load Capacity Test" enables the engineer / installer to satisfy themselves, that the Katana piles load capacity has been met. It must also be noted that the pull-out test, under the "Piling Code" AS2159, has a 1.3 factor of safety. In other words, the pull-out capacity in the nominated soil strata, is 70% of the end bearing capacity.

## Lateral Load Test

This test has been developed to determine the lateral capacity of the Katana Pile. The lateral capacity of vertical single piles has been determined from the least of the values calculated on the basis of soil failure, structural capacity of the pile and deflection of the pile head.

### Methodology

The lateral load test setup seen in figure 3. below consisted of a test pile installed approximately 2.0 metres away from a reaction pile. The reaction pile was installed a minimum of 1.0 metre below the final depth of the test pile. Pile tops were maintained approximately 100 mm above ground level, where applied loads were imposed using a 5 tonne winch in line with a calibrated 5 tonne scale measuring the applied loads as the winch was retracted. The winch acted by pulling the test pile head towards the reaction pile. Lateral movements were monitored at two points at the test pile top at a distance of 100 mm above the ground surface to measure lateral deflections at the point of load application. The lateral movement was measured using dial gauges with 0.01 mm accuracy and 150 mm travel. All dial gauge readings were recorded at the same time at each point additional load was applied.

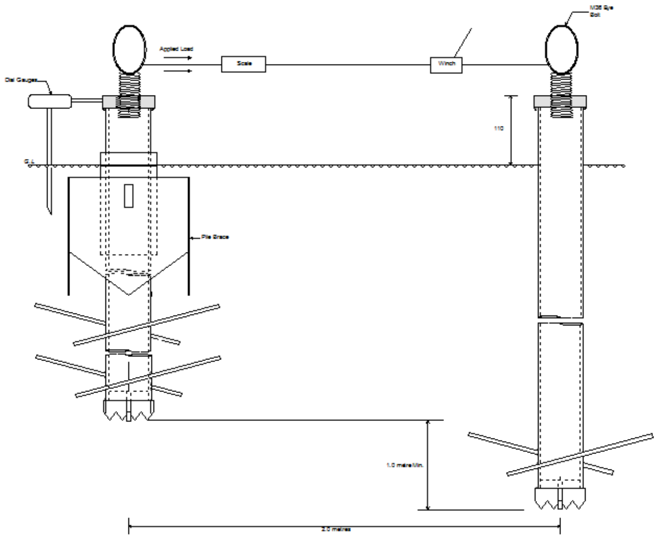



Figure 3

## Procedure

1. Install test pile to required target depth.

2. Record torque reading and document at final depth installed.

3. Install a single reaction pile after the installation of the test pile. Locate the reaction piles not less than 2.0m from the test pile. These distances are measured between the axis of the test pile and reaction piles.

4. Screw in high capacity eye bolts to top of test pile and reaction pile.

5. Mount in line scale and winch to pile tops between test pile and reaction pile.

6. Install dial gauges at base of test pile, with gauges measuring the deflection at the point of load application.

7. Begin to apply load by retracting winch, documenting the applied load on the in line scale. Maintain each applied load until stable, recording deflection on dial gauges throughout test duration.

8. Where required applied loads have been reached, release pressure from winch removing all applied load from test pile.

9. Record rebound of test pile on dial gauge after applied load removed.

10. Results of the lateral load test are to be presented in the form of a load deflection curve as presented in the following field test results.

## Acceptance Criteria

The engineer must satisfy themselves, that the bracing requirements of the intended construction do not exceed the lateral loading capacity of the installed screw piles. Where this is the case a review of bracing measures must be undertaken.

## Summary of Results

Test results for Compression and Tensile give a "Ultimate Geotechnical Load Capacity".

