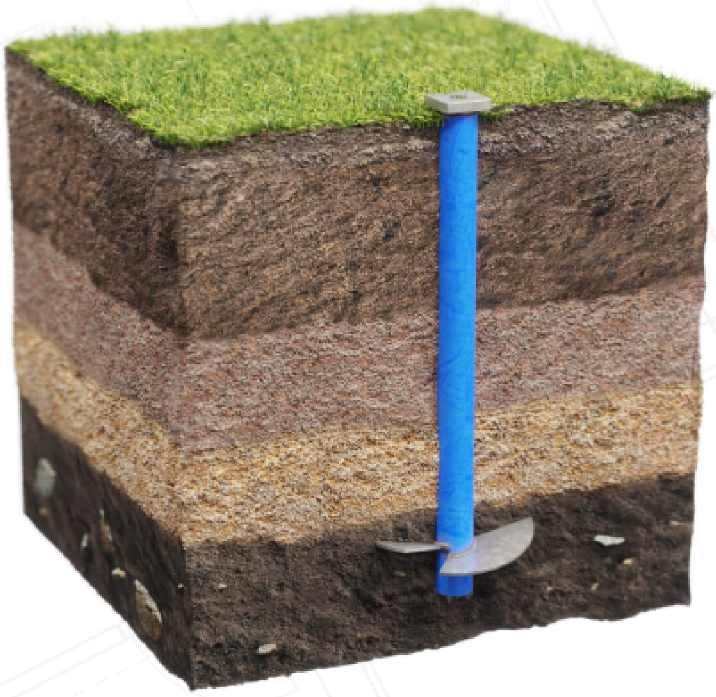
KATANA™
FOUNDATIONS

Katana Screw Pile
PERFORMANCE GUIDE

Technical design, specification, installation and compliance information for architects, engineers, builders and end users.



The Performance Guide

Contents

1.0 Katana Foundations
Introduction

At Katana Foundations, we strive to lead with best practice in everything we do. This Screw Pile Performance Guide demonstrates our commitment to transparency and collaboration with the various businesses that work with our products.

This document is primarily for use by our installers and suppliers but also as a guide for our customers and the engineers and building professionals our clients engage with. It is intended that this document will provide information for the proper design, testing, installation and certification of screw piles. We trust this document will assist in your understanding and the proper application of screw piles within the residential and light commercial building sector.

Should you have any questions or require further information, please feel free to contact us directly or access our additional resources below:

Email us at
info@katanafoundations.com.au

Our blog is packed with
helpful design and engineering tips, application info and more
katanafoundations.com.au/news

Our website
has all technical product information and brochures
katanafoundations.com.au

Our YouTube channel
helps you learn faster with our "how-to" videos

Our LinkedIn Page
is up to date with the latest company news at Katana

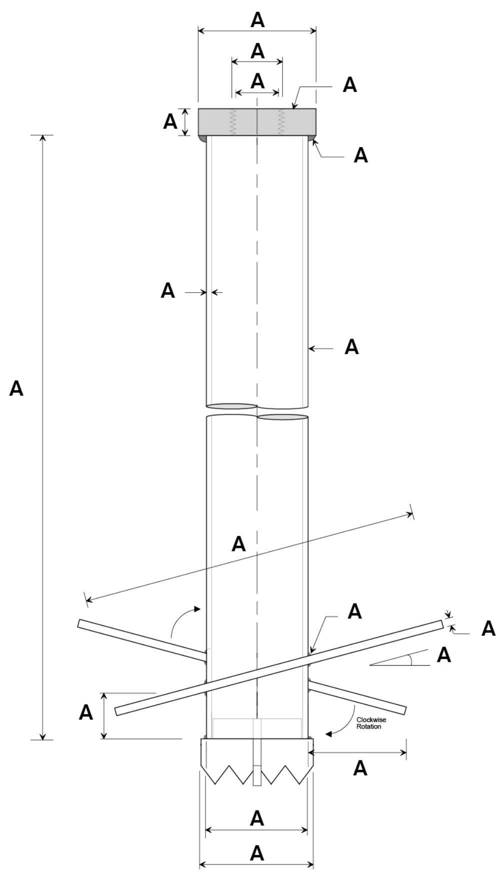
Our Facebook page
is the best way to follow our content as it get published

Katana Screw Pile Overview

The patented Katana Screw Pile is a twin-fin design foundation pile. It is made with high-tensile steel to deliver a high-performance foundation, piling through and bearing below the zone of influence, making it suitable for a multitude of applications.

The Top Plate

The top of the pile is capped with a 16mm thick plate with a 36mm threaded hole to accept various Katana pile accessories. The plate, when used with the Katana drive, has the safety benefit of engaging the pile to reduce the likelihood of the pile falling out of the drive head during the drilling process.



The Pipe

The pipe section (shaft) is made from Grade 400 high-tensile steel. It comes in a range of thicknesses, diameters and lengths to suit various applications and drilling depths.

The Helix

The helix has been designed to be one of the most efficient cutting devices for a screw pile. The result is a screw pile that can be drilled faster and deeper into harder soils. The helix diameter ranges from 250mm to 350mm, depending on the pile size. Basic plate bending analysis shows both helix plates achieve 4kN of SWL mostly at the leading edge (see Appendix TBC).

The Cutting Comb

As the first point of contact with the soil, the cutting comb serves two purposes. Firstly it makes drilling easier by the design of the teeth and being able to cut through hard material. Secondly it makes vertical alignment more accurate by the symmetry of the cutting teeth and twin fin helical blades.

Katana Pile Design Features

Most types of foundations try to wrestle mother nature into submission – and lose. We designed the Katana Screw Pile to work with the earth, so it would deliver superior ground connections. The Katana Screw Pile provides foundations that are more predictable, quantifiable, cost effective and low risk.

Australian Owned & Manufactured	Fabricated from Australian made pipe and plate	CodeMarked across Australia and New Zealand
Special mill 400+ MPa high-tensile yield feed	A full range of piles: 80kN, 100kN and 150kN	Stock fittings for raised floor and prefabricated modular projects
No spoil during drilling and no cartage/disposal costs	No unsafe open augered holes requiring covers or fencing	Cheaper than concrete bored piers and easier to install
No concrete pumping, labour and overruns	Accurate verification of capacity by torque	Low noise and minimal vibration
Longer life - options to cap, galvanise or electroplate	Complete installation certification	For more on the features and benefits of the Katana Screw Pile, download the **Product Brochure**

Product Range

The Katana Screw Pile range was specifically designed and tested for the Australian and New Zealand residential market. The core range consists of 3 screw piles sizes with load capacity ranging from 80kN to 150kN to suit a range of application needs. Each screw pile is available in customisable lengths up to 4 metres and can be connected to extension piles for applications requiring longer piles.

Shaft (diameter x thickness)	**Helix** (diameter x thickness)	**Lengths** (and increments)	**Typical capacity** (in stiff soils)
76.1mm x 4.0mm	250mm x 8mm	1.0m - 4.0m 0.5m increments	80 kN
76.1mm x 4.0mm	300 x 10mm	1.0m - 4.0m 0.5m increments	100 kN
88.9mm x 5.5mm	350 x 10mm	1.0m - 4.0m 0.5m increments	150 kN

Pile Options

The Katana Screw Pile can be further customised for your application requirements.

Pipe sealing	Unsealed | Sealed with welded steel plate top and bottom
Pile Coatings	Uncoated | Hot dip galvanised | Zinc electroplated
Applied coatings (applied by the customer)	Two-pack or fusion bonded epoxy or wrapping tapes

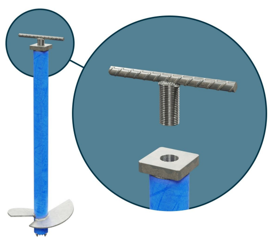
Accessories and Connectors

Katana Foundations have developed a range of connectors and accessories to complement the core Screw Pile product. These components enable the Katana pile to be used across a broad range of foundation and building applications.

All components have been designed and tested to provide a connected "system" capable of delivering the required load capacity and other engineering design requirements - thus eliminating the need for ad hoc connectors and providing greater design certainty.

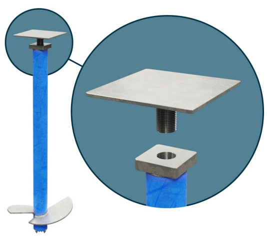
Slotted Bearer and Bearer Connector Plate

This connector is used to connect and support raised timber floors.



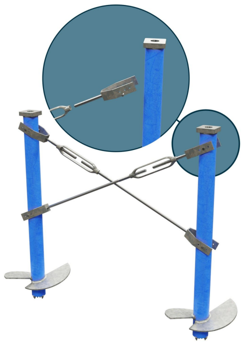
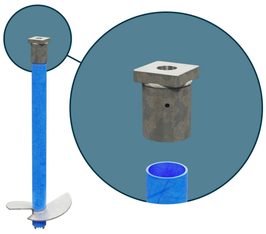
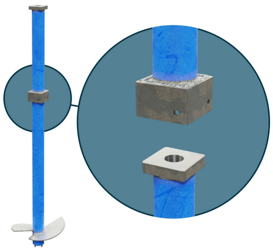
Edge Beam Connector

This adjustable connector is used for screw pile embedment into concrete footings or concrete slabs.



Slab Load Transfer and Bearer Plate

This adjustable connector is used to support concrete slabs where necessary.

	**Screw Pile Bracing** This adjustable bracing system is used to brace raised floors where piles are above ground level.
	**Pile Cap Adaptor** These adaptors are used where piles are cut on-site. They replace the 20mm pile top that has been cut off
	**Extension Pile** The extension is used where pile lengths of more than 4.0 metres are required.

Do you need a different connector?

If you have an application that is not supported by the above connectors and accessories, get in touch with us. We're always interested in helping people use the Katana Screw Pile in new ways and for new building applications.

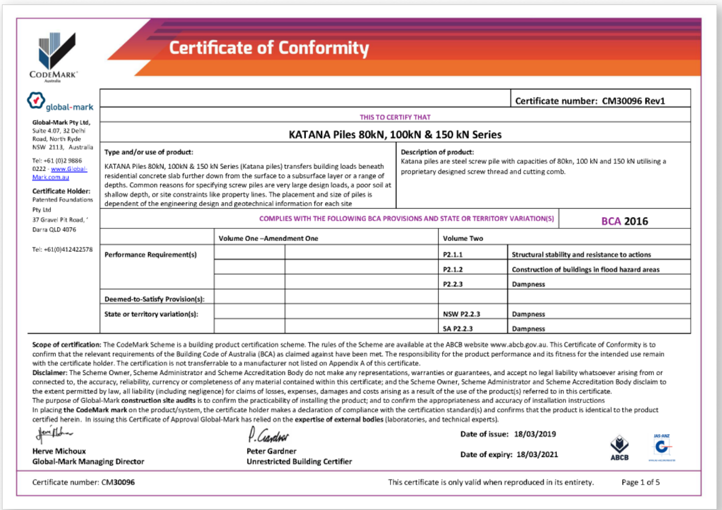
2.0 Katana Screw Pile

Technical Specification and Performance

IN THIS SECTION:

CodeMark

Katana Foundations are the only Australian or New Zealand screw pile company to have achieved CodeMark certification for their screw pile – the product, fabrication and installation.



