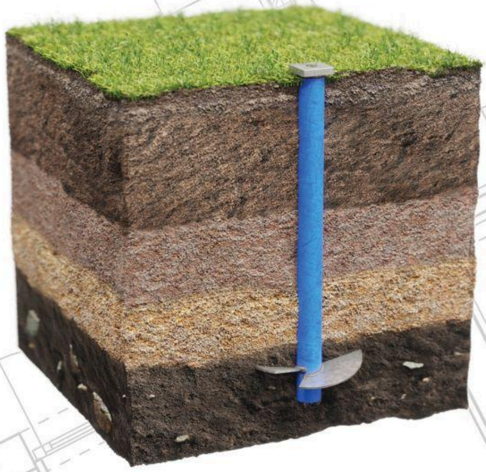
KATANA FOUNDATIONS

Katana Screw Pile
PERFORMANCE GUIDE

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



Document Version Control

Rev	Description	Date
X	**Removed exposure classification for steel piles & concrete guidance table**	**26/03/2024**
W	Minor corrections	23/02/2024
V	Comprehensive document review & reformatting	12/02/2024
U	Revised above ground life table	02/10/2023
T	Updated Nq factors	14/07/2023
S	Corrected bending moment units in steel capacity table, added table of contents & updated raised floor section	16/05/2023
R	Updated load capacity table for compression, tension, shear & bending	06/03/2023
Q	Amended bearing & stress table for pile drive nut	16/08/2022
P	Removed redundant slab plates based on the UoM study	02/08/2022
O	Added plastic slab plate & appendices	29/03/2022
N	Modified raised floor notes & revised Perko table	24/01/2022
M	Added additional compliance questions & included Denso SteelGard 400	18/01/ 2022
L	Added load torque guidelines	29/09/2021
K	Fixed helix size error in load table	17/09/2021
J	Included additional engineering details	18/08/2021
I	Updated bearing stress table 2.0	28/07/2021
H	Added compliance questions for certification	20/07/2021
G	Updated bearing stress table	10/06/2021
F	Updated load & spacing table	06/06/2021
E	Added concrete bearing stress information	18/05/2021
D	Included commentary on fill material	14/05/2021
C	Added performance summary tables for uncut & cut piles	14/04/2021
B	Extended Perko torsion table & added approximate torsional capacity of Katana pipe	22/04/2021
A	Provided clarification on Hs	22/02/2021

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1.0 Purpose & Overview

Scope

This Performance Guide covers the technical design, specification, installation and compliance details for Katana products. Tailored for architects, engineers, builders, building surveyors, and end users, this openly accessible guide underscores their commitment to transparency and adherence to best practices.

It is important to acknowledge that the information presented is intended to lay a foundation for understanding Katana products. The builder's engineer is tasked with the responsibility of supplying project-specific engineering and certification for each pile design and installation.

Should you identify any errors, wish to provide feedback, have inquiries, or require further information, feel free to reach out directly to Katana or access the additional resources provided below.

For further information or inquiries, one can reach out to Katana by emailing info@katanafoundations.com.au

The website showcases a variety of projects that Katana has worked on.

Katana's website includes comprehensive technical product information, quality details, and brochures accessible through the technical section.

Katana's YouTube channel is a valuable resource for learning through "how-to" videos, providing a faster way to acquire knowledge.

The LinkedIn page for Katana is regularly updated with the latest company news.

The Katana Facebook page serves as the optimal platform to stay updated on their published content.

A Foundation Solutions Company

SInce 2013, Katana Foundations has been committed to delivering reliable foundation solutions to customers. Setting themselves apart from other piling companies, Katana goes the extra mile by obtaining CodeMark certification for its products and services, utilising Australian-made steel with minimum thickness and yield strength standards, and offering a comprehensive product and performance guide. Katana understands that foundations entail inherent risk, and they urge customers to consider this seriously when comparing them to their competitors and traditional concrete bored piers.

Consideration Points	Katana	Others
Does the product design, manufacture and installation meet the nationally accepted NCC Codemark compliance?	☑	☐
Is the steel sourced from a trustworthy provider such as Bluescope, known for its operations across 16 countries? Has the pile fabrication been undertaken by a reputable expert like Stoddarts, known for their Quality Assurance certification to AS/NZS ISO 9001 by Global Mark?	☑	☐
Does the supplier have a comprehensive product Performance Guide publicly accessible and transparent for engineers and builders to reference?	☑	☐
Is there a $20 million public liability insurance in place?	☑	☐
In the event of a product issue, can the supplier effectively trace back to the heat in the mill and the specific welder who fabricated each component?	☑	☐
Will each installation have independent third-party certification?	☑	☐

Design Standards & Documentations

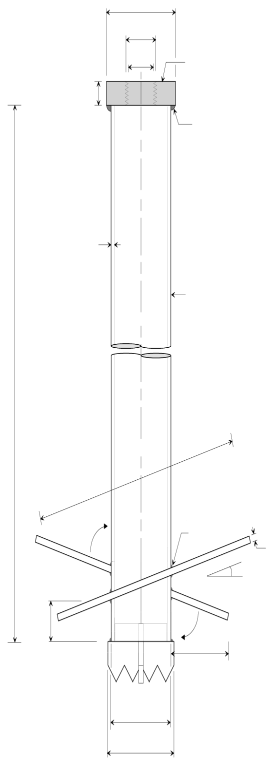
This Performance Guide is based on, but not limited to, the following Australian & New Zealand standards, regulations, and frameworks:

- AS/NZS 1163: 2016 | Cold-formed Steel Hollow Sections
- AS 2159: 2009 | Piled Footings Design & Installation
- AS 2870: 2011 | Residential Slab & Footing Classification
- AS 4100: 2020 | Steel Structures
- National Construction Code
    - The Suitability Handbook
- CSIRO | Foundation Maintenance & Footing Performance: A Homeowner's Guide

2.0 Katana Foundations Products

Katana Screw Pile

Katana Screw Piles serve as a robust solution for efficiently transferring building loads beneath concrete slabs, reaching various depths within the subsurface layers. In comparison to traditional concrete bored piers, the Katana Screw Piles offer superior effectiveness, allowing for greater depths, quicker installation, cost reduction and a significantly lower carbon footprint. Distinguishing itself from alternative piling products, Katana stands as the exclusive Australian and New Zealand company to attain CodeMark certification for the product, fabrication and installation processes.



Drive Nut Plate / Square Drive Head

At the top of the pile, a square plate, 16/20mm thick and constructed from 350 Grade material, is affixed. This plate features a 36mm threaded hole, designed to accommodate a range of Katana accessories.

The Pipe

The pipe, or shaft, is constructed as a Circular Hollow Section (CHS) using 350 Grade high tensile steel. It comes in a range of thicknesses, diameters and lengths to suit various applications and drilling depths.

The Twin Helical Plates

The helix has undergone a symmetrical design process, making it one of the most effective cutting devices for a screw pile. This design ensures that the screw pile can penetrate harder soils faster and at greater depths. The helix diameter varies between 250mm and 450mm, depending on the series of the pile.

The Cutting Comb

Serving as the initial point of contact with the soil, the symmetrical design of the cutting teeth facilitates the vertical alignment of the piles. Additionally, this design contributes to easier drilling and enables effective cutting through hard materials.

Sourcing & Fabrication

Katana procures high-strength steel for the Katana Screw Pile from the reputable Bluescope steel mill, renowned for its operations in **16 countries**. Subsequently, the steel undergoes the rolling process at one of two mills in Brisbane, where it is shaped into CHS pipes, with a minimum yield strength of 350. These pipes are then transported to their manufacturing partner, Stoddart, who are **Quality Management System certified to AS/NZS ISO 9001 - 2016 by Global Mark**. At Stoddart, both the piles and accompanying accessories are expertly fabricated before being dispatched to various locations across Australia and New Zealand.

Dimensions and Tolerances

The steel hollow sections comply with the manufacturing tolerances as outlined in AS/NZS 1163: 2016.

Welding

The welding specifications adhere to guidelines outlined in the report provided by e3K Global, a division of Gilmore Engineers. For detailed information, the report is accessible within their Katana Pile Product Statement.

Certification of Materials

Each Katana Screw Pile is accompanied by test certificates verifying the quality of the steel used in the product's manufacturing process. These certificates adhere to the standards outlined in AS/NZS 3679.1, which pertains to tests conducted by the manufacturer to ensure compliance with the specified standard and **CodeMark.**

Manufacturing Traceability

Complete traceability is ensured for each component of the Katana Screw Pile. In the event of a product-related concern, it is possible to trace the supplier back to the specific heat in the mill and identify the individual welder responsible for fabricating each component.

Key Technical Specifications

The material and manufacturing of the Katana Screw Pile Drive Nut Plate, shaft, and helix plate adhere to the AS/NZS standards outlined below. Additionally, the components are sourced from organisations accredited by the **National Association of Testing Authorities (NATA).**

Katana Screw Pile Component	Material Standard	Manufacturing Standard	Grade	Yield Strength fy	Tensile Strength fu
Drive Nut Plate	AS/NZS 3678	AS/NZS 1554.1	350	350 MPa	430 MPa
76.1 x 4.0 Pipe	AS/NZS 1163	AS/NZS 1554.1	350	350 MPa	430 MPa
88.9 x 5.5 Pipe	AS/NZS 1163	AS/NZS 1554.1	350	250 MPa	320 MPa
Helix Plate	AS/NZS 3678	AS/NZS 1554.1	350	350 MPa	430 MPa

Product Specifications

The Katana Screw Pile range is specifically engineered and tested to meet the demands of the Australian and New Zealand residential market. The currently available and CodeMark compliant products include the 80kN, 100kN and 150kN variants.