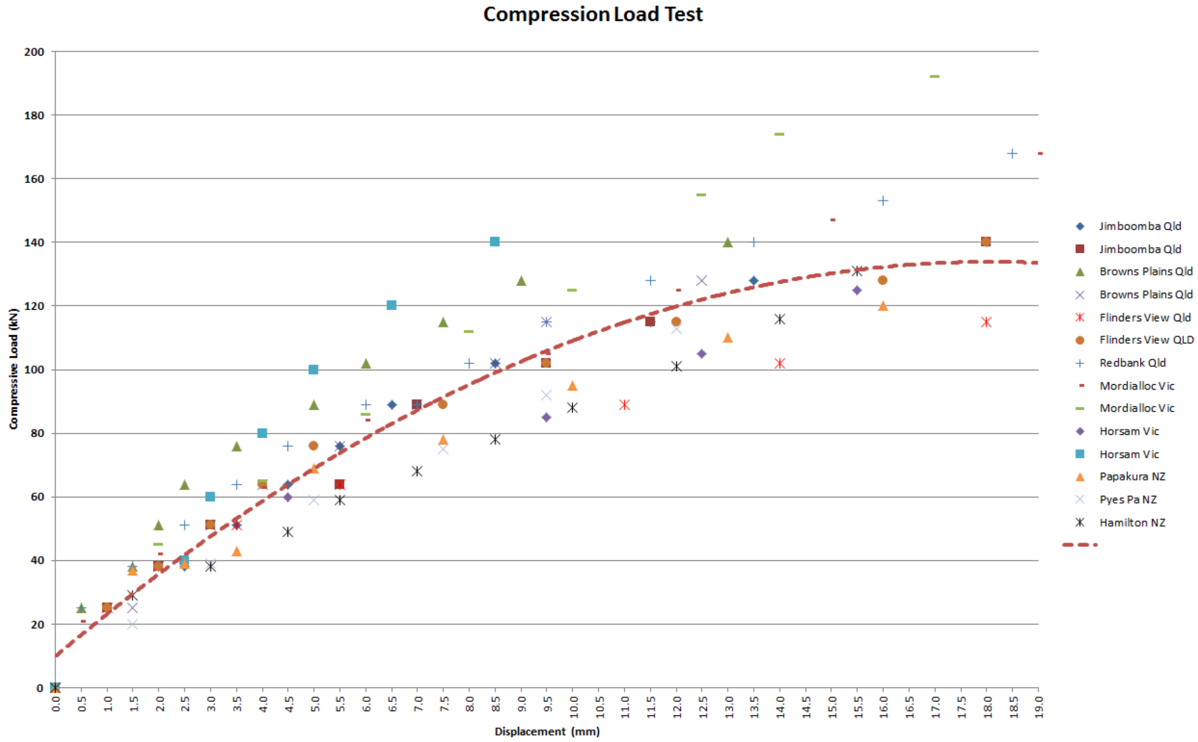
Lateral loads are nominated at a point where we had a 20mm deflection within the pipe. The 20mm mark was the point where we still achieve total rebound when load was released.

| Test No. | Location | Region | Series | Pile Depth | Compression | Lateral | Tension |
|---|---|---|---|---|---|---|---|
| | Suburb | | | m | kN | kN | kN |
| 1 | Jimboomba | QLD | 80 | 2 | 140 | 3.2 | |
| 2 | Jimboomba | QLD | 80 | 2 | 140 | | 102 |
| 3 | Browns Plains | QLD | 80 | 2 | 140 | 3.3 | |
| 4 | Browns Plains | QLD | 80 | 2 | 128 | | 89 |
| 5 | Flinders View | QLD | 80 | 2 | 76 | | 51 |
| 6 | Flinders View | QLD | 80 | 3 | 153 | | 115 |
| 9 | Redbank | QLD | 80 | 2 | 115 | 3.8 | 76 |
| 10 | Mordialloc | VIC | 80 | 3 | 168 | | |
| 11 | Mordialloc | VIC | 80 | 3 | 224 | | |
| 12 | Jimboomba | QLD | 100 | 3 | 176 | | 155 |
| 13 | Browns Plains | QLD | 100 | 3 | 199 | | |
| 14 | Flinders View | QLD | 100 | 3 | 198 | | 163 |
| 15 | Mordialloc | VIC | 100 | 3 | 168 | | |
| 16 | Papakura | NZ | 100 | 3 | 89 | | 73 |
| 17 | Jimboomba | QLD | 150 | 3 | 280 | | |
| 18 | Browns Plains | QLD | 150 | 3 | 278 | | |
| 19 | Flinders View | QLD | 150 | 4 | 256 | | |
| 20 | Mordialloc | VIC | 150 | 3 | 322 | | |
| 21 | Redbank | QLD | 150 | 4 | 300 | | |
| 22 | Horsam | VIC | 80 | 3 | 125 | | |
| 23 | Horsam | VIC | 80 | 3 | 150 | | |
| 24 | Papakura | NZ | 80 | 4 | 120 | | 80 |
| 25 | Pyes Pa | NZ | 80 | 7 | 113 | | |
| 26 | Hamilton | NZ | 80 | 4 | 116 | | 80 |