CODEMARK Australia

Certificate of Conformity

global-mark

Global-Mark Pty Ltd, Suite 4.07, 32 Delhi Road, North Ryde NSW 2113, Australia

Tel: +61 (0)2 9886 0222 - www.Global-Mark.com.au

Certificate Holder: Patented Foundations Pty Ltd, 37 Gravel Pit Road, Darra QLD 4076

Tel: +61(0)412422578

			Certificate number: CM30096 Rev1	
THIS TO CERTIFY THAT				
KATANA Piles 80kN, 100kN & 150 kN Series				
Type and/or use of product: KATANA Piles 80kN, 100kN & 150 kN Series (Katana piles) transfers building loads beneath residential concrete slab further down from the surface to a subsurface layer or a range of depths. Common reasons for specifying screw piles are very large design loads, a poor soil at shallow depth, or site constraints like property lines. The placement and size of piles is dependent of the engineering design and geotechnical information for each site			**Description of product:** Katana piles are steel screw pile with capacities of 80kn, 100 kN and 150 kN utilising a proprietary designed screw thread and cutting comb.	
COMPLIES WITH THE FOLLOWING BCA PROVISIONS AND STATE OR TERRITORY VARIATION(S)				BCA 2016
	Volume One –Amendment One		Volume Two	
Performance Requirement(s)			P2.1.1	Structural stability and resistance to actions
			P2.1.2	Construction of buildings in flood hazard areas
			P2.2.3	Dampness
Deemed-to-Satisfy Provision(s):				
State or territory variation(s):			NSW P2.2.3	Dampness
			SA P2.2.3	Dampness

Scope of certification: The CodeMark Scheme is a building product certification scheme. The rules of the Scheme are available at the ABCB website www.abcb.gov.au. This Certificate of Conformity is to confirm that the relevant requirements of the Building Code of Australia (BCA) as claimed against have been met. The responsibility for the product performance and its fitness for the intended use remain with the certificate holder. The certification is not transferrable to a manufacturer not listed on Appendix A of this certificate.
Disclaimer: The Scheme Owner, Scheme Administrator and Scheme Accreditation Body do not make any representations, warranties or guarantees, and accept no legal liability whatsoever arising from or connected to, the accuracy, reliability, currency or completeness of any material contained within this certificate; and the Scheme Owner, Scheme Administrator and Scheme Accreditation Body disclaim to the extent permitted by law, all liability (including negligence) for claims of losses, expenses, damages and costs arising as a result of the use of the product(s) referred to in this certificate.
The purpose of Global-Mark **construction site audits** is to confirm the practicability of installing the product; and to confirm the appropriateness and accuracy of installation instructions
In placing **the CodeMark mark** on the product/system, the certificate holder makes a declaration of compliance with the certification standard(s) and confirms that the product is identical to the product certified herein. In issuing this Certificate of Approval Global-Mark has relied on the **expertise of external bodies** (laboratories, and technical experts).

Herve Michoux
Global-Mark Managing Director

Peter Gardner
Unrestricted Building Certifier

Date of issue: 18/03/2019
Date of expiry: 18/03/2021

ABCB   JAS-ANZ

Certificate number: CM30096   This certificate is only valid when reproduced in its entirety.   Page 1 of 5

Read more about the importance and advantages of products with [CodeMark Certification here].

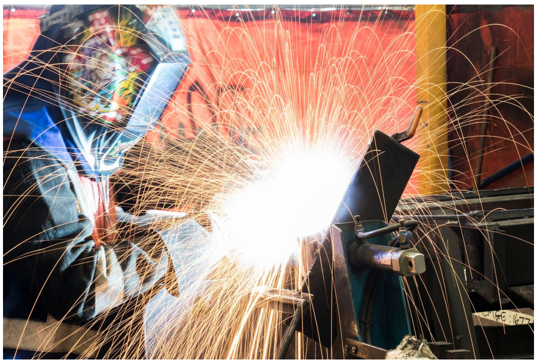
Download a copy of the Katana Screw Pile **CodeMark Certificate of Conformity** here.

Materials and Manufacturing

Katana Foundations source the steel for the Katana Screw Pile from Bluescope. Due to the high yield strength required and our production volume, we source a specific feed from the rolling mill.

The minimum yield strength of the pipe is 400 MPa.

The pipe is shipped to Stoddart, our manufacturing partner, where the piles and accessories are fabricated for dispatch around Australia and New Zealand.



Dimensions and Tolerances

The steel hollow sections conform to the manufacturing tolerances specified in AS 1163-2016.

Welding

Weld specifications comply with the report by e3K Global (Gilmore Engineers). Follow this link

Certification of materials

Test certificates are issued with the Katana piles for the steel used in the manufacture of the product in accordance with AS/NZS 3679.1 relating to tests performed by the manufacturer to establish compliance with the Standard.

Manufacturing Traceability

Full traceability of every manufactured component of the Katana Screw Pile can be provided. Each fabricated pile and accessory is visually inspected and approved by the manufacturer.

Key Technical Specifications

The steel Katana Pile shaft, bearing plates and helix are manufactured according to the following minimum technical specification in accordance with AS/NZS 1554.1. All steel complies with AS 4100.

	Unit	Standard	NATA	Manufacture	Value
MINIMUM YIELD STRENGTH					
Pipe	MPa	AS/NZS 1163	632 and 17051	AS 1554.1	400
Helix	MPa	AS/NZS 3678	632 and 631	AS 1554.1	350
Plate	MPa	AS/NZS 3678	632 and 631	AS 1554.1	350

Compression Load Capacity

Compression testing is conducted to determine the capacity of the Katana piling products.

Where soft or loose material is identified in the geotechnical report - is it always best practice to undertake a compression test to confirm soil and buckling capacity of the pile.

Load table: All Safe Working Loads (SWL) stiff clay and dense sand

Product	**Compression Load** Including where pile adaptor installed correctly*
76.1mm x 4.0mm, 250x8	80kN
76.1mm x 4.0mm, 300x8	100kN
88.9mm x5.5mm, 350x10	150kN

* Care to make a horizontal cut to the pile and ensure the pile adaptor sits firmly on the top of the cut pile after installation.

Torque Capacity

Torque Vs Compression Load

Our pile performance analysis (which is based on compression testing) indicates that when a torque of 4000Nm is achieved, a safe working load of 80kN is achieved in stiff soils.

The torque of 4000Nm is related back to hydraulic drive pressure which is shown on the pressure vs torque chart of an ED10,000 at 96 bar (converted to 1400psi).

Torsion Capacity

It is important to note the torsional capacity of the Katana Pile. Katana Piles are made from bespoke high strength steel with increased torsional capacity.

Torsion capacity = Ø 0.6 fy 2 (π(do^4-di^4)/32) /do

For a 101mm Ø pipe at 4mm thick: assume 250MPa - 350MPa yield strength steel from a mill (Ø = 0.9)*

- *Torsion capacity in theory is 7600Nm - 10700Nm*
- * assume yield between 250MPa and 350MPa

For a 76.1mm 400MPa - 500MPa high strength steel from a mill with proper QA (Ø = 0.989)

- Torsion capacity in theory is 7300Nm - 9200Nm

In practice we have found our pipe yields within the range above and while we do pre-drill from time to time in very hard material, mostly we are able to get our piles to depth without getting to the torsional yield point. The conclusion is that **higher yield strength makes quite a difference to being able to get your pile in the ground without the need to pre-drill**. Refer Mark's paper on Torsion - link.

Because our "special" steel is not one of the "official" grades in AS1163 - the mill cannot state that on the test certificate that it is a C400L0 product, however test certificates contain the results of regular testing carried out of the steel.

References: AS4100. Ø = design capacity factor, fy = design yield stress, do = outside diameter, di = inside diameter.

Tension Load Capacity

Tension testing is used to verify the capacity of the piles installed on a particular site and is carried out where uncertainty – of the soil conditions – may exist for a particular area or site. **It is critical to note** that when sand in particular is saturated, the uplift capacity is significantly reduced – if in doubt conduct an uplift test.

Product	Load – tension *where piles are cut Pile adaptor (3 Buildex Hex head screws rated at 5kN each)	Load – tension *where piles are cut Pile adaptor (3 M8 Tri-Fixx heavy duty screws rated at 9kN each)	Load – tension Edge Tie (if there is a 40mm CFW) between the N16 and 36mm threaded bar)	Load – tension 6mm slab plate
76.1x4 250x8	15kN	27kN	27.5kN	50kN
76.1x4 300x8	15kN	27kN	27.5kN	50kN
88.9x5.5 350x10	15kN	27kN	27.5kN	50kN

Edge Tie pull-out Test

(27.5kN SWL) – See Tension / uplift loading capacity table above

Some engineers may specify reinforcing through a hole in the top of the pile. The reinforcing is usually 29 diameters (29D) long to get full embedment into the concrete.

Katana Foundations uses an edge tie that is an N16 reinforcing bar 250mm long and when the pile is embedded into the concrete footing loads well in excess of what are required should satisfy the engineer that the Katana tie bar connector can be used as a replacement for the 50D (high due to 25MPa assumed as the concrete strength) reinforcing bar.

We have tested piles to failure and the result is **55kN (Ultimate load)** in uplift per pile or 110kN for two piles or **27.5kN (SWL) – per pile**.

Test Results

Test results of both uplift and lateral test undertaken on separate slabs, had given the test result of 110kN with a concrete strength of 25MPa. The test was undertaken on a concrete slab 19 days after initial pour. The results are as stated below.

Applied Load Type	Maximum Load Achieved
Vertical	11 Tonnes (110 kN)
Lateral	11 Tonnes (110 kN)

The Katana Piles were installed to an 80kN SWL at a depth of 2 metres with a spacing of 3 metres between each pile. The "Adjustable Edge Connectors", steel cage and slab mesh were installed as per this design manual. Taking into account the fact that this was a destructive test and only one undertaken for both "Lateral" and "Uplift" and the Katana Pile configuration, we can surmise the following:

In the Uplift mode, we contend that the load pressures distributed over the three piles, that the middle pile withstood a minimum 50% of the load. Also taking into account we base this on one test, we will use a FOS (Factory of Safety) of 2.0. In Lateral mode, we contend that the distribution of load was equal across the three Katana Piles.

Calculation:

Uplift (110kN / 2) / FOS = 27.5 kN per pile

Lateral (110kN / 3) / FOS = 18.3 kN per pile

In conclusion, the connections have significant capacity to achieve the required loads, both in uplift and lateral.

Cut Off Cap

(Tension or uplift SWL 15kN to 27kN)

Cut off caps may be problematic with raised floors or Polyvoid slabs as the capacity is limited by the self tapping screws (see tension table above) instead of the capacity of the pile - 80kN for example.

Where uplift is specified and piles are cut, there is the option to use an M8 heavy duty Tri-Fixx screw which is rated to 9kN SWL which will increase the capacity of the pile to the capacity of the edge tie.

Tri-Fixx M8 **Heavy Duty Self Drilling Screw *** Product Page Specification Sheet 	**Buildex 14-20 Hex Head** **Full Thread Teks Climaseal 4** Product Page Specification Sheet 	**Bunnings Zenith Screws** Not to be used 

** The Tri-Fixx M8 heavy duty screw needs to be drilled at a slower speed of less than 100rpm in order for the screw to start cutting the steel - high speed drilling of this screw will only heat treat the steel making it impossible for the screw to penetrate the steel.*

Options to further increase Uplift Loads

A hole can be drilled through the top of a Katana cut pile and reinforcing with a length (detailed in the table below) inserted into the hole to develop the tensile loads required. This is not our preferred method as it reduces the section capacity of the pile.

An eye bolt* with a 36mm thread can used (can only be used where the Katana pile is **NOT** cut).

See table can be used as a guide.