These are offered in customizable lengths up to 4.0m and can be extended using the Katana Pile Extension if deeper foundations are required. Additionally, 40kN, 200kN, 250kN and 300kN piles are **available upon request.**

Typical Application(s)	Load Capacity (kN)	Shaft (Dia x Thi) (mm)	Weight per metre (kg/m)	Helix (Dia. x Thi) (mm)	Lengths (m)	Increments (m)
Residential & Commercial Slabs	40	60.3 x 4.5	6.2	200 x 8	1.0	-
	80	**76.1 x 4.0**	**7.1**	**250 x 8**	**1.0 - 4.0**	**0.5**
	100	**76.1 x 4.0**	**7.1**	**300 x 8**	**1.0 - 4.0**	**0.5**
	100	**76.1 x 4.0**	**Extension**	**350 x 8**	**2.0 & 3.0**	**-**
	150	**88.9 x 5.5**	**11.3**	**350 x 10**	**1.0 - 4.0**	**0.5**
	150	**88.9 x 5.5**	**Extension**	**350 x 10**	**2.0, 3.0 & 4.0**	**-**
	200	**88.9 x 5.5**	**11.3**	**2 No 350 x 10** **2 No Helixes**	**1.0 - 4.0**	**0.5**
Commercial Slabs	250	114.3 x 5.4	16.0	450 x 12	1.0 - 4.0	0.5
	300	114.3 x 5.4	16.0	2 No 450 x 12 2 No Helixes	1.0 - 4.0	0.5

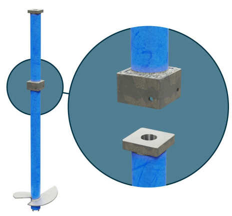
Connectors & Accessories

Katana has innovated a series of connectors and accessories designed to enhance the functionality of the threaded hole in the Square Drive Head. These elements facilitate the versatile use of Katana Screw Piles in various foundation and building applications.

Each component, within this range, has undergone meticulous design and testing, ensuring a seamlessly connected "system" that meets the necessary load capacity and other engineering design requirements. This approach eliminates the necessity for improvised connectors, providing enhanced design certainty.

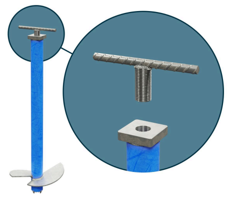
Require an extension for a pile?

The **Katana Pile Extension** is utilised when pile lengths **exceeding 4.0m** are required.



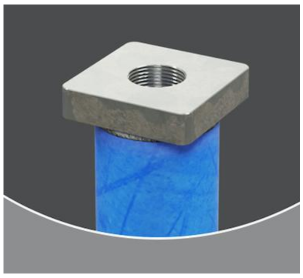
Need the pile to be embedded in the footing?

A **250mm N16 Adjustable Edge Beam Connector** is employed for the embedding of the Katana Screw Pile into concrete footings.



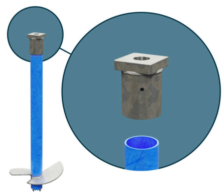
Worried about supporting the slab adequately?

Extensive studies conducted with the University of Melbourne affirm that the **Katana Square Drive Head** at the pile's top is sufficiently capable of supporting typical slabs.



Looking to cut the pile?

The **Katana Cut Drive Nut** can be positioned atop the trimmed pile, mimicking the Katana Square Drive Head.



Is the project in need of a raised floor?

Katana provides all the **essential connecting bearers** to meet any raised floor system specifications.

Is there a particular connector or accessory not mentioned above?

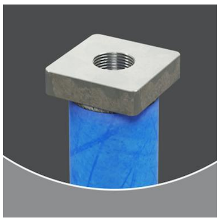
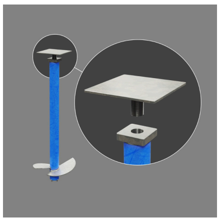
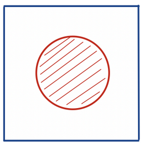
If the application is not covered by the listed connectors or accessories, individuals are encouraged to **contact Katana**. Katana may be able to create a **customer connector** tailored to specific foundation needs. Katana is enthusiastic about assisting individuals in exploring innovative uses of the Katana Screw Pile for various building applications.

Drive Nut Plate

At first, engineers favoured the use of 200mm x 200mm Slab Plates. However, it was discovered that the effect support area of the 200mm x 200mm Slab Plate is **limited to the threaded support and a limited surrounding area.** Katana conducted a comprehensive study, in collaboration with the University of Melbourne, specifically examining the interaction between the Drive Nut Plate of the Katana Screw Pile (excluding the Slab Plate) and the ground beam. The results indicate that the Slab Plate can be omitted without compromising the performance of either the slab or the pile. For detailed specifications and findings, refer to the University of Melbourne Capstone Report on the Interaction Between Katana Bored Pile Foundation and Ground Beam in Residential Application.

Katana strongly recommends that **future engineering designs exclusively specify the Katana Drive Nut Plate**. This not only has the potential to reduce costs linked to the Slab Plate but also minimises the number of components susceptible to corrosion.

To offer further guidance, a table comparing the loads and capacity of the Katana Drive Nut Plate with the Katana Slab Plate is provided, subject to verification by the builder's engineer. For more comprehensive insights and additional comparison with other types of Katana slab supports, refer to Appendix A.

Slab Support	Support Area	Shear Capacity	Bearing Load	Comments
 **Drive Nut Plate/ Square Drive Head**	76.1mm Dia. Shaft $A=85 \times 85 - \pi \times (18)^2$ A=**6,207mm²**	**100kN** SWL at the CENTRE of the footing **80kN** SWL 75 mm from the centre	**13MPa** (80kN SWL)	Experimental testing conducted by the University of Melbourne regarding the smallest permissible footing size as per AS2870.
	88.9mm Dia. Shaft $A = 110 \times 110 - \pi \times (18)^2$ A =**11,082 mm²**	**Varies based on the size of the footing**	**13.5MPa** (150kN SWL)	
 **Slab Plate**	$A=\pi \times (60/2)^2$ A=**2,827 mm²** 	**No empirical testing**	**28 MPa** (80kN SWL)	Assume providing support with an extra 12mm around the 36mm threaded rod, resulting in a **60mm diameter.**

It is important that screw piles situated on internal ribs should have the **waffle pod removed or cut out** to create a pad over the pile, typically measuring **350mm x 350mm**, enabling central placement of the pile. Even if the pile is accurately positioned at the rib, failure to provide a cutout may result in unacceptably high shear forces in the waffle slab.

Compression & Tension & Lateral Capacities

Compression Load Capacity

To date, Katana continues to conduct compression testing across Australia in diverse soil conditions to assess the capacity of its products. Based on the results from various tests, the following observations can be made:

- In instances where soft or loose material is highlighted in the geotechnical report, it is recommended best practice to conduct a **compression test.** This is crucial to confirm the soil's and the pile's capacity, particularly considering the material in which the piles will be found.
- The provided table below outlining the Safe Working Load (SWL) of Katana Screw Piles in **stiff clay and dense sand** serves as a reliable indicator of performance. Further calculations can be found in Appendix J. Additionally, refer to the load table in Appendix H for typical load specifications in residential applications, taking into account pile spacing.

Katana Variants	Compression SWL
76.1mm x 4.0mm Shaft, 250mm x 8mm Helix	up to 80kN
76.1mm x 4.0mm Shaft, 300mm x 8mm Helix	up to 100kN
88.9mm x 5.5mm Shaft, 350mm x 10mm Helix	up to 150kN
88.9mm x 5.5mm Shaft, 2 No 350mm x 10mm Helix	up to 200kN
114.3mm x 5.4mm Shaft, 2 No 450mm x 10mm Helix	up to 300kN

Compression Load and Torque Relationship

Through compression testing, Katana's examination of pile performance indicates that achieving a torque of **4000Nm** on the 76.1mm x 4.0mm Shaft, 250mm x 8mm Helix pile corresponds to a **safe working load of 80kN** in stiff / dense soils. The correlation between the torque of 4000Nm and the hydraulic drive pressure is illustrated on the pressure vs torque chart of an Earth Drill ED10,000, indicating 96 bar (converted to **1400 psi**). Emphasising the significance of the Katana Screw Piles torsional capacity, it's crucial to note that these piles are constructed from high-strength steel, resulting in an enhanced ability to withstand torsional forces, refer to Appendix I for pile steel capacity. For theoretical torsion capacity calculations, refer to Appendix B.

For an in-depth examination of the torsional capacity of Katana Screw Piles, refer to the research paper from the University of Melbourne titled "Investigation of the Torsional Capacity of 400MPa + 76.1mm and 88.9mm Circular Hollow Sections."