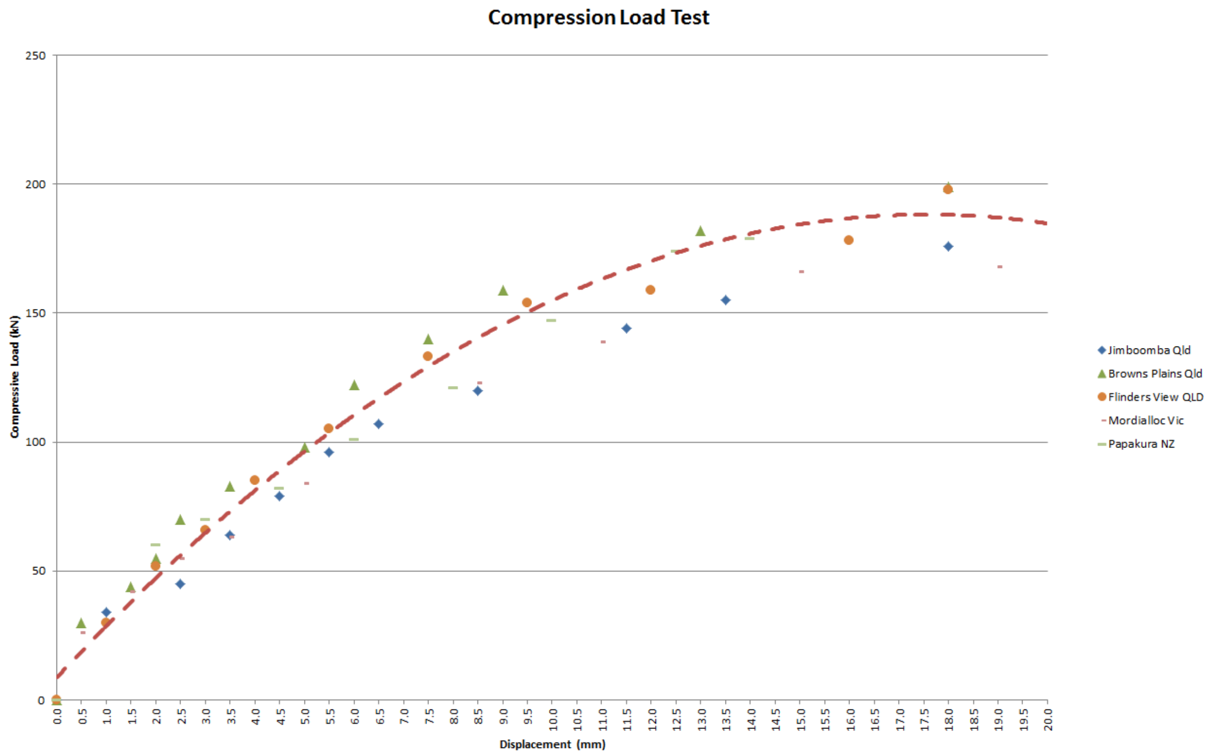
## Limitations

STA Consulting Engineers (STA) has prepared this report in accordance with the usual care and thoroughness of the consulting professional for the use of the Stoddart Foundation Systems Pty Ltd screw pile. It is based on generally accepted practices and standards at the time it was prepared. No other warranty expresses or implied, is made as to the professional advice included in this report.