Both options need to be signed off by the engineer (ensure reinforcing is a neat fit in the hole or eye bolt):

Approx Tensile Load	**Reinforcing -** placed centrally in the eye bolt or through a hole drilled in the cut Katana Pile	Eye bolt* Safe Working Load
28kN	12mm 1000mm long	3 tonne
50kN	16mm 1500mm long	5 tonne
75kN	20mm 2000mm long	7.5 tonne
95kN	24mm 2500mm long	10 tonne
110kN	28mm 2800mm long	15 tonne

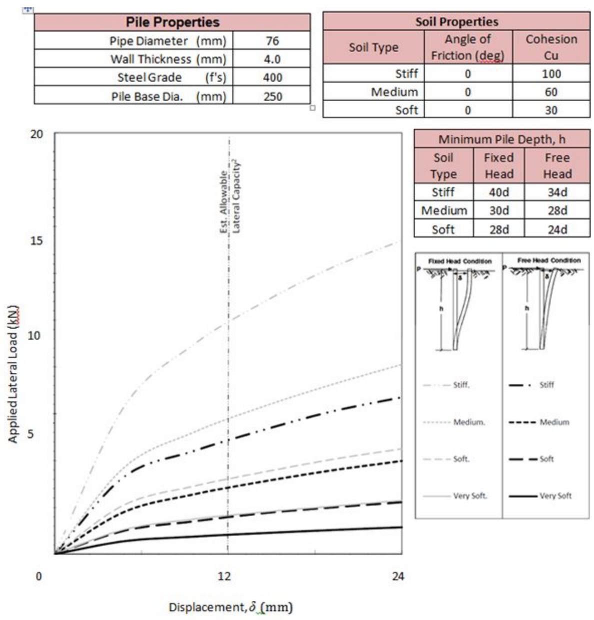
Lateral Load Capacity

Lateral testing is particularly important for raised floor applications and prefabricated buildings to understand the potential deflection of the piles and what bracing may be required.

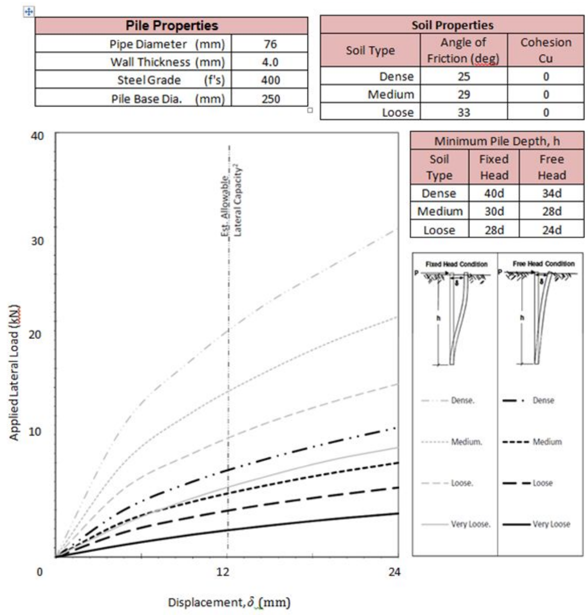
Product	Lateral Loads (AKA Shear Loads) dependent on soil stiffness
76.1x4 250x8	12mm 1000mm long
76.1x4 300x8	16mm 1500mm long
88.9x5.5 350x10	20mm 2000mm long

Refer link to these diagrams

Lateral Performance in Clay
80kN Pile



Lateral Performance in Sand
80kN Pile



Corrosion in ground

Steel Katana piles have been designed in accordance with AS 2159 Section 6.3 with an allowance for sectional loss based on the site corrosion classification and design life. Refer "Katana Twin-Fin Pile" corrosion manual by e3k Global in Appendix TBC.

Where the client provides a geotechnical or hydrological report indicating the exposure classification of the site, the expected lifetime of the pile is able to be calculated according to AS2159.

Typical results from a Geotechnical site investigation report are as per the table below.

Chlorides, pH and Resistivity are used in **AS 2159 (Table 6.5.2)** to determine the in-ground **Exposure Classification of steel piles**:

TABLE 6.4.2(A)

EXPOSURE CLASSIFICATION FOR CONCRETE PILES—PILES IN WATER

Exposure conditions	Exposure classification
Sea water—Submerged	Moderate
Sea water—Tidal/splash zone	Severe
Fresh water—Treat as in Table 6.4.2(C), Type A	Mild

TABLE 6.4.2(B)

EXPOSURE CLASSIFICATION FOR CONCRETE PILES—PILES IN REFUSE FILL

Exposure conditions	Exposure classification
Domestic waste	Severe
Industrial waste	Very severe

TABLE 6.4.2(C)

EXPOSURE CLASSIFICATION FOR CONCRETE PILES—PILES IN SOIL

Exposure conditions				Exposure classification	
Sulfates (expressed as SO_4*)		pH	Chlorides in groundwater	Soil conditions A†	Soil conditions B‡
In soil ppm	In groundwater ppm		ppm		
<5000	<1000	>5.5	<6000	Mild	Non-aggressive
5000–10 000	1000–3000	4.5–5.5	6000–12 000	Moderate	Mild
10 000–20 000	3000–10 000	4–4.5	12 000–30 000	Severe	Moderate
>20 000	>10 000	<4	>30 000	Very severe	Severe

* Approximately 100 ppm SO_4 = 80 ppm SO_3

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

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

NOTES TO TABLES 6.4.2(A), 6.4.3(B), AND 6.4.2(C):

1 This is a simplistic and sometimes conservative approach to the definition of aggressivity. It is common to find more than one chemical in the service environment and the effect of these chemicals may be modified in the presence of others. For example, sulfate ions become aggressive at levels of 600 to 1000 ppm when combined with magnesium or ammonium ions. In the presence of chloride ions, however, attack by sulfate ions generally exhibits little disruptive expansion with the exception of conditions of wetting and extreme drying where crystallization can cause surface fretting of concrete.

2 Corrosion damage by chlorides is only relevant to the steel reinforcement and steel inclusions. If there is no reinforcement or the reinforcement is otherwise adequately protected (e.g., by a coating or cathodic protection) the chloride content is not relevant to the exposure classification.

3 Chemical concentrations relate only to the proportion of chemical present that is water-soluble.

4 Acidic ground conditions can be caused by dissolved 'aggressive' carbon dioxide, pure and very soft waters, organic and mineral acids and bacterial activity. Care is required in the assessment of pH under pile installation and lifetime conditions since pH can change over the lifetime of the pile. Therefore the pH should not be assessed only on the basis of a present-day test result, rather the ground chemistry should be considered over the design life of the pile. Testing for pH should be carried out either in situ or immediately after sampling as there is otherwise a risk of oxidation with time, leading to apparent acidity, which does not correctly represent in situ conditions.

5 pH alone may be a misleading measure of aggressivity without a full analysis of causes (e.g. still vs. running water).

6 Contamination by the tipping of mineral and domestic wastes or by spillage from mining, processing or manufacturing industries presents special durability risks due to the presence of certain aggressive acids, salts and solvents, which can either chemically attack concrete or lead to a corrosion risk. Certain ground conditions cannot be properly addressed by reference only to Tables 6.4.2 (A), (B) and (C). These conditions include, for example, areas where acid-sulfate soils exist, contamination by industrial and domestic waste, or spillage from mining, processing, or manufacturing industries. This presents special durability risks due to the presence of certain aggressive acids, alkalis, salts and solvents, which can lead to either chemical attack of concrete or lead to a corrosion risk. In the absence of site-specific chemical information, the exposure condition should be assessed as 'severe' for domestic refuse and 'very severe' for industrial/mining waste tips. Chemical analysis of the latter may, however, allow a lower risk classification.

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

8 Attention is drawn to regions of dry land salinity where the chloride concentrations in the soil can be greater than seawater (e.g., Western Sydney, Murray River basin). This can affect the upper few metres of a pile where the aggressive salts accumulate.

9 Cathodic protection should not fall below the levels recommended in AS 2832.5.

Sulfates and pH are used in **AS 2870** to determine the in-ground **Exposure Classification of concrete**:

TABLE 5.2

EXPOSURE CLASSIFICATION FOR CONCRETE IN SULFATE SOILS

Exposure conditions			Exposure classification	
Sulfates (expressed as SO_4)*		pH	Soil conditions A†	Soil conditions B‡
In soil ppm	In groundwater ppm			
<5000	<1000	>5.5	A2	A1
5000–10 000	1000–3000	4.5–5.5	B1	A2
10 000–20 000	3000–10 000	4–4.5	B2	B1
>20 000	>10 000	<4	C2	B2

* Approximately 100 ppm SO_4 = 80 ppm SO_3

† 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

A **low resistivity soil** readily allows the flow of electric current and will result in a higher corrosion rate.

Groundwater or soil containing **high amounts of chlorides** will corrode the steel at a higher rate.

Lower Ph (or acidic soil) will corrode steel at a faster rate.

AS 2159 is clear on the treatment of contaminated sites - see note 6 under table 6.4.2 (severe and very severe). For these conditions, we can provide thicker steel, galvanising and even cathodic protection.

Note: Piles in seawater are considered Severe and Very Severe which means salinity should be considered in determining the life of the piles.

The client's geotechnical and/or chemical engineer needs to determine the exposure classification of the soil as in the example below and recommend the protection required. Predicting the corrosion rates, especially on contaminated sites should be left to the experts.

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

Below is a summary of the recommendations for the 76.1x4 Katana pile.

Exposure Classification	Uniform corrosion allowance (mm)	Uniform corrosion over 50 year life (mm)	Recommendations	Estimated Life (years)
Non Aggressive	< 0.01	< 0.5	Basic design OK	100+ (corrosion inside and outside)
Mild	0.01 - 0.02	0.5 - 1.0	Basic design OK	100+ (corrosion inside and outside)
Moderate	0.02 - 0.04	1.0 - 2.0	Fully sealed	100+ (corrosion inside and outside)
Severe	0.04 - 0.1	2.0 - 5.0	Fully sealed + increase wall thickness to 7mm + 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)

Best practice is to request the geotechnical engineer to classify the exposure of the pile in order to provide an estimated life of the piles.

Expected In-Ground Life

The life expectancy of a pile is directly related to the exposure classification in AS2159 and the thickness of the steel section.

Assumptions:

- Ground water well below ground level
- No moisture at ground level
- At end of life the pile has half its section thickness
- Refer Table 6.4 AS2159

Exposure Classification	Uniform corrosion allowance (mm)	**Unsealed** (corrosion on two surfaces)			**Sealed** (corrosion only on one surface)	
		76 x 4	88 x 5.5	10mm pipe one side - 5mm	76 x 4 w/ sealed end#	88 x 5.5 w/ sealed end#
Non Aggressive	< 0.01	100	137	500	200	275
Mild	0.01 - 0.02	50-100	68-137	250-500	100-200	138-275
Moderate **	0.02 - 0.04	25-50	34-68	125-250	50-100	68-138
Severe ***	0.04 - 0.1	10-25	13-34	50-125	20-50	27-68
Very Severe ****	> 0.1	<10	<13	<50	<20	<27

** Recommend pile is sealed (corrosion only from one side)

*** Recommend that piles have at least 10mm thick walls. Sealed piles cannot be galvanised or zinc coated - paint it likely to come off during the installation process.

**** Steel piles in ground - not recommended

Only applies where pile extensions are NOT used - where extensions are used, assume pile must be uncapped.

A guide for the use of 76x4 piles by incorporating Exposure Classification for steel (pH) and concrete (Sulphates)

	Table 5.2 AS 2870 Exposure classification for concrete			
	A1	A2	B1	B2

		pH > 5.5	pH 4.5-5.5	pH 4-4.5	pH <4
Table 6.5.2 (C) AS 2158 Exposure Classification for steel piles - piles in soil	Non Aggressive pH > 5	**76x4**	**76x4 sealed**	**Galvanised**	
	Mild pH 4-5	**76x4**	**76x4 sealed**	**Galvanised**	
	Moderate pH 3-4	**76x4 sealed**	**76x4 sealed**	**Galvanised**	
	Severe pH < 3				

Expected Above-Ground Life

Where piles are located above ground, Katana Foundations recommends the use of an appropriate coating system – giving consideration to the expected life of the structure and exposure conditions – to be determined by the design engineer.