Katana's extensive compression testing has provided a thorough understanding of the correlation between torque and a pile's safe working load. The following offers guidance on the torque required for each Katana variant to achieve a specific safe working load, based on the assumptions of natural soil being dense/stiff or consisting of rock, with a bearing capacity of 100kPa. Refer to table in Appendix C for calculations and a detailed comparison of torque and SWL.

Australia

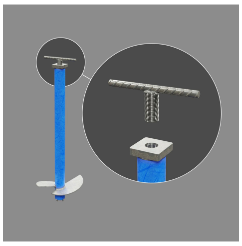
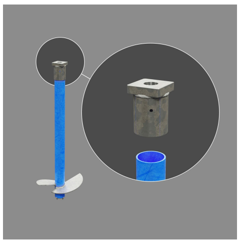
	76.1 x 4.0 250 x 8	76.1 x 4.0 300 x 8	88.9 x 5.5 350 x 10	88.9 x 5.5 2 No 350 x 10	114.3 x 5.4 450 x 12	114.3 x 5.4 2 No 450 x 12
Safe Working Load	Torque (Nm)					
60kN	3000	3000	3000			
80kN	4000	4000	4000			
100kN	5000	5000	5000	5000		
150kN			6000	6000		
200kN				9000		
250kN					14000	
300kN						17000

New Zealand

	76.1 x 4.0 250 x 8	76.1 x 4.0 300 x 8	88.9 x 5.5 350 x 10	88.9 x 5.5 2 No 350 x 10	114.3 x 5.4 450 x 12	114.3 x 5.4 2 No 450 x 12
Safe Working Load	Torque (Nm)					
60kN	4000	4000	4000			
80kN	5000	5000	5000			
100kN			6000	6000		
150kN				9000		
250kN					16000	
300kN						19000

Tension Load Capacity

Testing for tension or uplift is crucial in cases of uncertain soil conditions, particularly in saturated sand, where uplift capacity of Katana Screw Piles is notably diminished. In instances where concerns arise about uplift capacity, the presented table can provide guidance on potential solutions to strengthen uplift resistance:

UNCUT Pile			Cut Pile	
				
N16 Adjustable Edge Beam Connector	**Slab Plate**	**Eye Bolt with Reinforcement Bar**	**Cut Drive Nut with Buildex Hex Head Screws**	**Cut Drive Nut with Tri-Fixx M8 Heavy Duty Self Drilling Screws**
Refer to Appendix D.			The cut pile capacity is **limited** by the screws rather than the pile's capacity. Refer to Appendix E.	
Additional Tensile Load				
Up to 27.5kN	Up to 50kN	Varies from 28kN to 110kN, as indicated in the table below	Up to 15kN	Up to 27kN

Eye Bolt & Reinforcement Bar

The implementation of an eye bolt, notably with a **36mm thread, along with a reinforcement bar,** is a technique that can significantly enhance uplift capacity of the uncut Katana Screw Pile. The reinforcement bar can be incorporated in two ways: either by threading it through the eye bolt or by inserting it through a hole drilled in the Katana Screw Pile. However, opting for the latter method is discouraged, as it diminishes the section capacity of the pile and may introduce bearing capacity issues in the concrete. It's important to note that this option needs to be signed off by the builder's engineer. The table below serves as a guide, outlining the additional uplift capacity for the eye bolt and reinforcement bar method.

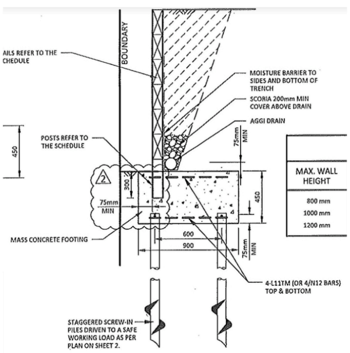
Additional Tensile Load	Reinforcement Bar	Eye Bolt
28kN (2.8t)	N12, 1000mm long	3.0t
50kN (5.0t)	N16, 1500mm long	5.0t
75kN (7.0t)	N20, 2000mm long	7.5t
95kN (9.0t)	N24, 2500mm long	10.0t
110kN (11.0t)	N28, 2800mm long	15.0t

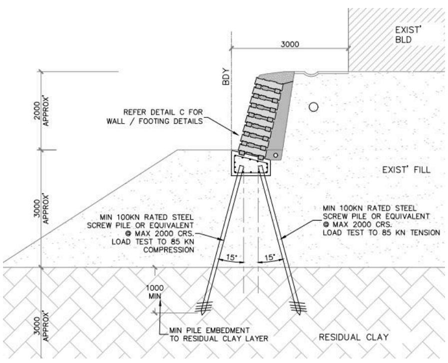
Lateral Load Capacity

Conducting lateral testing holds significant importance in evaluating the Katana Raised Floor System, allowing for a thorough understanding of potential pile deflection and the necessary bracing measures. Katana has undertaken assessments of the **lateral performance** of the **80kN and 150kN Katana Screw Piles in both clay and sand soils** for the builder's engineer to consult; see Appendix F for Katana Screw Lateral Capacity Graphs.

Alternative Applications

Katana Screw Piles serve a dual purpose beyond providing support to slabs. They can be effectively integrated with retaining wall structures, adept at transferring both tension and compression loads to appropriate material, thereby ensuring steadfast support for the retaining wall. In certain instances, a staggered arrangement, as depicted in the following example, can be employed to leverage both tension and compression loads, creating a footing with the necessary moment capacity.





Katana Raised Floor System

The Katana Raised Floor Systems stands out as a superior and more efficient alternative to traditional concrete and timber stumps. The primary feature includes adjustable height bearer plates that facilitate a level building installation without the need for packing. Additionally, the system's hot-dipped galvanising ensures enhanced protection, making it an excellent choice for modular projects and ground mounted solar installations.

Summary of Important Factors:

- The Katana Raised Floor System allows for a **maximum SWL of 80kN.**
- Ensure all loads are positioned at the **centre** of the piles.
- A **lock nut must be installed** on each pile within the raised floor systems.
- A general guideline is to maintain Katana Raised Floor Systems at a height **no greater than 1.5m** above the ground.
- The default coating system for the Katana Raised Floor System exposed to environments with corrosivity factors C1, C2 and C3 is **galvanising**.
- Collaborate with Katana to ensure the **appropriate setout** of piles and confirm their locations during and after installation completion.

What is the MAXIMUM height above ground?

A general guideline is to maintain Katana Raised Floor Systems at a height **no greater than 1.5m** above the ground. Having one pilot pile is typically preferable to minimise movement within the system. In cases where there are concerns about the pile's buckling capacity, the builder's engineer may opt for the **88.9 x 5.5 Katana Screw Piles** instead of the standard 76.1 x 4.0 pile.

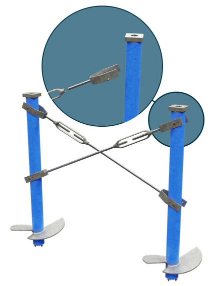
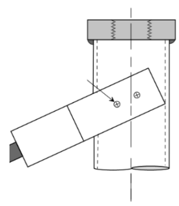
However, when the **height exceeds 1.5m** above the ground, it is advisable for the builder to install concrete pads around the screw piles, along with structural steel above the pads, following the design provided by the builder's engineer.

Lateral Loading

The Katana Raised Floor System is anticipated to experience lateral loading, primarily from wind forces. For piles exceeding **500mm above the ground** or situated in **soft soil,** bracing becomes essential. Builder's engineers are encouraged to utilise the Katana Screw Lateral Capacity graphs (see Appendix F) and consider the following **recommendations** to determine the most suitable means of enhancing the lateral capacity of raised floor piles.

- Utilise cross (X) bracing.
  - It is essential to acknowledge that introducing cross bracing may introduce bending moments into the piles.
  - Katana can suggest and provide bracing kits, subject to **approval by the builder's enginee**r.

- For optimal effectiveness, the bracing should follow continuous lines along the building to minimise deflection at the top of the piles.
- The recommended procedure involves installing the piles first, measuring the distance between them, and then fabricating the cross bracing accordingly. The angle of the bracing should fall within the range of 30 to 60 degrees to the horizontal, with the specific angle to be confirmed by the builder's engineer. Additionally, the tightening of the bracing should only occur once the piles are under load.
- The capacity of the bracing system is significantly influenced by the fixings at the ends of the bracing collar. The builder's engineer is responsible for specifying the fixing screws based on the required bracing loads and can refer to the table below for guidance:

Pair of Fixings	Type of Screws		
	Buildex Hex Head Screws @ 5kN	Tri-Fixx M8 Heavy Duty Self Drilling Screws @ 9kN	
1	10kN	18kN	
2	20kN	36kN	

→ Employ concrete pads around piles
  - In cases where soil is soft, piles are spaced excessively, or the bracing is inadequate, this approach can be employed with the approval of the builder's engineer.

→ Introduce additional footings.

→ Implement horizontal bracing.
  - This entails attaching a Rectangular Hollow Section/ L-Angle steel to the piles through welding or bolting. It is crucial for the builder's engineer to assess whether there is any reduction in section capacity resulting from bolting through the pile.