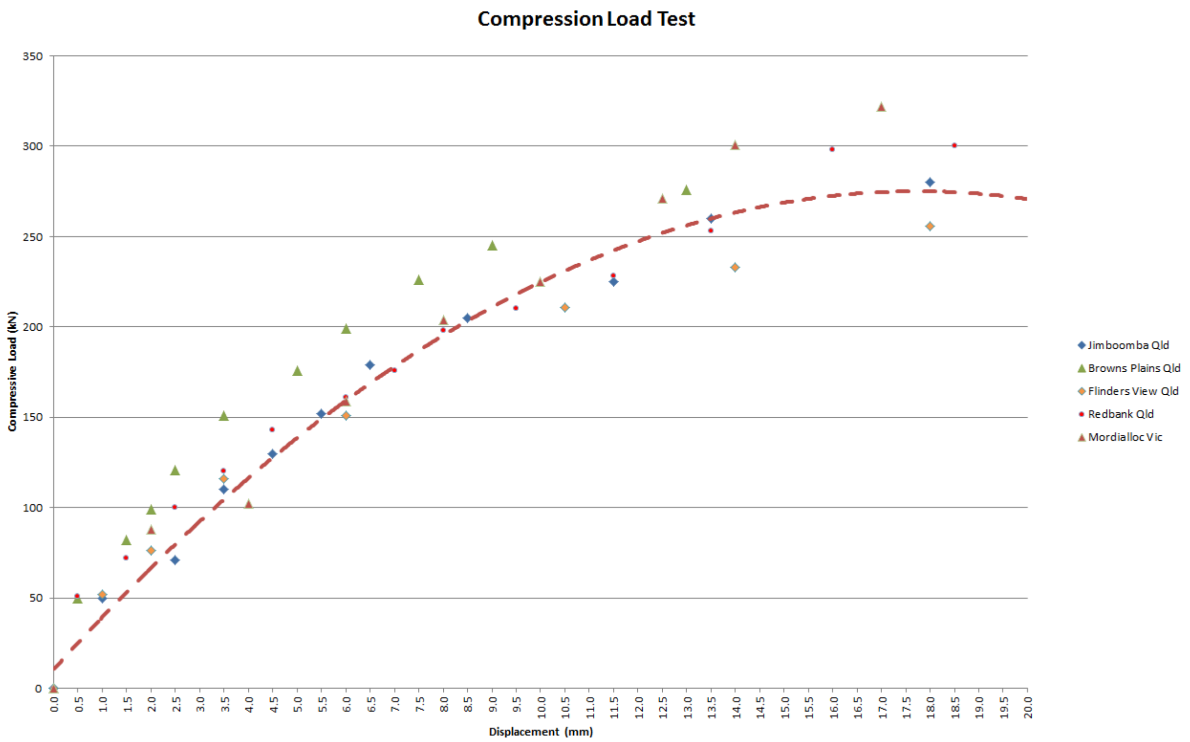
## Katana – 80kN Series



# Katana – 100kN Series




# Katana – 150kN Series



# Appendix F

**Bracing Plate**

## Introduction

A series of two lateral tests were undertaken to present a report of results in accordance with, AS 2159-2009 specifications requirements. The test objectives were:

- To determine capacity of the bracing pile.

These tests relate to the lateral load capacity of the bracing Katana pile supporting the footings.

## Lateral Load Test

This test has been developed to determine the lateral capacity of the Katana Pile. The lateral capacity of vertical single pile has been determined from the least of the values calculated on the basis of soil failure, structural capacity of the pile and deflection of the pile head.

## Methodology

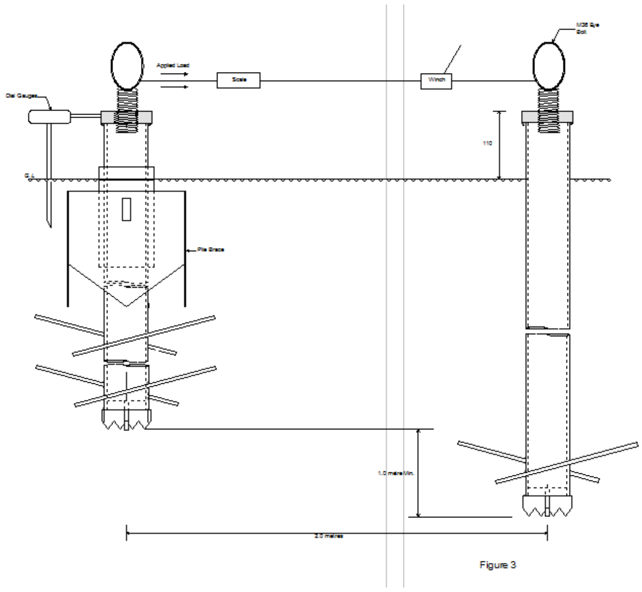
The lateral load test setup seen in figure 3. below consisted of a test pile installed approximately 2.0 metres away from a reaction pile. The reaction pile was installed a minimum of 1.0 metre below the final depth of the test pile. Pile tops were maintained approximately 100 mm above ground level, where applied loads were imposed using a 5 tonne winch in line with a calibrated 5 tonne scale measuring the applied loads as the winch was retracted. The winch acted by pulling the test pile head towards the reaction pile. Lateral movements were monitored at two points at the test pile top at a distance of 100 mm above the ground surface to measure lateral deflections at the point of load application. The lateral movement was measured using dial gauges with 0.01 mm accuracy and 150 mm travel. All dial gauge readings were recorded at the same time at each point additional load was applied.

## Procedure

1. Install test pile to required target depth.
2. Record torque reading and document at final depth installed.
3. Install a single reaction pile after the installation of the test pile. Locate the reaction piles not less than 2.0m from the test pile. These distances are measured between the axis of the test pile and reaction piles.
4. Screw in high capacity eye bolts to top of test pile and reaction pile.
5. Mount in line scale and winch to pile tops between test pile and reaction pile.
6. Install dial gauges at base of test pile, with gauges measuring the deflection at the point of load application.
7. Begin to apply load by retracting winch, documenting the applied load on the in line scale. Maintain each applied load until stable, recording deflection on dial gauges throughout test duration.
8. Where required applied loads have been reached, release pressure from winch removing all applied load from test pile.