Expected above ground life for Galvanised or Zinc Electroplated Katana Piles

Corrosivity Factor*	Zinc corrosion rate Table 2 ISO 9223 um/annum	Galvanising - assume min 55um*	Zinc Electroplating - min 12um	Zinc Electroplating - average 25um* (difficult to measure)	Uncoated mild steel (2mm) or 2000um**
C1	0.1	550	120	250	1538
C2	0.7	78.5	17.1	35	80
C3	2.1	26.1	5.7	11.9	40
C4	4.2	13.1	2.8	5.9	25
C5	8.4	6.5	1.4	2.9	10
Cx	25	2.2	.5	1	2.8

* Coating thicknesses from Fero and C.P. Plating (Stoddart suppliers)

** https://gaa.com.au/performance-in-various-environments/

Refer ISO 9223 - add uncoated life of mild steel

For explanations of Corrosivity Factors, see tables below.

Corrosivity category	Comparative corrosion rates for steel and zinc from ISO 9223 r_{corr}		
	Unit	**Carbon steel**	**Zinc**
C1	g/(m²·a)	$r_{corr} \leq 10$	$r_{corr} \leq 0.7$
	µm/a	$r_{corr} \leq 1.3$	$r_{corr} \leq 0.1$
C2	g/(m²·a)	$10 < r_{corr} \leq 200$	$0.7 < r_{corr} \leq 5$
	µm/a	$1.3 < r_{corr} \leq 25$	$0.1 < r_{corr} \leq 0.7$
C3	g/(m²·a)	$200 < r_{corr} \leq 400$	$5 < r_{corr} \leq 15$
	µm/a	$25 < r_{corr} \leq 50$	$0.7 < r_{corr} \leq 2.1$
C4	g/(m²·a)	$400 < r_{corr} \leq 650$	$15 < r_{corr} \leq 30$
	µm/a	$50 < r_{corr} \leq 80$	$2.1 < r_{corr} \leq 4.2$
C5	g/(m²·a)	$650 < r_{corr} \leq 1,500$	$30 < r_{corr} \leq 60$
	µm/a	$80 < r_{corr} \leq 200$	$4.2 < r_{corr} \leq 8.4$
CX	g/(m²·a)	$1,500 < r_{corr} \leq 5,500$	$60 < r_{corr} \leq 180$
	µm/a	$200 < r_{corr} \leq 700$	$8.4 < r_{corr} \leq 25$
The classification criterion is based on the methods of determination of corrosion rates of standard specimens for the evaluation of corrosivity (see ISO 9226[xi]).			
The corrosion rates, expressed in grams per square metre per year [g/(m²·a)], are recalculated in micrometres per year (µm/a) and rounded.			
Corrosion rates in category CX are considered extreme. Corrosivity category CX refers to specific marine and marine/industrial environments.			
Specific calculation models, guiding corrosion values and additional information on long-term corrosion behaviour, are given in ISO 9224[xii].			

Corrosivity category	Corrosivity	Typical environments – Examples from ISO 9223	
		Indoor	**Outdoor**
C1	Very low	Heated spaces with low relative humidity and insignificant pollution, e.g. offices, schools, museums	Dry or cold zone, atmospheric environment with very low pollution and time of wetness, e.g. certain deserts, Central Arctic/Antarctica
C2	Low	Unheated spaces with varying temperature and relative humidity. Low frequency of condensation and low pollution, e.g. storage, sport halls	Temperate zone, atmospheric environment with low pollution (SO_2 < 5 $\mu g/m^3$), e.g. rural areas, small towns Dry or cold zone, atmospheric environment with short time of wetness, e.g. deserts, subarctic areas
C3	Medium	Spaces with moderate frequency of condensation and moderate pollution from production process, e.g. food-processing plants, laundries, breweries, dairies	Temperate zone, atmospheric environment with medium pollution (SO_2: 5 $\mu g/m^3$ to 30 $\mu g/m^3$) or some effect of chlorides, e.g. urban areas, coastal areas with low deposition of chlorides Subtropical and tropical zone, atmosphere with low pollution
C4	High	Spaces with high frequency of condensation and high pollution from production process, e.g. industrial processing plants, swimming pools	Temperate zone, atmospheric environment with high pollution (SO_2: 30 $\mu g/m^3$ to 90 $\mu g/m^3$) or substantial effect of chlorides, e.g. polluted urban areas, industrial areas, coastal areas without spray of salt water or, exposure to strong effect of de-icing salts Subtropical and tropical zone, atmosphere with medium pollution
C5	Very high	Spaces with very high frequency of condensation and/or with high pollution from production process, e.g. mines, caverns for industrial purposes, unventilated sheds in subtropical and tropical zones	Temperate and subtropical zone, atmospheric environment with very high pollution (SO_2: 90 $\mu g/m^3$ to 250 $\mu g/m^3$) and/or significant effect of chlorides, e.g. industrial areas, coastal areas, sheltered positions on coastline
CX	Extreme	Spaces with almost permanent condensation or extensive periods of exposure to extreme humidity effects and/or with high pollution from production process, e.g. unventilated sheds in humid tropical zones with penetration of outdoor pollution including airborne chlorides and corrosion-stimulating particulate matter	Subtropical and tropical zone (very high time of wetness), atmospheric environment with very high SO_2 pollution (higher than 250 $\mu g/m^3$) including accompanying and production factors and/or strong effect of chlorides, e.g. extreme industrial areas, coastal and offshore areas, occasional contact with salt spray
Deposition of chlorides in coastal areas is strongly dependent on the variables influencing the transport inland of sea salt, such as wind direction, wind velocity, local topography, wind sheltering islands outside the coast, distance of the site from the sea, etc. Extreme effect by chlorides, which is typical of marine splash or heavy salt spray, is outside of the scope of this Chart. Corrosivity classification of specific service atmospheres, e.g. in chemical industries, is outside of the scope of this Chart. Surfaces that are not sheltered or rain-washed in marine atmospheric environments where chlorides are deposited can experience a higher corrosivity category due to the presence of hygroscopic salts.			
In environments with expected "CX category", it is recommended that the atmospheric corrosivity classification from one-year corrosion losses be determined. One-year exposure tests should start in the spring or autumn. In climates with marked seasonal differences, a starting time in the most aggressive period is recommended.			
The concentration of sulfur dioxide (SO_2) should be determined during at least one year and is expressed as the annual average. However, in Australia, SO_2 is so low in most environments that it is generally considered that It can be ignored, other than for specific industrial applications or extreme traffic examples.			
Coastal areas are normally defined as between 50 metres to 1 Km inland from sheltered seas and between 1 Km and 10-50 Km from surf beaches depending upon prevailing winds and topography. More details and examples are available in AS 4312.			

3.0 How to Design
with the Katana Screw Pile

IN THIS SECTION:

Calculation of building loads

Calculation of Live and Dead structure loads

Ultimate Load Transmitted to Edge Beam, kN/m

Based on the above parameters, the following dead loads (G), live loads (Q), and ultimate limit state loads (U) transmitted to the edge beam can be derived.

a. Roof loads
   - Live load = 6m x 0.25kPa = 1.5kN/m (Q).
   - Concrete tile roof DL = 6m x 0.9kPa = 5.4kN/m (G).
   - Metal sheet roof DL = 6m x 0.4kPa = 2.4kN/m (G).
   - Ultimate tile roof load = 1.2G + 1.5Q = 1.2 x 5.4 + 1.5 x 1.5 = 8.73kN/m (U).
     Or 1.35G = 1.35 x 5.4 = 7.29kN/m (U).
   - Ultimate metal roof load = 1.2G + 1.5Q = 1.2 x 2.4 + 1.5 x 1.5 = 5.13kN/m (U).
     Or 1.35G = 1.35 x 2.4 = 3.24kN/m (U).

b. Brick veneer loads
   - Single storey = 3m x 2.44kPa = 7.32kN/m (G).
   - Double storey = 6m x 2.44kPa = 14.64kN/m (G).
   - Ultimate single storey load = 1.2G = 1.2 x 7.32 = 8.78kN/m (U).
     Or 1.35G = 1.35 x 7.32 = 9.88kN/m (U).

- Ultimate double storey load = 1.2G = 1.2 x 14.64 = 17.57kN/m (U).

  Or 1.35G = 1.35 x 14.64 = 19.76kN/m (U).

c. Timber / light gauge steel suspended floor loads –

- Live load = 3m x 1.5kPa = 4.5kN/m (Q).
- Timber suspended floor DL = 3m x 0.9kPa = 2.7kN/m (G).
- Ultimate single storey load = 1.2G + 1.5Q = 1.2 x 2.7 + 1.5 x 4.5 = 9.99kN/m (U).

  Or 1.35G = 1.35 x 2.7 = 3.65kN/m (U).

d. Ground floor void slab

- Live load = 1.5m x 1.5kPa = 2.25kN/m (Q).
- Dead loads are slab self-weight = 3kPa

  + partition allowance = 0.5kPa

  + floor tile allowance = 0.5kPa
- Total dead load = 4.0kPa x 1.5m = 6.0kN/m (G).
- Ultimate ground floor load = 1.2G + 1.5Q = 1.2 x 6.0 + 1.5 x 2.25 = 10.58kN/m (U).

  Or 1.35G = 1.35 x 6.0 = 8.10kN/m (U).

Various Line Loads to Edge Beam (Ultimate limit state) (Examples)

Single, Storey, Tile Roof, Brick Veneer Wall

Element	1.2G + 1.5Q	1.35G
Roof tiles	8.73kN/m	7.29kN/m
Brick veneer (3m)	8.78kN/m	9.88kN/m
Ground floor slab	10.58kN/m	8.10kN/m
Line load (ULS)	28.09kN/m	25.27kN/m

Controlling line load (ULS) = 1.2G + 1.5Q = 28.09kN/m.

Single Storey, Metal Sheet Roof, Brick Veneer Wall

Element	1.2G + 1.5Q	1.35G
Sheet roof	5.13kN/m	3.24kN/m
Brick veneer (3m)	8.78kN/m	9.88kN/m
Ground floor slab	10.58kN/m	8.10kN/m
Line load (ULS)	24.49kN/m	21.22kN/m

Controlling line load (ULS) = 1.2G + 1.5Q = 24.49kN/m.

Double, Storey, Tile Roof, Brick Veneer Wall

Element	1.2G + 1.5Q	1.35G
Roof tiles	8.73kN/m	7.29kN/m
Brick veneer (6m)	17.57kN/m	19.76kN/m
Timber suspended floor	9.99kN/m	3.65kN/m
Ground floor slab	10.58kN/m	8.10kN/m
Line load (ULS)	46.87kN/m	38.80kN/m

Controlling line load (ULS) = 1.2G + 1.5Q = 46.87kN/m.

Double Storey, Metal Sheet Roof, Brick Veneer Wall

Element	1.2G + 1.5Q	1.35G
Sheet roof	5.13kN/m	3.24kN/m
Brick veneer (6m)	17.57kN/m	19.76kN/m
Timber suspended floor	9.99kN/m	3.65kN/m
Ground floor slab	10.58kN/m	8.10kN/m
Line load (ULS)	43.27kN/m	34.75kN/m

Controlling line load (ULS) = 1.2G + 1.5Q = 43.27kN/m.

Once the line loads have been determined, then the piles loads can be calculated based on the possible spacing of the piles.