Axial Loading

→ Ensure all loads are positioned at the **centre** of the piles.

→ The Katana Raised Floor System allows for a **maximum SWL of 80kN,** to accommodate variations in installation accuracy.

→ A **lock nut must be installed** on each pile within the raised floor systems.

→ Confirm allowable bearer and slab plate loads with the builder's engineer.

- ➔ If loads are not centred on the pile, the builder's engineer must design the suitable bearer plate and supports to accommodate the extra bending moments caused by the eccentric loads..

Refer to the table below for the maximum loading on raised floor system, considering its offset from the centreline of the pile:

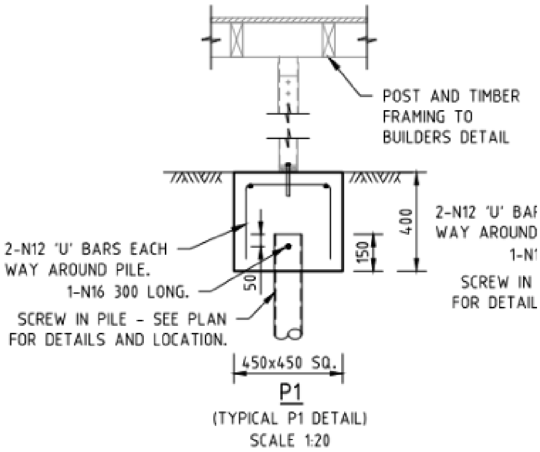
Offset from Centre Line (mm)	Allowable Loading (kN)
13	80
15	75
16	70
18	65
20	60
22	55
25	50
28	45

Coating System

- ➔ The default coating system for the Katana Raised Floor System exposed to environments with corrosivity factors C1, C2 and C3 is **galvanising**.
- ➔ Should the corrosivity factor exceed C4, the coating system can still be galvanising, provided the owner conducts routine inspections and recoats if corrosion appears. Alternatively, the builder is obligated to explore system protection by consulting an expert in coating systems. An example of such a system is the Denso Steelcoat 400.

Installation Guidelines

- ➔ Prior to installation, conduct **test piling** on site to identify and address any potential issues.
- ➔ Collaborate with Katana to ensure the **appropriate setout** of piles and confirm their locations during and after installation completion.
- ➔ After initial installation, piles may be loose, requiring **3-4 weeks** for the surrounding material to settle and provide adequate support. If piles remain loose, it is recommended that the builder install **concrete pads** around the piles, subject to the approval of the builder's engineer (refer to the engineering detail example below).
- ➔ In cases of **pre-drilled piles** or when **extensions** are used, the builder may need to install **concrete pads** around the screw piles as designed by the builder's engineer (refer to the engineering detail example below).



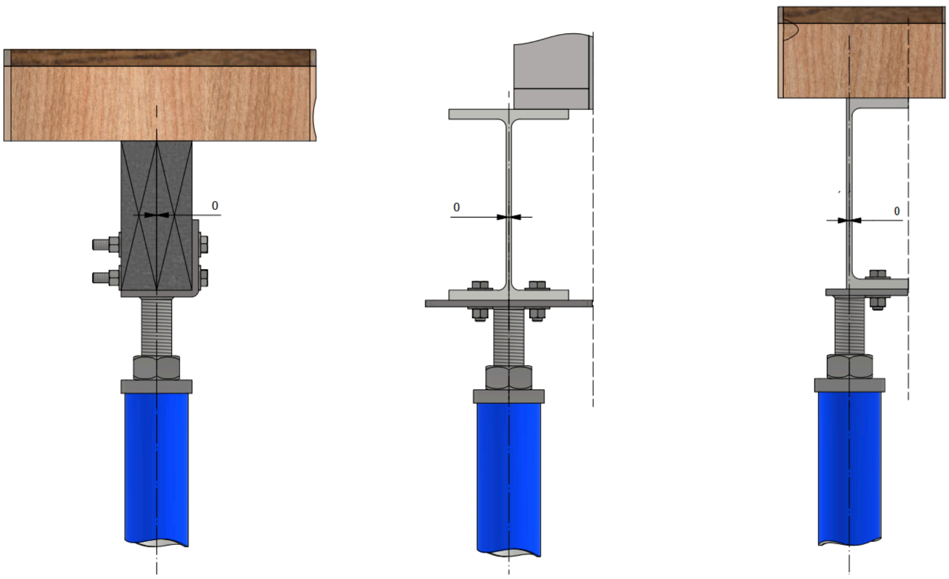
- If **encountering rock** during installation, reach out to Katana to explore alternative solutions, as screw piles may not be a suitable option.
- When **cutting piles**, it is advisable to consult with Katana to evaluate any risk related to **uplift loads,** as shorter piles may not be suitable for the structure.

Responsibility of the Various Parties

- The owner:
  - Is responsible for the **routine inspection** and **maintenance** of the Raised Floor System, including assessments for ANY corrosion with C1, C2, and C3 corrosivity factors every 24 months, 12 months and 6 months, respectively.
  - Is encouraged to remove rust with a **wire brush** and protect the system with a **suitable coating** for instances of minor corrosion.
- The builder
  - Is tasked with establishing **separation between steel members** (e.g., pile & PFC bearer) to minimise the potential for increased corrosion rates between different types of steel.
  - Is responsible for developing a comprehensive risk assessment and **Safe Working Method (Statement)** when sliding buildings on the Katana Screw Piles.
- The engineer is responsible for **designing** the structure and providing loads for the piles and associated bracing required above ground level.
- Katana:
  - Can provide drawings for bracing, bearer plates, etc., which the engineer may integrate into their design. For guidance of the most practical chassis option aligning with screw piles, feel free to inquire and discuss chassis configuration with Katana.
  - Can facilitate a referral to a consulting engineer well-versed in the Katana Raised Floor System.

Examples

Here is an image showcasing the components of the Katana Raised Floor System, along with examples of the system featuring timber, UB and PFC.



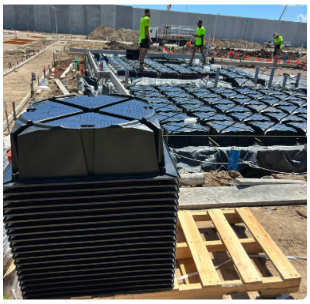
3.0 Foundation Solutions

In their commitment to foundation solutions, Katana goes beyond simply providing piles; they extend their dedication to *doing what is right* by collaborating with clients to identify the optimal foundation approach for each project.

To exemplify this approach, let's consider a project in Regional NSW where Katana was involved. Initially, the geotechnical report categorised the site as H2. Drawing from nearby historical projects, Katana identified that the site classification could be H1. Katana promptly communicated this disparity to the customer and advocated strongly for further site classification testing, emphasising potential significant cost savings. Upon retesting, the soil was indeed classified as H1, resulting in considerable reduction in the number of piles and depths required compared to the initial H2 classification.

Alternative Sustainable Solutions to Waffle Pods

Katana consistently seeks sustainable foundation solutions as alternatives to conventional EPS waffle pods. Systems like Biax offer cost-effective and eco-friendliness, along with advantages such as ease of transportation and storage on site, lightweight and manageable handling, minimal waste due to no cutting, elimination of bar chairs, improved concrete yield, and prevention of pod movement post-placement. For further insights into Biax Foundations, visit biax.com.au or refer to their Overview Brochure.



These instances showcase Katana's ongoing dedication to offering customers the most innovative, cost-effective and sustainable foundation solutions.

4.0 Comparative Evaluation with Competitors

Katana Screw Piles Vs. Alternative Piling Solutions

CodeMark Compliant Screw Piles

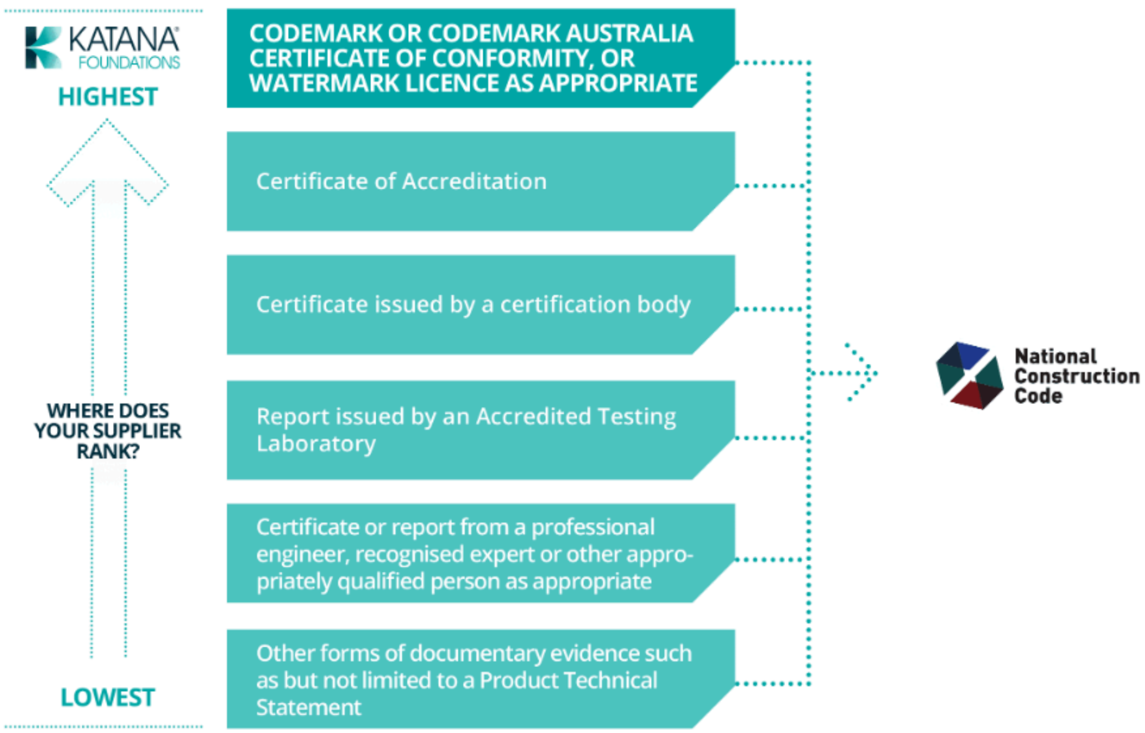
Katana Foundations stands out as the **sole screw pile company in Australia and New Zealand** to attain CodeMark certification for their entire screw pile system, covering the product, fabrication, and installation processes.