9. Record rebound of test pile on dial gauge after applied load removed.

10. Results of the lateral load test are to be presented in the form of a load deflection curve as presented in the following field test results.



### Acceptance Criteria

The engineer must satisfy themselves, that the bracing requirements of the intended construction do not exceed the lateral loading capacity of the installed screw piles. Where this is the case a review of bracing measures must be undertaken or additional portals must be created to improve the lateral stability of the system.

### Summary of Test Results

Test results for Compression and Tensile give an "Ultimate Geotechnical Load Capacity".

Lateral loads are nominated at a point where we had a 20mm deflection within the pipe. The 20mm mark was the point where we still achieve total rebound when load was released.

| Test No. | Location | Pile Depth | Lateral |
|---|---|---|---|
| | Suburb | m | kN |
| 1 | Browns Plains | 2 | 8.35 |
| 2 | Browns Plains | 2 | 8.61 |

### Limitations

STA Consulting Engineers (STA) has prepared this report in accordance with the usual care and thoroughness of the consulting professional for the use of the Stoddart Foundation Systems Pty Ltd and Katana Pile. It is based on generally accepted practices and standards at the time it was prepared. No other warranty expresses or implied, is made as to the professional advice included in this report.

**Section 3 - Bore Logs**

## Bore Log Sheet

### Test Location # 1 - Test Piles # 1 & # 2

| | |
|---|---|
| **Project Job No. Testing**<br>**Client: Stoddart Screw Pile** | **Date Drilled: 13th November, 2012**<br>**Drill Method: Power Auger** |

| Depth (m) | Sample Location | Groundwater | Graphic Log | Extent of Fill | Symbols | SOIL DESCRIPTION | PP Value | D.C.P blows/ 100 mm | N'q ( kPa ) |
|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | **SILTY CLAY**<br>**(Brown)**<br>**Dry to Moist & Stiff** | | 2<br>3<br>3 | <br><br>70 |
| 0.5 | | | | | | | | 3<br>3<br>3<br>2<br>2<br>3 | <br><br>80<br><br><br>60 |
| 1.0 | | | | | | **Friable**<br>**Silt & Sand Increase**<br>**Friable** | | 3<br>4<br>3<br>4 | <br><br>90 |
| 1.5 | | | | | | | | | |
| 2.0 | | | | | | **EXTREMELY WEATHERED ROCK**<br>**(Brown)**<br>**Moist & Weak** | | | |
| 2.5 | | | | | | | | | |
| 3.0 | | | | | | **END** | | | |
| 3.5 | | | | | | | | | |
| 4.0 | | | | | | | | | |
| 4.5 | | | | | | | | | |
| 5.0 | | | | | | | | | |

Bore Hole Terminated - 3.0m

**Terms :-**

D.C.P.:- Dynamic Cone Penetrometer
N'q:- Allowable Bearing Capacity (kPa)
PP:- Pocket Penetrometer Strength (kPa)
U.T.P:- Unable to Penetrate
→ Slope Direction

**Note : kPa value is allowable bearing pressure caculated in accordance with paper 'Determination of allowable bearing pressure under small structures' by M.J Stockwell (June 1977)**