SWL of piles in kN - (FOS = 1.5) based on the above ULS building load table * Assumption - founding soil carries no load:

Pile Spacing	Load (kN/m)	1.5m SWL kN	2.0m SWL kN	2.5m SWL kN	3.0m SWL kN
Single Story Brick Veneer Tile Roof	28.09	2.81	37.5	46.8	56.2
Single Story Brick Veneer Metal roof	24.49	24.5	32.7	40.8	49
Double Story Brick Veneer Tile Roof	46.87	46.9	62.5	78.1	93.7
Double Story Brick Veneer Metal Roof	43.27	43.3	57.7	72.1	86.5

Soil capacity

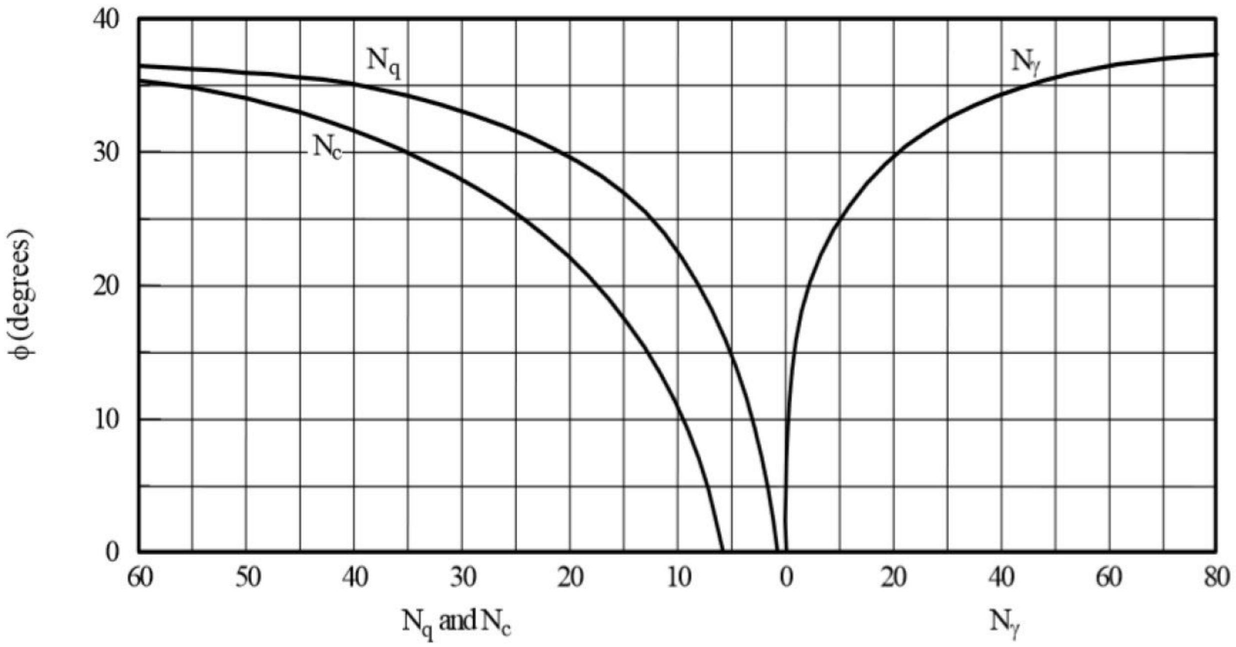
A good general guide is the Practice Note 28 "Screw Piles: Guidelines for Design, Construction & Installation. Engineers New Zealand (IPENZ)

One theoretical approach is by Donald J. Clayton "Basic Helical Screw Pile Design".

Some rules of thumb are:

- Where piles are relatively long in loose soils (Penetrometer tests indicate loose material), reduced buckling capacity must be considered
- Screw pile helix are individually effective when spaced more than 3 helix diameters apart

N = Bearing capacity factors (Terzaghi 1943 and Meyerhof 1951)



CAPACITY = Capacity of a cohesionless sand + Capacity of a cohesive clay

= Sum of areas of helices (q Nq + c Nc) + skin friction ignored

Capacity of a cohesionless sand = (area of helix) x (overburden) x Nq

For sand phi is related to Nq

Capacity of a cohesive clay = (area of helix) x (shear strength) x Nc

For clay or phi=0 Nc = 9 (Skempton 1951)

Several other theories exist such as Perko, Winkler, Walsh, Mitchell etc. Whatever theory the reader decides to adopt - it is always prudent to take the most conservative theoretical calculation.

Calculating the theoretical capacity of a screw pile is helpful to design the pile shaft, number and thickness of plates/helices, shaft diameter but it is only an approximation of what will occur in the field.

Pull up or compression testing on site or in the field, in areas where there may be uncertainty is always recommended by the screw piling company.

Steel Capacity

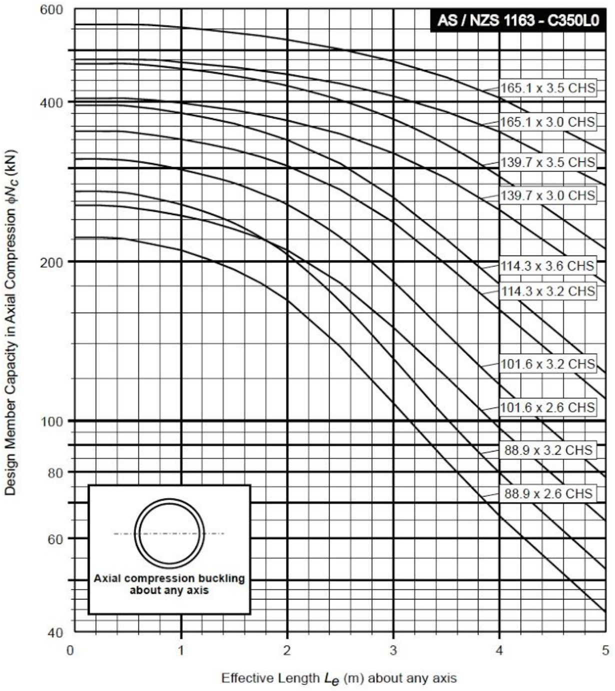
The Pipe

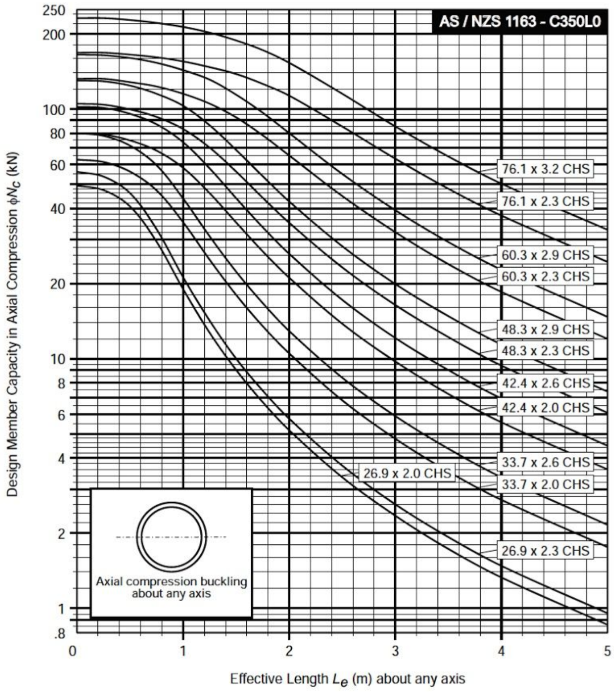
76.1mm pipe axial capacity (unbraced) 4.0mm thick 400MPa = 289kN. This is for a pile that is in stiff material i.e. fully supported along its entire length.

Note that in softer soils a 76.1mm pile longer than 4m may have a buckling load less than 80kN due to the reduction in its buckling load capacity.

The chart below shows how the axial capacity is reduced the longer the length of the pile.

The piling contractor to ensure the axial strength confirmed by the engineer.





The Helix

Basic plate bending analysis with both plates contributing 4kN of SWL mostly at the leading edge.

Ultimate load testing was then carried out on various soil types and the helixes inspected for any bending.

In loose / soft soils the strength of the plate / helix will always be more than the soil and in the case of dense / hard soils over time the soil above the helix consolidates and the helix acts more in shear along the shaft rather than in bending.

Design Method 1:
Estimating ultimate capacity from Installation torque

An approximation of the capacity of a pile can be made from empirical evidence below. One needs to however understand that there are a number of variables and the answer can only ever be considered an approximation.

Reference: Perko

Qu = KT

Qu = ultimate capacity

K = Ratio (m-1 / ft-1)

T = Torque

From the regression analysis (Perko graph below) K is correlated to pile diameter and is different - metric vs imperial.

Assume we get 6kNm of torque on our 76.1mm pipe

K=27

Qu = ultimate load = 27 x 6kNm = 162kN

Our true blue pipe could be torqued to between 7.3kNm and 9.2kNm - above 160kN.

For our 88.8mm pipe assume a torque of 13kNm: Qu = 23 x 13kNm = 300kN

The governing factor is usually always the bearing capacity of the soil.

In the chart, there is clearly a variance in K and that is because torque and ultimate capacity can be affected by:

Pile: number and Helix diameter, helix thickness, helix pitch, shaft shape, connection detail

Soil: type, strength, stiffness, water table Installation: rotation rate, advance rate, down force

Testing: Load rate and increments, waiting time, interpretation

Take care with K - but by all means use it to approximate the capacity of what your piling contractor has installed in the field.

Design Method 2:
Calculating Load Capacity, by Donald J. Clayton

There are numerous theories dealing with the calculation of screw piles load capacity. A working example of one theory is provided below. Calculating pile capacities by using a number of theories will give different answers and ultimately these calculations should be verified in the field by testing.

Ultimate load testing was carried out on various soil types and the helixes inspected for any bending.

In loose / soft soils the strength of the plate / helix will always be more than the soil and in the case of dense / hard soils over time the soil above the helix consolidates and the helix acts more in shear along the shaft rather than in bending.

Katana Pile load table for various soil types - remember CAPACITY = Sum of areas of helixes (q Nq + c Nc) + skin friction ignored:

Capacity of a cohesionless sand = (area of helix) x (overburden) x Nq

For sand phi is related to Nq

For a plate 250mm in dia, depth of pile 3m and sand with a density of 16kN/m3 and phi = 32 deg, Nq = 81

Capacity = 0.0446 x (16kN/m3 x 3m) x 81 = 173kN / 1.5 = 115kN

GUIDE CAPACITY TABLE - PILE IN SAND: Single Helix, Depth of Helix 3m (for shallow depths loads will be lower), FOS 1.5 - Assumes pipe torsion will not be a limiting factor!

Soil Type	Density - phi	**80kN** 76x250(8) (kN)	**100kN** 76x300(8) (kN)	**150kN** 88x350(10) (kN)	**250kN**** 114x450(12) (kN)
SAND:					
Loose	15 - 28	53	79	107	266
Medium	16 - 32	**115**	171	230*	300*
Dense	17 - 36	200*	200*	230*	300*
Gravel with some sand	17 - 40	200*	200*	230*	300*
Silts	16 - 30	81	120	230*	300*

** Limited by helix weld assuming a helix shear weld failure*

*** Comprehensive testing has not been carried out on this product - see note under compression load table*

Capacity of a cohesive clay = (area of helix) x (shear strength) x Nc

For clay or phi=0 Nc = 9 (Skempton 1951)

For a plate 250mm in dia and a clay with shear strength of 100 kPa

Capacity = 0.0446 x 100kPa x 9 = 40.5kN / 1.5 = 27kN

GUIDE CAPACITY TABLE - PILE IN CLAY: Single Helix, Depth of Helix 3m, FOS 1.5 - Assumes pipe torsion will not be a limiting factor!