Engaging with non-conforming building products exposes stakeholders to a range of risks, including financial losses, enduring reputational damage, regulatory investigations and potential litigation. However, **CodeMark compliance mitigates these risks.**

What is CodeMark?

The CodeMark Scheme, overseen by the Australian Building Codes Board (ABCB), serves as a certification initiative for building products. Designed to facilitate the use of new or innovative building materials in specific situations in Australia and New Zealand, the scheme offers a nationally recognized process for demonstrating compliance with the National Construction Code (NCC). The issuance of both Certificates of Conformity (CM 30096 and CMNZ 30097) validates that the Katana 80kN, 100kN, and 150kN series satisfy the specified requirements outlined in the Building Code of Australia (BCA).

NCC Evidence of Suitability Framework Hierarchy



Katana Screw Piles Vs. Concrete Bored Piers

Efficient, Quick, Cost-Effective & Environmentally Friendlier

Katana Screw Piles emerge as a superior choice over traditional concrete bored piers in diverse construction scenarios. Advantages include:

- **Reduced Site Disruption:** Unlike concrete bored piers that necessitate extensive excavation and soil removal, Katana Screw Piles minimise disruption to the site.
- **Cost-Effective Process:** Katana Screw Piles prove to be more economically viable than concrete bored piers, as they eliminate spoil removal, dewatering, concrete waste and reduce overall turnaround times.
- **Safety Assurance:** The absence of open augered holes in Katana Screw Piles eliminates the need for covers or fencing, enhancing safety measures during construction.
- **Lower Carbon Footprint:**
    - **Environmental Impact:** A standard screw pile installation typically utilises 500kg of steel, whereas concrete bored piers require 23,000kg of concrete. In terms of materials alone, screw piles result in approximately ¼ of the carbon footprint compared to concrete bored piers.
    - **End of life sustainability:** At the end of their life cycle, screw piles have the potential for reuse or recycling.

For a more in-depth understanding, consider viewing the informative Youtube video comparing Steel Screw Piles to Concrete Bored Piers, presented by Katana Foundations.

5.0 Determining Pile Depths

AS2870

Site Classification

Site Classification is determined by the **anticipated ground surface movement** and the **depth that this movement occurs at**. Sites where ground movement is primarily influenced by soil reactivity under standard moisture conditions are classified based on the expected level ground movement, as specified in the table below:

TABLE 2.1

CLASSIFICATION BASED ON SITE REACTIVITY

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites, which may experience only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which may experience moderate ground movement from moisture changes
H1	Highly reactive clay sites, which may experience high ground movement from moisture changes
H2	Highly reactive clay sites, which may experience very high ground movement from moisture changes
E	Extremely reactive sites, which may experience extreme ground movement from moisture changes

In cases where sites exhibit significant moisture changes typical of dry climates, aligning with a design depth of suction change (Hs) equal to or exceeding 3m, the classification shall be M-D, H1-D, H2-D or E-D, as deemed appropriate.

Site experiencing ground movement that is substantially influenced by factors beyond reactive soil movements under standard moisture conditions shall be classified as **Class P.**

Characteristic Surface Movement (Ys)

The characteristic surface movement **(Ys)** will be used to establish the site class by applying the constraints outlined in the table below.

TABLE 2.3

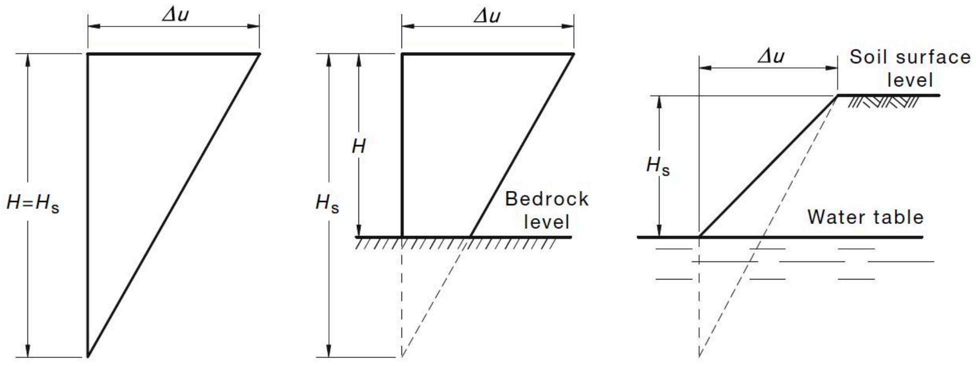
CLASSIFICATION BY CHARACTERISTIC SURFACE MOVEMENT (y_s)

Characteristic surface movement (y_s) mm	Site classification in accordance with Table 2.1
$0 < y_s \leq 20$	S
$20 < y_s \leq 40$	M
$40 < y_s \leq 60$	H1
$60 < y_s \leq 75$	H2
$y_s > 75$	E

Soil Suction Profile

The depth of the design soil suction change **(Hs)** is a critical parameter influencing the necessary pile depth. Simply put, as we descend through the layers of the stratum, moving down Hs, the soil suction change (Δu) diminishes, indicating less soil movement.

- ➔ In scenarios where we encounter **shallow bedrock**, it should be treated as a non-reactive soil layer, having **no impact** on the design suction change.
- ➔ If there is a **permanent water table** within the depth Hs from the surface, the suction change shall be **modified.**



(a) Soil to depth $\geqslant H_s$ (b) Effect of bedrock (c) Effect of groundwater

Δu and H_s are to be taken from Table 2.4 (except that H_s is taken as the depth to water table if it is less than the value in Table 2.4)

Ideally, when evaluating each installation site, the **climatic zone** is provided, and the table below can be utilised to match the accurate Hs depths.

Depth of design suction change (H_s), m	Climatic zone
1.5 m	1
1.8 m	2
2.3 m	3
3.0 m	4
4.0 m	5
>4.0 m	6

However, in the absence of the climatic zone, AS2870 offers a table specifying the approximate Hs depth for various locations below:

TABLE 2.4

SOIL SUCTION CHANGE PROFILES FOR CERTAIN LOCATIONS

Location	Change in suction at the soil surface (Δu) pF	Depth of design soil suction change (H_s) m
Adelaide	1.2	4.0
Albury/Wodonga	1.2	3.0
Brisbane/Ipswich	1.2	1.5–2.3 (see Note)
Gosford	1.2	1.5–1.8 (see Note)
Hobart	1.2	2.3–3.0 (see Note)
Hunter Valley	1.2	1.8–3.0 (see Note)
Launceston	1.2	2.3–3.0 (see Note)
Melbourne	1.2	1.8–2.3 (see Note)
Newcastle	1.2	1.5–1.8 (see Note)
Perth	1.2	1.8
Sydney	1.2	1.5–1.8 (see Note)
Toowoomba	1.2	1.8–2.3 (see Note)

NOTE: The variation in H_s depends largely on climatic variation.

Minimum Depth of Screw Piles

AS2870 specifies that the minimum depth of screw piles should **NOT be less than 1.25Hs.** However, Katana emphasises that this guideline is independent of the site reactivity or considerations of likely movement below the pile. It's also crucial to note that Appendix G6.3 is labelled as "informative" within the standard and serves solely for guidance purposes.

G6.3 Minimum depth

The installed depth of screw piles in reactive foundations should not be less than $1.25H_s$, where H_s is given in Table 2.4. Where screw piles are used to support footing systems adjacent to deep service trenches, the depth of pile should be not less than the depth of the trench.