# Appendix G

**Lateral Capacities**

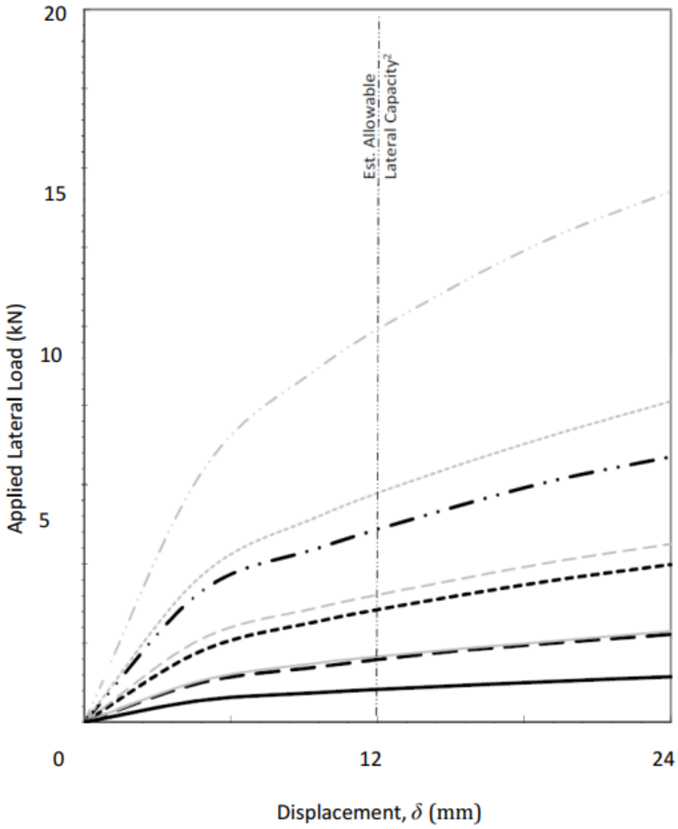
# Katana Pile - 80kN

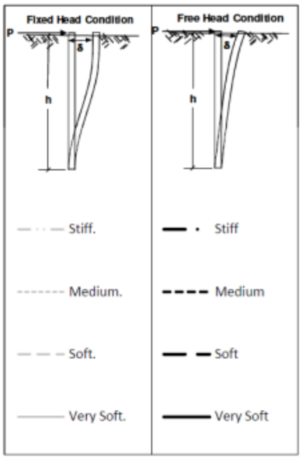
## Lateral Performance in Clay

| Pile Properties | | |
|---|---|---|
| Pipe Diameter | (mm) | 76.1 |
| Wall Thickness | (mm) | 4.0 |
| Steel Grade | (f's) | 400 |
| Pile Base Dia. | (mm) | 250 |

| Soil Properties | | |
|---|---|---|
| Soil Type | Angle of Friction (deg) | Cohesion Cu |
| Stiff | 0 | 100 |
| Medium | 0 | 60 |
| Soft | 0 | 30 |

| Minimum Pile Depth, h | | |
|---|---|---|
| Soil Type | Fixed Head | Free Head |
| Stiff | 40d | 34d |
| Medium | 30d | 28d |
| Soft | 28d | 24d |



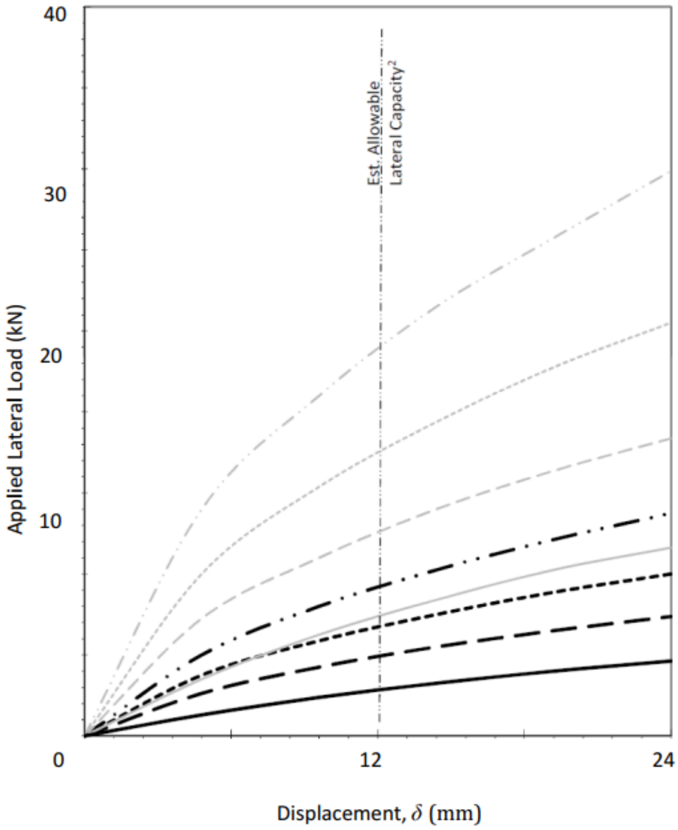

These charts are for Katana Piles only as lateral performance is highly dependent on the connections rigidity and shaft properties. It is Katana's opinion that these graphs represent a reasonable approximation of the average performance of the Katana Pile in the indexed soils. Using the average performance is reasonable for multiple redundant structures (e.g. buildings, bridges, marina piers, etc.)

AS2159 - 2009, states that the allowable lateral capacity of a pile is half load causing a 25mm of displacement. Many practitioners take this to be nearly the same as the lateral load predicated at 12mm displacement. The graph presented here can be used to evaluate capacity for either condition as well as to judge lateral performance under other displacement criteria and codes. The design allowable displacement is the responsibility of the design engineer.