Soil Type	Undrained Shear Strength (kPa)	76x250(8) (kN)	76x300(8) (kN)	88x350(10) (kN)	114x450(12) (kN)
CLAY:					
Soft	25	7	10	14	22
Firm	50	13	20	27	45
Stiff	100	**27**	40	54	89
Very Stiff	200	53	79	108	179
Hard	>200				

If you had a sandy clay as an example above the soil capacity would be 115kN + 27kN + skin friction (ignored) = 142kN

AS2870 and the Hs rule

Katana's default position is 1.25Hs as per G6.3 of AS2870 - this clause applies 1.25Hs for "reactive" soils irrespective of their reactivity or consideration of the likely movement below the pile.

Engineers and Katana Foundations will consider the likely movement of the pile referring to the reactivity of the soil below the pile.

This rule does not apply to bored piers and does result in significant confusion in the industry.

Katana Foundations should rely on the design engineer to specify the depth of the pile.

KATANA FOUNDATIONS

Designing for:
Prefabricated buildings and bracing

How high can I have my building out the ground?

Typically around 1.5 to 2m. The issue is really around trying to have one pilot pile (rather than extending the pile as this introduces movement into the system). A 5.5t excavator may only be able to install a 3.5m long pile.

The next issue is the buckling capacity of the pile and the engineer may choose to use a 88.9mmx5.5mm pile rather than a 76.1mmx4mm pile.

It may be possible to have longer piles out of the ground but the engineer may want to consider a rigid / welded connection at ground level and a comprehensive bracing system.

Axial loading

All loads must be located on the centre line of the piles.

In the Technical Docs and Product Guide folder, there are some calculations for bearer plate capacity that can be used as a guide – subject to the engineer signing them off.

MUST BE CONFIRMED BY ENGINEER – Allowable bearer and slab plate loads

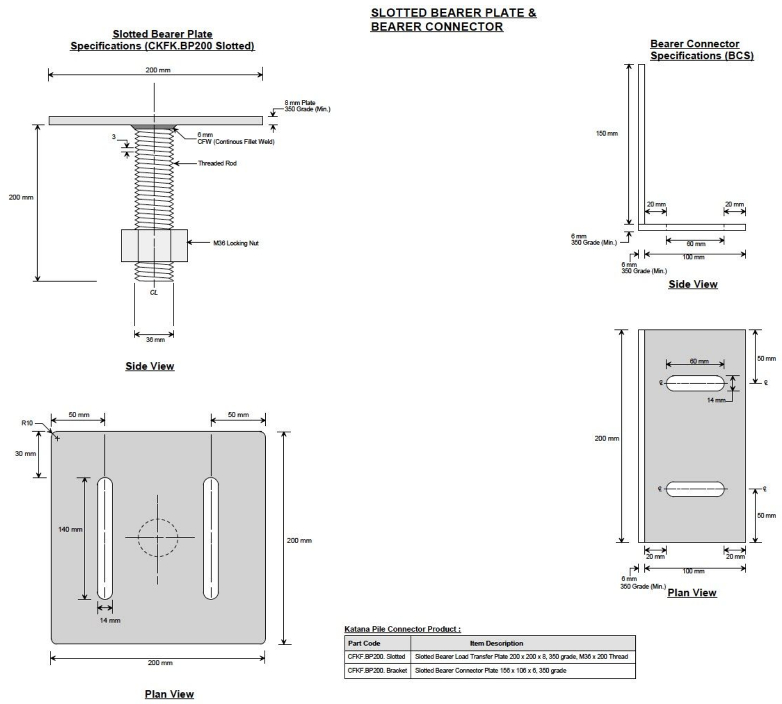
Where loads are eccentric to the centre of the pile, the appropriate bearer plate and supports must be designed for the additional bending moment introduced by the eccentric loads.

Tolerance

As the tolerance of the pile may vary up to 75mm the 200mm plate will accommodate this, but will need to be cut on site to match the outside edge of the PFC. The plate will need to be coated with an appropriate cold galv paint after it has been cut.

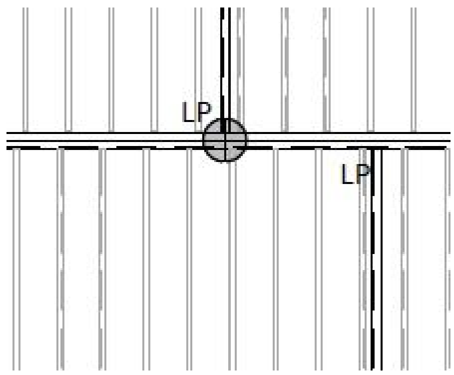
Connection details

Below are the standard bearer plate and connector plate options which can be provided to suit the 20mm plate at the top of the Katana Pile.

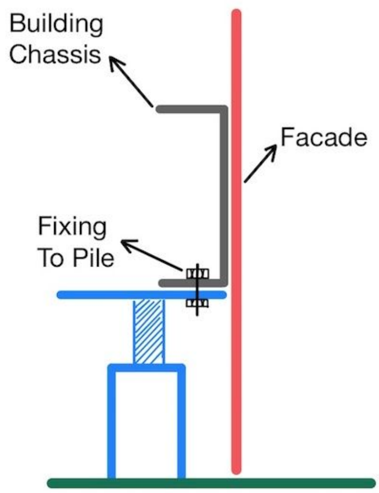


Part Code	Item Description
CFKF.BP200. Slotted	Slotted Bearer Load Transfer Plate 200 x 200 x 8, 350 grade, M36 x 200 Thread
CFKF.BP200. Bracket	Slotted Bearer Connector Plate 156 x 106 x 6, 350 grade

The bearer plate connector (backing plate) may clash with the chassis in the corner and joists in certain locations.



FIX: Engineer to reposition piles away from the edges and joists to avoid this clash or avoid the use of the backing plate as detailed below.



Lateral Loading

Where piles more than 500mm above the ground or in soft soil should be braced.

Improving the lateral capacity of the pile is possible with:

- Bracing piles
- Piles drilled on an angle and connected to the structure
- Horizontal cross bracing
- Concrete footings at ground level

It is always preferred to have piles that are only one piece with no extensions. Where extensions are required for the piles – the extension should be as long as possible and the connection as deep in the ground as practically possible.

A full risk assessment and Safe Working Method must be developed by the client when sliding buildings on screw piles.

When buildings are "slid" into place, there is a concern about the lateral capacity of the pile and any eccentricity introduced on the pile.

In Australia rails are used on top of the piles to slide buildings into place.

In other circumstances a temporary steel beam can be used to slide buildings – which is removed when the building is in place by jacking the building to release the beam – however the piles need to be laterally supported during the sliding process.

Horizontal bracing or a permanent beam can also be used.

Rubber mats should be used between steel members to avoid the possibility of any sliding and higher corrosion rate between different steel materials.

Bracing

Katana can provide a bracing system for raised floors. Ideally the raised floor is installed and the measurements taken in order to fabricate the bracing.

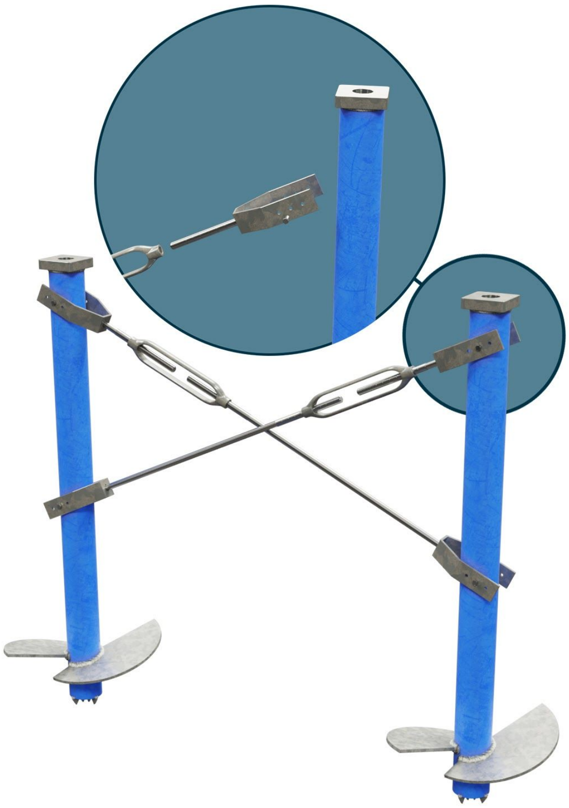
Alternatively the length of each member can be provided to Katana and Katana will label each member with an individual tag.

Bracing should be undertaken along continuous lines along the building (to minimise deflection at the top of the piles) and tightened only once the piles are under load.

A guide to lateral loading and deflection graphs for the Katana piles can at the following link – capacities depend on soil stiffness.

Structural engineers are free to use our bracing product but can also specify welding or bolting angle/RHS bracing etc to the piles – the engineer just needs to check any loss of section capacity with any bolting through to our piles.

The other option is a horizontal bracing system (acting as beams on ground) which will introduce bending moments into the piles.

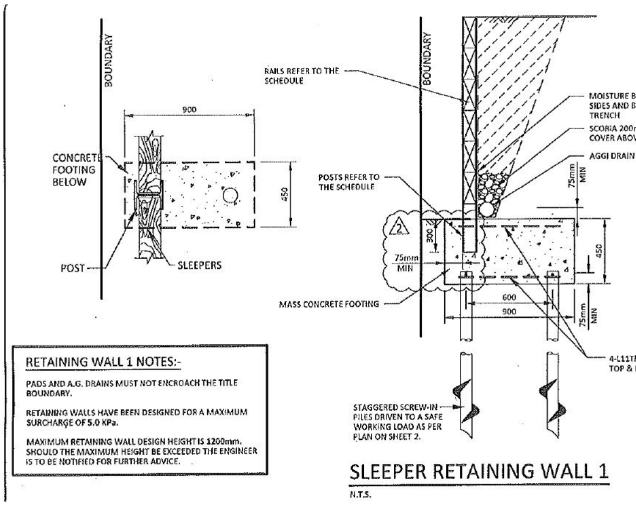


The engineer specifies the screw to be used according to the bracing loads. Below is an example of a data sheet with Drive Teks with a shear strength of 10.9kN.

Designing for:
Retaining Walls

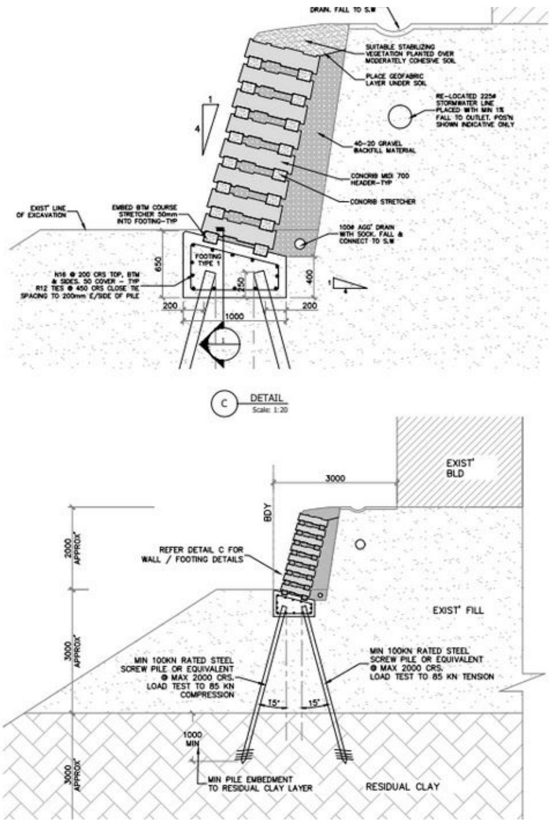
The lateral capacity of screw piles is limited for applications such as retaining walls.