To address this, Katana has developed an Excel formula sheet that incorporates Hs and Ys/Site Classification to precisely determine soil movement at various depths within the soil, as illustrated below:

Hs (m) =	3	S (Slighty Reactive)		M (Moderately Reactive)		H1 (Highly Reactive)		H2 (Highly Reactive)		E (Extremely Reactive)
Depth	ys (mm)	0	20	20	40	40	60	60	75	> 75
0.5	m	0	17	17	33	33	50	50	63	> 63
1	m	0	13	13	27	27	40	40	50	> 50
1.5	m	0	10	10	20	20	30	30	38	> 38
2	m	0	7	7	13	13	20	20	25	> 25
2.5	m	0	3	3	7	7	10	10	13	> 13
3	m	0	0	0	0	0	0	0	0	> 0
3.5	m	0	0	0	0	0	0	0	0	> 0
4	m	0	0	0	0	0	0	0	0	> 0

Green	Movement less than 10mm
Yellow	Movement between 10mm and 20mm
Red	Movement above 20mm

This information has been utilised to create a table providing guidance on suitable pile depths (with less than 5 mm of soil movement below the pile) based on Hs and Site Classification, as depicted below.

Climatic Zone	Hs	Site Classification		
		S (0-20)	M, M-D and H1 (20-60)	H2, H1-D (60-75)
		Depth of Screw Pile (Ys Movement @ Depth)		
		0.75 x Hs	1 x Hs	1.25 x Hs
1	1.5	1.5m (0mm)	1.5m (0mm)	2.0m (0mm)
2	1.8	1.5m (3.3mm)	2.0m (0mm)	2.5m (0mm)
3	2.3	2.0m (2.6mm)	2.5m (0mm)	3.0m (0mm)
4	3.0	2.5m (3.3mm)	3.0m (0mm)	4m (0mm)
5	4.0	3.0m (5mm)	4.0m (0mm)	5.0m (0mm)

Ultimately, Katana refers to the **builder's engineer or the certifier** responsible for validating the pile installation to **specify the depth of the pile**.

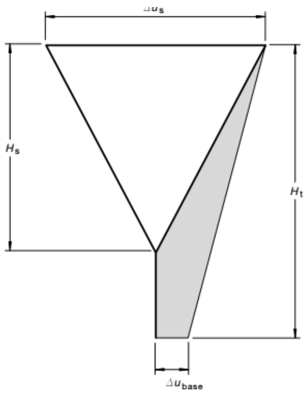
Absence of Depth Guidelines for Concrete Bored Piers

Currently, depth guidelines exist only for screw piles, with **no specific recommendations** for concrete bored piers in AS2870. In numerous instances, bored piers are found within shallow Hs depths, where significant soil movement can occur, raising questions about the sustainability of this foundation solution. Katana has created a Youtube video providing a visual representation of Reactive Soil Settlement in Home Foundations comparing Katana Screw Piles to Concrete Bored Piers.

Maximum Design Drying Depth (Ht)

The introduction of a **single tree or a group of trees** to the soil, theoretically absorbing moisture from the soil, can lead to an increase in soil movement. Here, **Ht,** the maximum design dry depth due to tree(s), becomes the governing factor influencing the pile depth. The impact is illustrated in the diagram, and the Ht value can be obtained from the table below.

Depth of design suction change, (H_s)	Single tree		Tree group	
	Maximum extra suction change (Δu_{base})	Maximum design drying depth (H_t)	Maximum extra suction change (Δu_{base})	Maximum design drying depth (H_t)
m	pF	m	pF	m
1.5	0.30	2.5	0.38	3.0
1.8	0.33	2.7	0.40	3.3
2.3	0.35	3.0	0.43	3.6
3	0.38	3.4	0.46	4.1
4	0.43	4.0	0.55	4.5



AS2870 does not specify a minimum depth requirement for the influence of Ht, but the same understanding as described above for Hs can be also applied to Ht. The table is as follows:

Site Classification		
S (0-20)	**M, M-D and H1 (20-60)**	**H2, H1-D (60-75)**
Depth of Screw Pile (Ys Movement @ Depth)		
0.75 x Ht	**1 x Ht**	**1.25 x Ht (min)**

Zone of Influence

Piles are frequently employed to accommodate the zone of influence emanating from nearby pools or deep service trenches such as sewer or stormwater pipes. The determining factors for pile depth are the depth of the pool or service trench in relation to the distance from the pile. It is imperative for the builder's engineer to thoroughly assess all pertinent **information, pool specifications, and comply with council or authorities' requirements.**

Geotechnical Report

For **optimal pile depth determination**, the geotechnical report ideally includes the following information:

- Site Classification
- Applicability of a Class 'P' designation to the site
- Site Geology
- Climatic Zone
- Allowable Bearing Pressures
- Borehole logs detailing soil moisture, density, consistency and strength
- Borehole logs with 3 or more boreholes strategically distributed across the site
- Borehole logs testing beyond fill areas, reaching at least into natural soil
- DCP, SPT results
- Identification of water table

Borehole Logs

AS2870 specifies that the minimum depth of investigation below natural ground level **should be 0.75Hs, but not less than 1.5m unless rock is encountered.** Additionally, a **minimum of one borehole per site is required**, but this increases to **three boreholes if Hs is greater than 3.0m.** However, Katana emphasises the importance of having as many boreholes as possible distributed across the site, and the site investigation going as deep as possible, ideally extending past fill areas and reaching into natural soil.

2.4.3 Depth of investigation

The soil profile shall be examined to a minimum depth below the surface or below the depth of cutting where known at the time of site classification equal to 0.75 times the depth of design suction change (H_s), for the locality, but not less than 1.5 m unless rock is encountered.

2.4.4 Minimum number of exploration positions

The following shall apply to building sites:

(a) A minimum of one borehole or pit per building site.

(b) A minimum of three boreholes per site in localities where $H_s \geq 3.0$ m, and areas where the soil profile is known to be highly variable.

In many scenarios, the borehole logs reach a depth of 1.8m, while fill extends beyond this depth. Although the structural plans specify a pile depth of 2.3m, uncertainty exists regarding whether the piles will be found past the fill. Fill presents a complex challenge, and **Katana's default approach is to drive piles through fill.** While fill can yield high torque readings that may be interpreted as sufficient capacity, its unpredictable nature introduces a risk of differential settlement. Katana will only proceed with founding piles within fill (controlled) if the builder's engineer approves this approach and a disclaimer will be included, noting the possibility of differential settlement.

Another example is when one borehole log has been completed at the very front of the building site, but piles are required at the back of the building site. Here, there is uncertainty about whether the soil is consistent throughout the site, raising questions about whether the nominated pile depth will be in sufficient material.

With inconclusive information, **Katana may request further testing to ensure the suitability of piles**. This is essential not only for confirming the adequacy of the piles but also for providing the customer with a clearer understanding of the expected depths and costs associated with the piles.

DCP & SPT

The Dynamic Cone Penetrometer (DCP) and Standard Penetration Test (SPT) are valuable indicators of soil compactness, providing insights into the suitability for pile foundation. Paul Uno from ETIA is acknowledged for sharing the tables below, which correlates DCP and SPT values with soil identity in clay and sand.

SPT for Clay

Material	*Description*	*SPT – N (blows/300 mm)*		*Strength*
Clay	V. Soft	≤2	← Note the doubling each level ie 5 →10 →20 →40	0–12 kPa
	Soft	2–5		12–25 kPa
	Firm	5–10		25–50 kPa
	Stiff	10–20		50–100 kPa
	V. Stiff	20–40	Similarly with the strengths →	100–200 kPa
	Hard	>40		>200 kPa

SPT for Sand

Description	Relative density D_r	SPT – N (blows/300 mm)		Strength
		Uncorrected field value	Corrected value	Friction angle
V. Loose	<15%	$N \leq 4$	$(N_o)_{60} \leq 3$	$\phi < 28°$
Loose	15–35%	$N = 4–10$	$(N_o)_{60} = 3–8$	$\phi = 28–30°$
Med dense	35–65%	$N = 10–30$	$(N_o)_{60} = 8–25$	$\phi = 30–40°$
Dense	65–85%	$N = 30–50$	$(N_o)_{60} = 25–42$	$\phi = 40–45°$
V. Dense	>85%	$N > 50$	$(N_o)_{60} > 42$	$\phi = 45°–50°$
	100%		$(N_o)_{60} = 60$	$\phi = 50°$

- Reduce ϕ by 5° for clayey sand.
- Increase ϕ by 5° for gravely sand.

DCP for Clay & Sand

Material	Description	DCP – n (Blows/100 mm)	Strength
Clays	V. Soft	0–1	$C_u = 0–12$ kPa
	Soft	1–2	$C_u = 12–25$ kPa
	Firm	2–3	$C_u = 25–50$ kPa
	Stiff	3–7	$C_u = 50–100$ kPa
	V. Stiff	7–12	$C_u = 100–200$ kPa
	Hard	>12	$C_u > 200$ kPa
Sands	V. Loose	0–1	$\phi < 30°$
	Loose	1–3	$\phi = 30–35°$
	Med dense	3–8	$\phi = 35–40°$
	Dense	8–15	$\phi = 40–45°$
	V. Dense	>15	$\phi > 45°$
Gravels, Cobbles, Boulders*		>10	$\phi = 35°$
		>20	$\phi > 40°$
Rock		>10	$C' = 25$ kPa, $\phi > 30°$
		>20	$C' > 50$ kPa, $\phi > 30°$

Engineering/Structural Plans

The **final decision on depth lies with the builder's engineer,** and Katana will adhere to their guidance. Ideally, the structural plans should clearly outline screw pile locations, loads, pile details, and minimum depths. If there are any concerns regarding the nominated depth, Katana shall seek clarification from the builder's engineer.