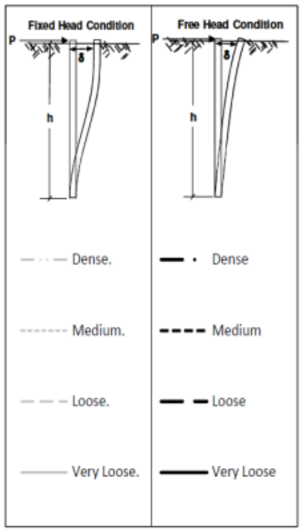
# Katana Pile - 80kN
## Lateral Performance in Sand

| Pile Properties | | |
|---|---|---|
| Pipe Diameter | (mm) | 76.1 |
| Wall Thickness | (mm) | 4.0 |
| Steel Grade | (f's) | 400 |
| Pile Base Dia. | (mm) | 250 |

| Soil Properties | | |
|---|---|---|
| Soil Type | Angle of Friction (deg) | Cohesion Cu |
| Dense | 25 | 0 |
| Medium | 29 | 0 |
| Loose | 33 | 0 |




| Minimum Pile Depth, h | | |
|---|---|---|
| Soil Type | Fixed Head | Free Head |
| Dense | 40d | 34d |
| Medium | 30d | 28d |
| Loose | 28d | 24d |




These charts are for Katana Piles only as lateral performance is highly dependent on the connections rigidity and shaft properties. It is Katana's opinion that these graphs represent a reasonable approximation of the average performance of the Katana Pile in the indexed soils. Using the average performance is reasonable for multiple redundant structures (e.g. buildings, bridges, marina piers, etc.)

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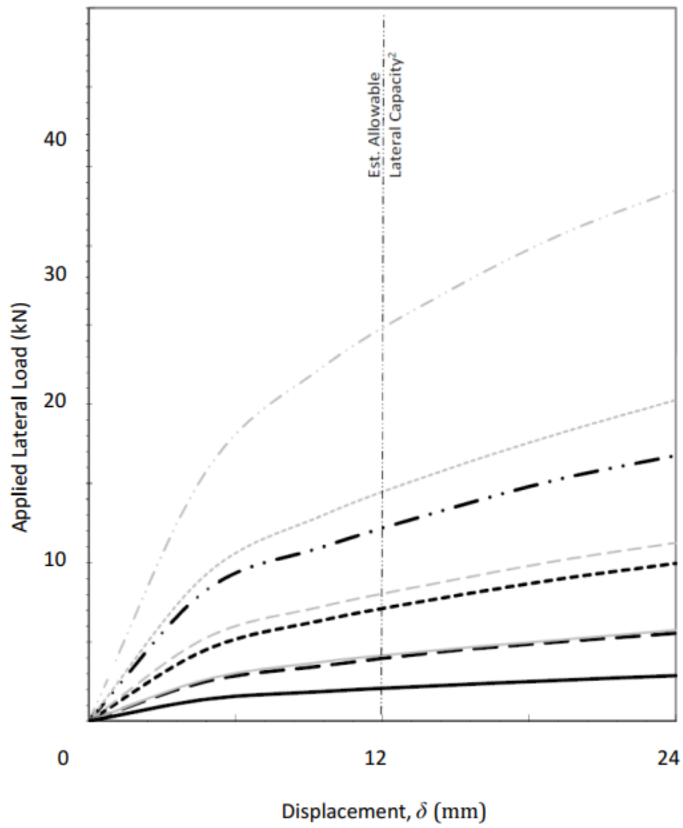
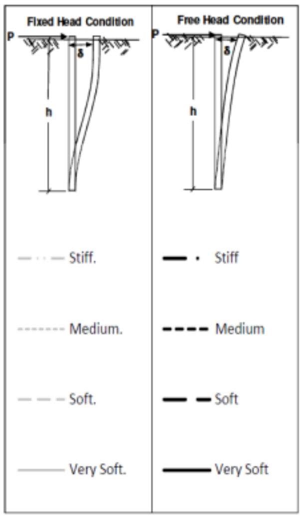
# Katana Pile - 150kN
## Lateral Performance in Clay

| Pile Properties | |
|---|---|
| Pipe Diameter (mm) | 88.9 |
| Wall Thickness (mm) | 5.5 |
| Steel Grade (f's) | 350 |
| Pile Base Dia. (mm) | 350 |

| Soil Properties | | |
|---|---|---|
| Soil Type | Angle of Friction (deg) | Cohesion Cu |
| Stiff | 0 | 100 |
| Medium | 0 | 60 |
| Soft | 0 | 30 |




| Minimum Pile Depth, h | | |
|---|---|---|
| Soil Type | Fixed Head | Free Head |
| Stiff | 40d | 34d |
| Medium | 30d | 28d |
| Soft | 28d | 24d |