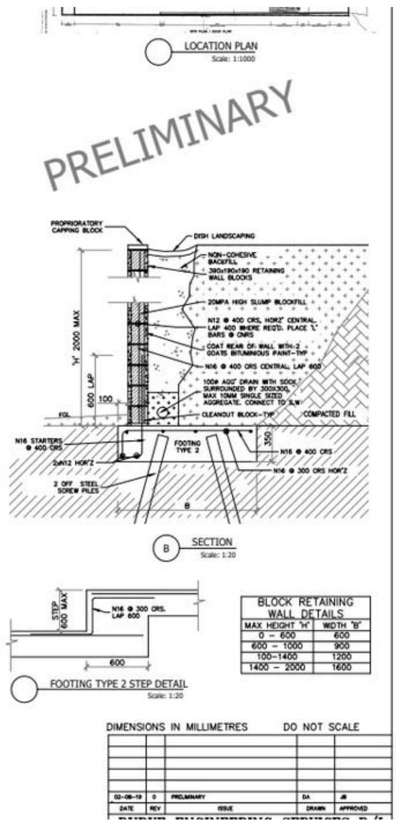
Piles can be driven into the retained material and tied to the wall of the retaining wall or they can be staggered as per the example below in order to create a footing with the required moment capacity to support the retaining wall supports.



RETAINING WALL 1 SCHEDULE

MAX. WALL HEIGHT	POST SIZE	POST CENTRES	RAILS	PAD SIZE	PAD DEPTH
800 mm	100 UC 15	1800 mm	200 x 75 F7	450 x 900	450
1000 mm	100 UC 15	1800 mm	200 x 75 F7	450 x 900	450
1200 mm	100 UC 15	1800 mm	200 x 75 F7	450 x 900	450





4.0 Katana Screw Pile
Installation and Certification

IN THIS SECTION:

Introduction

The Katana piles shall be installed using specialised equipment correctly calibrated to allow torque reading to be monitored and recorded for each pile during installation.

The Katana piles shall be installed by an experienced accredited "Katana Piling" contractor.

Katana Pile installation tolerances

The maximum variation shall be no more than ± 25mm from the plan position as shown on the drawings.

The Katana pile shaft shall be installed vertically with a variation of not more than 4% from the vertical.

The maximum variation of the cut-off level shall be ± 25mm from that shown on the drawings.

The most common method adopted today in determining the installation depth of screw piles is purely based on the torque of the pile at the time of being installed, it has been identified that large inconsistencies can occur between the results of the site investigation and the final screw pile depth achieved when only using this method. This can clearly have large implications on the final cost of the pile installation, thus impacting on the final overall cost of the foundation system as a whole.

The Katana Pile has been developed as a concrete pier replacement to be installed to a nominated target depth as identified within the soil test and foundation design report. Rather than rely purely on torque as a means of measure, the installation depth of a Katana Pile may be determined/ confirmed by an onsite Uplift Load Test which eliminates the possibility of installing piles beyond what is required avoiding unnecessary cost.

This manual presents the minimum procedures for the nationwide conduct of the installation of the Katana Pile in accordance with the specifications and requirements of AS - 2159-2009 and meeting the minimum design parameters set out by the designing engineer within the soil test and foundation design report.

Scope

The scope of this document is focussed on the installation of the Katana pile for the purpose of residential and light industrial/commercial construction as outlined within AS 2870-2011 'Residential Slabs and Footings'.

Construction uses outside the scope of this manual include but are not limited to the following:

- Commercial/ Civil Buildings or structures and associated applications
- Free Standing Retaining Walls
- Light Poles, Signs etc.
- Roads, Bridges and civil works
- Embankment stability

Questions to ask your piling contractor

1. Product Development Documentation - Compression testing
2. Steel mill test results - is there traceability
3. Product drawings / corrosion reports
4. Observation of the product (welds, steel)
5. On site testing - pull out test
6. Auger calibration and torque/pressure
7. Independent third party accreditation - CodeMark / 9001

Builders responsibility

All service locations must be identified on site by the builder. It is the builders responsibility to clearly identify and notify Katana Foundations of all underground services, prior to screw piling works being conducted.

Should the locations of any underground services/works be within the engineered screw pile locations, Katana Foundations accepts no responsibility for any damage, time delays or costs incurred for rectification of such services/works.

Materials

Equipment register

The following outlines the minimum information and equipment that all Certified Katana Installers must have on site at the time of installation:

1. Latest Version of Architectural Drawings including siting plan and floor plans.
2. A full copy of the soil/ geotechnical test and foundation design report.
3. Installation Record Checklist.
4. Installation and Testing Manual
5. Uplift Testing and Installation Record Data Sheets (refer appendix).
6. Digital Camera or Phone for high resolution images.
7. Pile Uplift Load Testing Unit with Hand Pump and calibrated Bar Pressure Gauge. Approved testing devices only to be used. Devices are available from Katana Foundations.
8. Minimum 5 tonne Excavator or equivalent.
9. Appropriate earth drill/ drive motor attachment to suit excavator flow
10. Laser and receiver instrumentation to asses pad and pile levels
11. Perpendicular instrumentation for vertical alignment
12. Bar/ PSI pressure gauge for excavator
13. Pipe Cutting Device/ Reciprocator Saw or similar
14. Katana Pile Installation Adapter Tool
15. Appropriate number of Katana Piles to meet requirements of installation layout
16. Spare Katana Pile Extensions to gain adequate depth
17. Appropriate number of proprietary accessories as per engineering detail plan

18. Other consumables to assist with site survey, marking out, identification or cleaning.

Site Preparation

Site identification

Clearly it is imperative that the correct site be identified prior to any works being undertaken on any given site. It is the responsibility of the Certified Katana Installer to ensure the correct site has been identified. The following should be checked prior to commencement on site:

- Sufficient access for plant to gain entry
- Any spoil, debris, obstacles, steep slopes or other trades preventing the scope of work to start
- All surveying pegs and marks are visually identifiable

On-site preparation

Prior to the installation of any Katana Pile, the following site preparations must be undertaken to ensure the pile installed meets the requirements of the foundation method adopted within the design.

The Certified Katana Installer must be satisfied the ground pad is level (+ or - 100 mm) with confirmation from the Builder/ Client.

Check and confirm that the peg layout on site matches the Architectural and Engineering Drawings supplied. Where these differ, do not proceed with installation until such time the builder and engineer are contacted for appropriate advice.

Upon confirmation that the peg layout is consistent with architectural and engineering drawings, mark out the screw pile locations in accordance with the engineering drawings taking into consideration possible step down levels within the future concrete slab.

Mark out the location of any excavated strip footings or isolated pad footings incorporated into the engineered design. Depth and width of footings are to be specified on engineering detail plans.

Review the soil test report and foundation design report to gain an understanding of the soil conditions and the minimum target depth/ founding required by the designing engineer. If in doubt, the installer must contact the designing engineer to clarify prior to installation.

Using PP, kPA, SWL, kN, DCP values are all relevant data to evaluate prior to confirming the type and length of the Katana pile with the nominated engineer.

Installation Method

What to look for in a geotechnical report

- Depth of undisturbed natural soil – ideally piles should be embedded in natural soil
- Boreholes should be deeper than the expected depth of the piles
- If there is a significant layer of fill – the piling contractor should request advice on the fill. Is it controlled? What settlement can be expected below the depth of the pile?
- In wet clays – the piling contractor will either provide additional helixes or drill deeper as they may not get the required minimum torque to verify capacity.
- In wet sands – the piling torque will generally be lower than expected due to the liquification of the sand during drilling, however sand is known to have good bearing capacity.
- Is information on Chlorides, resistivity, Ph, Acid Sulphates provided to determine the expected life of the piles.
- What is the depth of the water table?
- Is there any rock that may prove difficult to drill piles into.

Expand on what Katana can do to access previous drills in the area

With a database of many thousands of drills undertaken across Australia and sound relationships with many Geotechnical and Consulting Engineers - Katana is likely to have access to extensive information concerning a site where drilling is proposed to be undertaken.

Good piling practice

Reach the required bearing capacity you must achieve the necessary TORQUE which correlates to your compression tests - usually happens at shallower depths.

In the case of the Katana 80kN pile, this is 4000Nm or 1400psi for the ED10,000 from Auger Torque. Other augers will differ in their psi, however 4000Nm is the required min torque required for the 80kN pile.

In reactive soils we should comply with the "climatic zone of influence - Hs" - G6.3 of AS2870. 1.25xHs - however the Design Engineer may specify a shallower depth.

G3 GEOTECHNICAL SITE INVESTIGATIONS

A geotechnical site investigation for the design of deep footings should be taken to a depth not less than 1.5 m beyond the founding depth of the footings, and not less than 1.5 times H_s for the site.

The geotechnical strength of the foundation should be determined by appropriate field and laboratory testing of the ground at depths relevant to the design. The information required from the site investigation, as defined in AS 2159, should also apply to this Standard for deep footings.

Piles to be founded in NATURAL ground - or well controlled fill (only as directed by the Design Engineer) so there are no surprises beyond the pile depth.

Where the depth cannot be reached as per the engineering notes - the piling contractor must take written instruction from the engineer and advise the builder/client of the necessary action.

Without written approval of a shallower drill depth from the engineer, the piling contractor may run the risk of the occupancy permit not being granted for the home or for potential damage to the home due to settlement.

Where there is a significant difference in torque readings across a site, consideration should be given as to the reasons for the differences and any potential differential SETTLEMENT which may result.

Where the ground is particularly loose - i.e. penetration tests indicate the soil is loose - consideration should be given to the potential reduction in SWL due to buckling.

The piling contractor should also understand at which point the piles may yield in torsion. Torsional yield depends on yield strength, diameter and thickness of the shaft of the pile.

Helical piles should NEVER be unscrewed if they are too low - a pocket of loose material will remain below the pile - always add an extension and cut to the required height.

Pre-Drilling

Clause G7 of AS2870 allows drilling to 90% of the min pile diameter. Katana will generally pre-drill with a 200mm diameter pre-drill which is 80% of a 250mm diameter helix in order to comply with AS2870.

We have found with tension testing that within a few weeks of the pile being installed the ground around the pile has settled significantly and the pile performs to its capacity.

Where there is a concern that moisture may accelerate corrosion due to pre-drilling, we assume that good building practice will direct water away from the slab and it is good practice for the client carry out testing as per AS2159 to confirm the exposure classification according to AS2159.

During the normal process of piling the ground for the helix diameter is disturbed in any event - predrilling only disturbs the ground marginally more than with no pre-drilling.

Initial Installation Procedure

The installation process is to be undertaken by a two-man crew as a minimum, the Certified Katana Installer and an experienced offsider. All piling contractors installing the Katana Pile must be Certified by Katana Foundations Australia Pty Ltd and certified as required by any state or local government specific legislation.

Where the site has been correctly identified and nominated site preparations have been completed and confirmed, installation of the Katana pile may be undertaken as follows:

Step 1: Attach drive head

Attach the appropriate Katana drive head to the excavator drill.

Step 2: Check pile length

Confirm that pile length supplied is consistent with the minimum requirements set out within the supplied engineering design.

Example 80kN, 100kN, 150kN @ 1M-4M length

Where in doubt contact the engineer prior to continuing installation.

Step3: Choose location for first pile

Once pile size and length is confirmed, choose a suitable location for the initial pile, preferably at the rear of the site first working the way out to the street. The initial screw pile being undertaken is about determining the cut/ fill line and how much fill has been introduced after the original soil test was conducted. This method will confirm if the soil profile is consistent with the soil test investigation report or whether some changes in incremental size will be necessary to adjust.