In instances where the structural plan lacks minimum depth specifications, Katana will rely on their expertise, taking into account all the factors mentioned above, to **estimate depths.** However, these estimations are subject to confirmation by the builder's engineer.

6.0 Design for Durability

Katana engaged e3K Global to perform an **extensive corrosion review**. This involves evaluating potential effects and limitations, exploring measures to protect the Katana Screw Pile in soils with varying pH at depths up to 500mm.

For additional details on this review, refer to Katana Screw Pile Corrosion Review.

Exposure Classification

Frequently overlooked, it is **strongly recommended** to obtain an Exposure Classification at each site with steel and/or concrete foundations in accordance with AS2159. If assistance is needed in understanding the benefits of an Exposure Classification report, Katana can provide support.

For Steel Piles

According to AS2159 Section 6.5, the design of steel piles should incorporate considerations for durability by evaluating the **Exposure Classification**. The classification, determined from factors such as pH, Chlorides, Resistivity, and Sulphates forms the basis for calculating corrosion allowances:

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.

For Concrete

In accordance with AS2870 Section 5.5, sulphates and pH are utilised to establish the Exposure Classification of concrete. In theory, if information on sulphates is available, assumptions can be made about the resistivity to roughly estimate the Exposure Classification for steel piles.

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

BELOW the ground

Typically, for piles situated below ground level, the Katana Screw Piles can be either left **unsealed** or **sealed,** depending on soil conditions.

If no protective systems are intended for application on steel piles, provisions must be made for uniform corrosion and potential section loss, as per AS2159. In the absence of alternative information, the corrosion allowance should be referenced in the table below:

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

In cases where site-specific corrosion rates are identified, these rates may be applied. However, corrosion on the internal faces of a fully sealed closed-form pile may be assumed to be **negligible**. Bearing this in mind, along with the considerations from the corrosion allowances table above, the subsequent table has been formulated to illustrate the anticipated lifespan of the 76.1 x 4.0 and 88.9 x 5.5 Katana Screw Pile variants, whether unsealed or sealed.

Assumptions & Considerations:

- Groundwater is well below ground level.
- No moisture at ground level.
- At the end of its life, the pile has half its section thickness.
- When extensions are used, and groundwater may enter the pile, it may be deemed **unsealed.**

Exposure Classification	Uniform corrosion allowance (mm/year)	**Unsealed** (corrosion affecting both the internal & external surfaces).		**Sealed** (corrosion affecting ONLY one/the external surfaces).	
		76.1 x 4.0	88.9 x 5.5	76.1 x 4.0 Sealed	88.9 x 5.5 Sealed
Non Aggressive	< 0.01	100	137	200	275
Mild	0.01 - 0.02	50 - 100	68 - 137	100 - 200	138 - 275
Moderate	0.02 - 0.04	25 - 50	34 - 68	50 - 100	68 - 138
Severe	0.04 - 0.1	10 - 25	13 - 34	20 - 50	27 - 68
Very Severe	> 0.1	<10	<13	<20	<27

From this, the following recommendations are made:

- ➔ In "non-aggressive" and ""mild" environments, the basic Katana Screw Pile is expected to have a design life of 50 years or more.
- ➔ In "moderate" environments, it is advised to fully seal the inside of the Katana Screw Pile to achieve a design life of 50 years.
- ➔ In "severe" environments, it is recommended to fully seal the inside of the Katana Screw Pile and increase pile thickness to at least 7.0mm. Alternatively, sealing and additional corrosion protection are required, with options such as hot-dipped galvanisation or zinc coating being excluded.
- ➔ In "very severe" environments, seeking consultation with Katana is recommended.
  - ◆ There have been instances where the shaft is fully core-filled and considered acceptable, subject to approval by the builder's engineer.

The party best placed to understand the Exposure Classification of the soil is the Geotechnical Engineer. Where there is any doubt a sample can be analysed by a laboratory at what has to be considered a negligible cost.

ABOVE the ground

According to AS2159, the design durability for the structure supported by the piles shall also extend to any section of piles exposed above ground level. An appropriate corrosion protection system, tailored to the environment, must be employed, adhering to the requirements of AS/NZS 2312. The selection of the best protection system is at the discretion of the builder's engineers.

Katana's default coating system for the Raised Floor System is **hot-dipped galvanising**, as previously mentioned. To reiterate, corrosivity factors C1, C2 and C3 are suitable for galvanising, while for anything exceeding C4, the builder is obliged to explore system protection by consulting an expert in coating systems. Although **zinc electroplating** is generally an uncommon coating system for Katana, it can be provided upon request.

With reference to the Galvanizers Association of Australia's estimated corrosion rates of steel & zinc in Australia, derived from AS4312 and AS/NZS2312, Katana has devised a table indicating the expected above ground life for galvanised or zinc electroplated Katana Screw Piles.

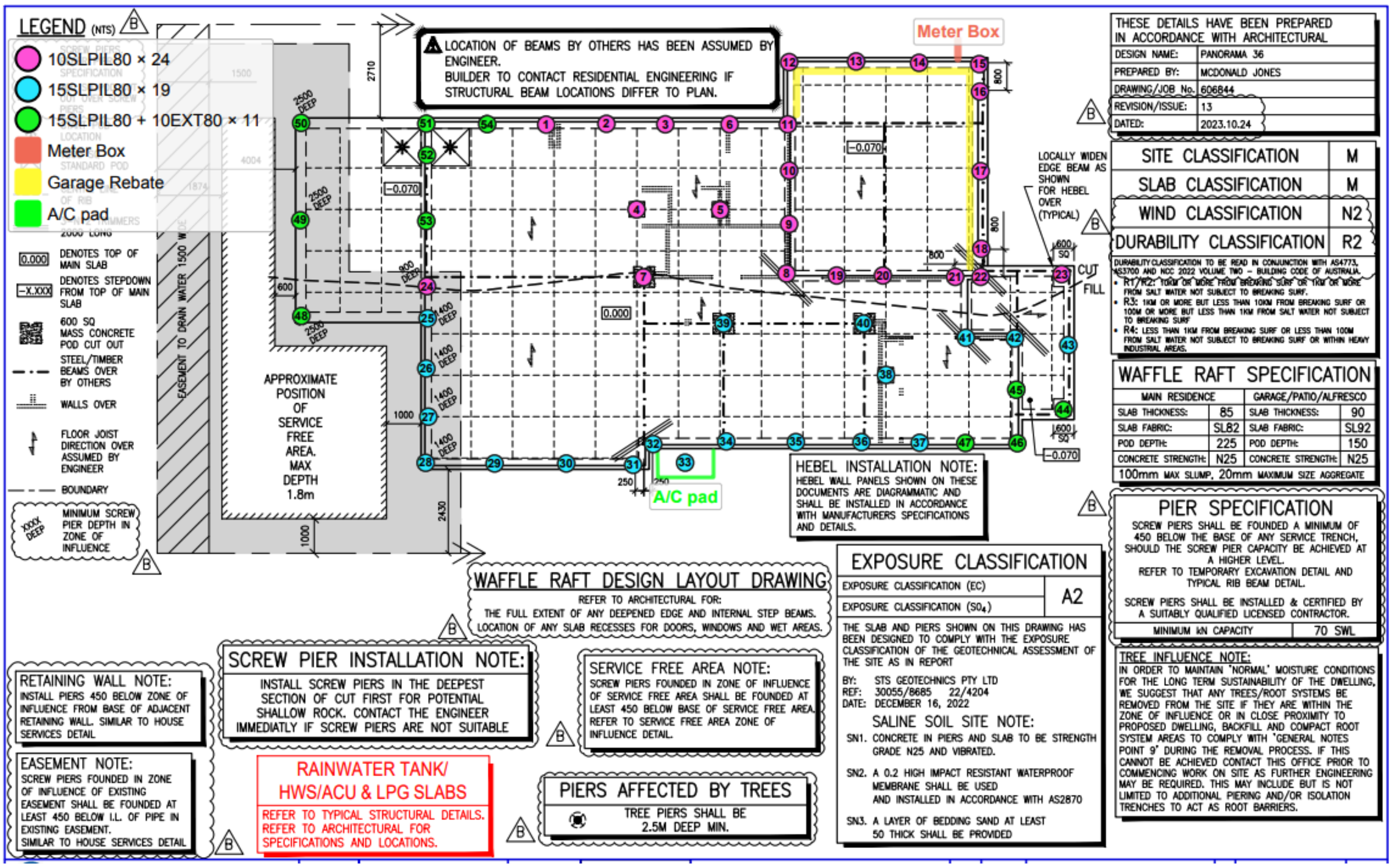
						Life of Uncoated + Life of Galv/ Zinc Electro.	
Corrosivity Category	Mild Steel Corrosion Rate for the 1st Year (µm/year)	Life of Uncoated Mild Steel 2000 µm (years)	Zinc Corrosion Rate for the 1st Year (µm/year)	Life of Galvanising: Assume min. 55 µm (years)	Life of Zinc Electroplating: Assume min. 12 µm (years)	Total Expected life Galvanised Pipe (years)	Total Expected Life of Zinc Electroplated Pipe (years)
C1	1.3	1538	0.1	550	120	**2088**	**1658**
C2	25	80	0.7	79	17	**159**	**97**
C3	50	40	2.1	26	6	**66**	**46**
C4	80	25	4.2	13	3	**38**	**28**
C5	200	10	8.4	7	1	**17**	**11**
Cx	700	2.8	25	2	0	**5**	**3**

Refer to Appendix G for tables providing detailed explanations of corrosivity factors.