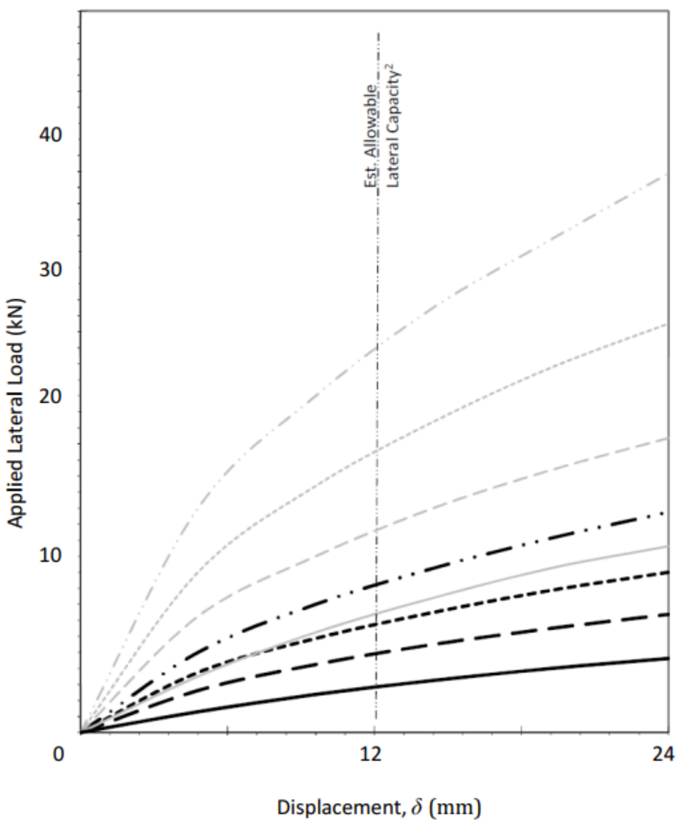

These charts are for Katana Piles only as lateral performance is highly dependent on the connections rigidity and shaft properties. It is Katana's opinion that these graphs represent a reasonable approximation of the average performance of th Katana Pile in the indexed soils. Using the average performance is reasonable for multiple redundant structures (e.g. buildings, bridges, marina piers, etc.)

AS2159 - 2009, states that the allowable lateral capacity of a pile is half load causing a 25mm of displacement. Many practitioners take this to be nearly the same as the lateral load predicated at 12mm displacement. The graph presented here can be used to evaluate capacity for either condition as well as to judge lateral performance under other displacement criteria and codes. The design allowable displacement is the responsibility of the design engineer.

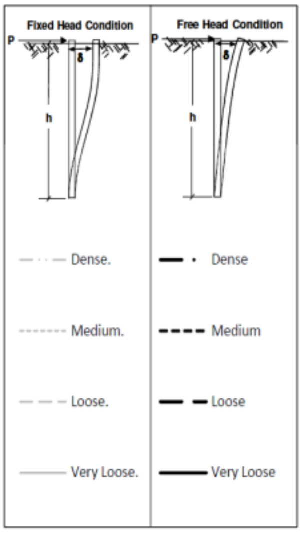
# Katana Pile - 150kN
## Lateral Performance in Sand

| Pile Properties | |
|---|---|
| Pipe Diameter (mm) | 88.9 |
| Wall Thickness (mm) | 5.5 |
| Steel Grade (f's) | 350 |
| Pile Base Dia. (mm) | 350 |

| Soil Properties | | |
|---|---|---|
| Soil Type | Angle of Friction (deg) | Cohesion Cu |
| Dense | 25 | 0 |
| Medium | 29 | 0 |
| Loose | 33 | 0 |




| Minimum Pile Depth, h | | |
|---|---|---|
| Soil Type | Fixed Head | Free Head |
| Dense | 40d | 34d |
| Medium | 30d | 28d |
| Loose | 28d | 24d |




These charts are for Katana Piles only as lateral performance is highly dependent on the connections rigidity and shaft properties. It is Katana's opinion that these graphs represent a reasonable approximation of the average performance of the Katana Pile in the indexed soils. Using the average performance is reasonable for multiple redundant structures (e.g. buildings, bridges, marina piers, etc.)

AS2159 - 2009, states that the allowable lateral capacity of a pile is half load causing a 25mm of displacement. Many practitioners take this to be nearly the same as the lateral load predicated at 12mm displacement. The graph presented here can be used to evaluate capacity for either condition as well as to judge lateral performance under other displacement criteria and codes. The design allowable displacement is the responsibility of the design engineer.