Step 4: Commence first pile install

Commence the installation of the first Katana Pile to the minimum target depth as nominated, recording the pressure reading reached on the machine gauge using the Katana 'record sheet'.

Step 5: Uplift test

Once the target depth of the first pile has been achieved, the uplift load of the pile may be tested using the approved 'rapid uplift test device' in accordance with the procedures outlined. This process is required to be documented by video and photographic evidence.

Pile Uplift Load Testing Procedure

The uplift test has been developed to be used in material where – e.g. due to liquefaction of the sand, single graded sand, wet silts, the required torque is unable to be achieved but where the material has good bearing capacity.

Decision process:

1. Torque Achieved (1400psi – 4000Nm – 250mm helix)? No – proceed to 2.
2. Min depth 2m? Yes proceed to 3.

3. Profile the site to get an understanding of the torque's being achieved and understand if there will be an issue with differential settlement.
4. Perform a pull-up test (seek sign off from engineers at Katana and STA). Type of construction type (i.e. single story construction supported by material with good bearing capacity is less of a risk than double storey supported by material with poor bearing capacity)
5. NOTE - the deflection during the uplift test must be noted but it is only a function of the looseness of the material above the helix, not the bearing capacity of the material below the helix.
6. Compression test (anything less than 1200psi - 250mm helix)

The On Site Rapid Load Test can only be performed by an Certified Katana Installer. The procedure outlined below may be implemented upon the installation of the initial Katana pile as described above. The testing procedures are as follows:

Step 6: Achieve minimum target depth

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

Step 7: Record pressure

Record the pressure achieved on the machine gauge at installation when at the required target depth.

Step 8: Perform rapid load test

Place the Rapid Load Testing Device over the Katana Pile, ensuring a level firm base under the test unit. Note - Test is not suitable on piles installed at less than 2.0 meters depth.

Step 9: Attached connect threaded rod

Screw in the connecting threaded rod, placing the hollow cylinder jack over and securing with a washer and locking nut. As per illustrations below.

Step 10: Connect hand pump unit

Connect the hand pump unit (complete with calibrated bar pressure gauge) as shown in figure 2 below.

Step 11: Jack the ram

Jack the ram (contains 100mm stroke) 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 meters clear of the testing unit prior to jacking.

Step 12: Jack until required capacity achieved

Once pre loading is completed and there is no further settlement observed, continue jacking the ram until such time the required PSI capacity nominated by the engineer has been achieved. Typically the measured uplifting load is ~ 100 % of the calculated load-bearing capacity of the pile.

RCH-20100 for 80kN / 8 Tonne pile must read 4,000psi

RCH-30100 for 80kN / 8 Tonne pile must read 2,700psi

Step 13: Maintain pressure for 5mins

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

Step 14: Record pressure

Record bar pressures achieved on the supplied record sheets (refer appendix) and document using photographs or video evidence.

Step 15: Pass conditions

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.

Step 16: If the pile fails

Where the tested pile fails to hold the required load capacity, that is to say the pile HAS displaced under load, the test has failed, confirming the pile has NOT achieved the required load capacity. In this situation, the pile depth is to be extended using Katana Pile Extensions, then repeat the test as described until such time the required load capacities have been achieved.

Step 17: Install remaining piles

With test pile complete and target depth confirmed, the remaining piles are to be installed to the nominated target depth as outlined within the soil test and foundation design report and as confirmed with the initial test pile. Note, the pressure to which the remaining piles are installed must match or better the bar pressure achieved at the time of the test pile. In the event that the pressure reading value is lower than that of the initial test pile, the Uplift Load Test must be repeated to ensure the bar pressure acquired meets the minimum load capacity required.

Step 18: If further fails occur

Where any pile fails to meet the required load capacity, pile extensions must be added until the required load capacity is achieved.

Step 19: Documentation

Record and document the installation of all piles including the pile number, final depth achieved for each pile, length of pile used to include any extensions and minimum bar pressure achieved at final installation depth.

Step 20: Final inspection

Upon completion of the pile installation and prior to leaving the site, the piling contractor must inspect/ review all piles installed to confirm that the correct number and location of piles have been installed in accordance with the engineering drawings and architectural plans supplied.

Pile Refusal Procedures

Where difficulties are experienced in achieving the minimum required pile depth due to very stiff to hard soils, cobble or contaminated ground, the pre-drilling of a pilot hole for the Katana pile prior to installation may be required.

This is to involve drilling a 150mm diameter specialised auger in the location of the required screw pile, extending the hole to the target depth, or until such time the unfavourable ground has been penetrated. Once drilled, continue to install the screw pile as required.

In the instance where the screw pile installation refuses onto the natural rock profile, it can be assumed that the pile has reached the typical 80kN load capacity required, therefore the testing of individual piles is not considered necessary - refer this scenario to the engineer for their approval.

Where piles encounter the weathered rock profile, thus not allowing the pile to be installed to the required RL, the pile top may be cut by use of a power tool or similar to achieve required lasered height. (see figs below) - refer this scenario to the engineer for their approval.




On Site Installation Issues

Differential settlement

One of the most important with residential piling is differential settlement. Where a site is cut on one half and filled on the other half and the installation torques during installation reflect this, then potentially there could be a concern around how the home will settle and where the cracking will take place.

As on site soil conditions can vary considerably over relatively short distances, particularly within Australia, some issues can arise from time to time with regards to the installation of screw piles.

Issues pertaining to torque or depth requirements must be directed to the engineer, this includes any design issues pertaining to the requirements of the foundation design as a whole.

Where issues pertaining to the supply or delivery of the Katana Pile or Accessories, these queries are to be directed to the manufacturer.

The checklist below are the minimum requirements that must be recorded and supplied by the Certified Katana Installer to the engineer in order for final certification to be issued on the installation of the Katana Pile. This information is to be recorded on the approved Screw Pile Installation Checklist (refer appendix)

Document job details including the following:

- Site Address
- Certified Katana Installer
- Engineer Report Job No.
- Installation Date
- Principal Contractor

Document details of the pile type used including the following:

- Pile Type
- Design Load
- Pipe Diameter
- Founding Material
- Helix Size

Site photographic evidence is required for record keeping.

Results of the initial Uplift Load test which are to be recorded on the supplied record data sheet.

Video footage or photographs of the initial Uplift Load test are to be taken. Showing clear gauge read and surrounding location.

Record and document the installation of all piles including the pile number, final depth achieved for each pile, length, extensions, pressure, accessory and any cut increments also.

A corresponding layout is to be provided showing the location and the number allocated to the screw pile installed.

Photograph the site and accessories left on site upon completion of installation. A minimum of 2 photographs are required.

Approved Piling Contractor must submit all documentation supplied.

Is a heading needed here re: Certification?

In order for final certification to be issued with regards to the installation of the Katana Pile, the information listed above must be supplied to the certifying engineer in the format described and presented in the attached appendix.

Where the Certified Katana Installer fails to record, document and supply the installation information in a legible format as outlined above, the certifying body reserves the right to refuse documentation and certification in relation to the installation of the screw pile.

KATANA FOUNDATIONS

Queensland Government

Department of Housing and Public Works

Form 15—Compliance certificate for building design or specification

Version 4 – July 2017

NOTE: This is to be used for the purposes of section 10 of the *Building Act 1975* and/or section 46 of the *Building Regulation 2006*.

RESTRICTION: A building certifier (class B) can only give a compliance certificate about whether building work complies with the BCA or a provision of the Queensland Development Code (QDC). A building certifier (Class B) can not give a certificate regarding QDC boundary clearance and site cover provisions.

1. Property description

Street address (include no., street, suburb/locality and postcode): NO 18 MADDEN STREET SILKSTONE, Postcode 4304

Lot and plan details (attach list if necessary): LOT 140 ON RP 141885

In which local government area is the land situated? IPSWICH CITY COUNCIL

2. Description of components certified

Katana Foundations PolyVoid Pod with Katana Screw Pile with Adjustable Steel Load Transfer Plates "Void Slab System" Edition 3rd October 2013 Page 1 of 197

3. Basis of certification

Design Criteria

AS 1579 Arc Welded Steel Pipes and Fittings for Water and Waste Water

AS 2159 -2009 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 1163 Structural Steel hollow sections

AS 4100 Steel Structures

AS/NZS 1553.1 Low Carbon Steel Electrodes for Manual Metal-arc Welding of Carbon Steels & Carbon Manganese Steels

AS/NZS 1554.1 Welding of Steel Structures

AS/NZS 3678 Structural Steel – Hot rolled Plates, Floor plates and slabs

AS 3600-2009 Concrete Structures

AS 2870-2011 Residential Slab & Footings

4. Reference documentation

Katana Foundations PolyVoid Pod with Katana Screw Pile with Adjustable Steel Load Transfer Plates "Void Slab System" Edition 3rd October 2013 Page 1 of 197

5. Building certifier reference number

Building certifier reference number

6. Competent person details

Name (in full): Angelo Ianou

Company name (if applicable): STA Consulting Engineers — Contact person: Nicole Strano

Phone no. (business hours): 07 3071 7444 — Mobile no.: 0412 595 491 — Fax no.:

Email address: engineering.dept@staconsulting.com.au

Postal address: PO Box 2629 Toowong, Postcode 4066

Licence or registration number (if applicable): Registered Professional Engineer RPEQ 4425

7. Signature of competent person

Signature

STA CONSULTING ENGINEERS

The *Building Act 1975* is administered by the Department of Housing and Public Works

LOCAL GOVERNMENT USE ONLY

Date received		Reference Numbers	

Queensland Government

Department of Housing and Public Works

Form 16 - Inspection Certificate / Aspect Certificate / QBCC Licensee Aspect Certificate

NOTE: This form is to be used for the purposes of section 10(c) and 239 of the *Building Act 1975* and/or sections 32, 35B, 43, 44 and 47 of the *Building Regulation 2006*.

1. Indicate the type of certificate

☐ Inspection Certificate for

☐ Stage of building work (for single detached class 1a or class 10 building or structure) (indicate the stage)

☐ Aspect of building work (indicate the aspect) Installation of Screw Piles

☐ QBCC Licensee Aspect Certificate

Scope of the work

Scope of the work covered by the licence class under the Queensland Building and Construction Commission Regulation 2003 for the aspect being certified, e.g. scope of work for a waterproofing licence is "installing waterproofing materials or systems for preventing moisture penetration". An aspect being certified may include "wet area sealing to showers".

2. Property description

Street address (include no., street, suburb/locality and postcode): Lot 19 18 MADDEN STREET SILKSTONE, Postcode 4304

Lot and plan details (attach list if necessary)

In which local government area is the land situated? IPSWICH CITY

3. Building/structure description

Building/structure description: As per design documentation produced by Structerre Consulting Engineers, Project Job No. 107528

Class of building/structure

LOCAL GOVERNMENT USE ONLY

DATE RECEIVED		REFERENCE NUMBERS	

7. Building certifier reference number and development approval number

Building certifier reference number — Development approval number

8. Building Certifier, competent person or QBCC licensee details

Name (in full): Angelo Ianou BSc PEng ME Aust (Civil, Structural) AGS RPEQ

Company name (if applicable): STA Consulting Engineers — Contact person: Nicole Strano

Phone no. (business hours): 07 3071 7444 — Mobile no. — Fax no.: 07 3876 2783

Email address: engineering.dept@staconsulting.com.au

Postal address: PO Box 2629 Toowong, Postcode 4066

Licence class: Registered Professional Engineer — Licence number: RPEQ 4425

Date approval to inspect received from building certifier

9. Signature of building certifier, competent person or QBCC licensee

Signature

STA CONSULTING ENGINEERS

The *Building Act 1975* is administered by the Department of Housing and Public Works