7.0 Pile Installation

Pre-Site Preparation

- Builders must **identify and inform Katana of all service locations on-site** before the screw piling work begins. If any underground services or works are found within the engineered screw pile locations, Katana holds no responsibility for damages, delays or associated rectification costs.
- Katana will evaluate essential documents, including architectural and structural plans, geotechnical reports, exposure classifications, and nearby installation history reports, to assess the site's suitability for piles. The number and depth of piles will be determined accordingly, as indicated in Section 4.0 of this performance guide. Subsequently, a Katana Pier Layout (refer below) will be generated, providing on-site crews with guidelines for the installation process.



- A crew comprising the **Certified Katana Installer/Contractor** and an offsider, would typically be assigned to the project.
  - To become a Certified Katana Installer, the contractor must demonstrate proficiency in answering all questions in Appendix K. Subsequently, a Katana Representative will supervise the initial screw pile installation to verify adherence to the correct process. Upon satisfaction and obtaining approval from a Katana Representative, the installer will be granted an Installer Certification making them eligible to carry out future installations on behalf of Katana.

On-Site Preparation

Before commencing work on-site, the Certified Katana Installer should perform the following checks:

- ➔ **Verify and identify the correct site.**
- ➔ Assess and complete site-specific Safe Work Method Statements (SWMS)
- ➔ Ensure sufficient access for plant entry
- ➔ Clear any spoil, debris, obstacles, steep slopes, or other trades hindering the scope of work.
- ➔ Verify the visibility of all surveying pegs and marks, ensuring alignment with architectural and structural documents. If disparities arise, the job is **NOT** to proceed until appropriate advice is provided by the builder.
- ➔ Identify whether there are any underground services and ensure they correlate with the structural/architectural plans.
- ➔ Ensure the ground pad is level with tolerance of ±100mm.
- ➔ Review the geotechnical report to understand soil conditions and determine minimum target depth required. If in doubt, the installer must contact the builder's engineer for clarification.

Once all checks are complete, the Certified Katana Installer can proceed to mark out the screw pile and any excavated strip footing/isolated pad footing locations in accordance with the structural documents.

Installation Equipment

The following lists the essential information, documents, and equipment that all Certified Katana Installers must have on site during installation:

1. Latest revision of architectural & structural plans, along with geotechnical reports.
2. Installation Record Checklist.
3. Installation & Testing Manual.
4. Uplift Testing & Installation Record Data Sheets.
5. Digital Camera or Phone - for capturing high-resolution images.
6. Pile Uplift Load Testing Unit with Hand Pump and calibrated Bar Pressure Gauge. Only approved testing devices should be used, available from Katana.
7. Minimum 5-tonne Excavator or equivalent.
8. Appropriate earth drill/drive motor attachment (Auger Torque ED10,000) - to match the flow of the excavator.
9. Laser and receiver instrumentation - for evaluating pad and pile levels.
10. Perpendicular instrumentation - for maintaining vertical alignment.
11. Bar/ PSI pressure gauge for excavator.
12. Pipe Cutting Device/ Reciprocator Saw or similar. If opting for a tool other than a Recipro, it must be clearly specified in the SWMS.
13. Katana Pile Installation Adapter Tool.
14. Appropriate number of Katana Screw Piles - to meet installation layout requirements.

15. Spare Katana Pile Extensions - for achieving adequate depth.
16. Appropriate number of Katana accessories.
17. Other consumables for site survey, marking out, identification, or cleaning.

Installation Guidelines

The installation process is carried out by a two-person crew, including the Certified Katana Installer/Contractor and an experienced offsider at a minimum. If the Pre-Site and On-Site Preparations meet the requirements, the installation of the Katana Screw Pile may proceed as follows:

Step 1: Attach Square Drive Head

- Attach the Katana Square Drive Head to the excavator drill.

Step 2: Check Pile Length

- Confirm that the supplied pile length aligns with the minimum requirements specified in the provided engineering design. For instance, 80kN, 100kN, 150kN @ 1.0m - 4.0m length. In case of uncertainty, contact the builder's engineer before proceeding with the installation.

Step 3: Choose Location for First Pile

- Once the pile size and length are confirmed, select a suitable location for the initial pile, **preferably starting at the rear of the site and working towards the street**.
- The first screw pile installation aims to determine the cut/fill line and assess how much fill has been added since the original soil test. This method helps confirm if the soil profile matches the geotechnical report or if adjustments in incremental size are needed.

Step 4: Commence Installation of Initial Three Piles

- Commence the installation of the initial three Katana Screw Piles (front, middle, and rear), ensuring they reach the **minimum target depth** as specified in structural plans. Record the pressure reading reached on the machine gauge using the Installation Record Checklist.

Step 5: Conduct Testing (If Required)

- After reaching the target depth of the first pile, four questions should be considered:
    - Has the required torque been achieved for the specific type of pile?
    - Has the minimum depth of at least 2 metres been achieved?
    - Is there potential differential settlement?
    - What is the construction type? (single storey or double storey)

- If any concerns arise with the above, **a rapid load or compression load test may be conducted.**

On-Site Rapid Load Test

1. Using the Rapid Uplift Test Device:
    a. Place the Rapid Load Testing Device over the Katana Screw Pile, ensuring a level firm base under the test unit.
    b. The test is **NOT suitable for piles installed at less than 2..0m depth.**
2. Attach connecting threaded rod:
    a. Screw in the connecting threaded rod, placing the hollow cylinder jack over it and securing it with a washer and locking nut.
3. Connect the hand pump unit:
    a. Connect the hand pump unit, complete with a calibrated bar pressure gauge, as shown below.

4. Jack the ram:
    a. Jack the ram (containing a 100mm stroke), preloading the test device to allow for potential settlement at the base of the testing unit. The extent of settlement may vary depending on the soil conditions beneath the test unit.
    b. As a safety precaution, ensure all individuals are located a minimum 3m clear of testing units before jacking.
5. Jack until required capacity is achieved:
    a. One preloading is completed, and there is no further settlement observed, continuing jacking the ram until the required psi capacity, as specified by the engineer, has been achieved. Typically, the measured uplifting load is approximately 100% of the calculated load-bearing capacity of the pile.

For RCH-20100 with an 80kN/ 8T pile, the pressure must read 4000 psi

For RCH-30100 with an 80kN/ 8T pile, the pressure must read 2700 psi.

	GHC20100H	
psi	kN	T
0	0	0
500	10	1
1000	20	2
1500	30	3
2000	40	4
2500	50	5
3000	**60**	**6**
3500	70	7
4000	**80**	**8**
4500	90	9
5000	**100**	**10**
5500	110	11
6000	120	12
6500	130	13
7000	140	14
7500	**150**	**15**
8000	160	16
8500	170	17
9000	180	18
9500	190	19
10000	200	20
20100	**10000psi = 20T**	

	GHC30100H	
psi	kN	T
500	15	2
1000	30	3
1500	45	5
2000	**60**	**6**
2350	71	7
2700	**81**	**8**
2850	86	9
3350	**101**	**10**
3500	105	11
4000	120	12
4500	135	14
5000	**150**	**15**
5500	165	17
6000	180	18
6500	195	20
7000	210	21
7500	225	23
8000	240	24
8500	255	26
9000	270	27
9500	285	29
10000	300	30
30100	**10000psi = 30T**	

6. Maintain pressure:
   a. Maintain a minimum constant pressure on the pile at the load capacity requirement for a minimum of 5 minutes, ensuring the pile does not displace.
7. Record pressure:
   a. Record the bar pressures achieved on the record sheets and document using photographs or video evidence.
8. Pass conditions:
   a. If the tested pile continues to hold the required load capacity with no displacement for the specified minimum time, it can be confirmed that the screw pile has passed the load requirement.
   b. If the tested pile fails to hold the required load capacity, indicating displacement under load, the test has failed. In this situation, extend the pile depth using a Katana Pile Extension and repeat the test until the required load capacities are achieved.

Step 6: Install Remaining Piles

- Following the completion of the test pile and confirmation of the target depth, the remaining piles should be installed as per the structural plans.
- Installer should ensure the bar pressure matches or exceeds that achieved during the test pile. If the pressure reading is lower, conduct a repeat Uplift Load Test.

Step 7: Document Installation Details

- Document the installation of all piles, including pile number, final depth for each pile, length of pile used (including any extensions), and minimum bar pressure achieved at the final installation depth. Refer to the example below for reference.

Location No.	Final Depth (m)	Pilot Size (m)	Ext. 1 (m)	Cut Length (m)	Sealed	Machine PSI	Machine BAR	Torque (Nm)	Comment	Load (kN)
1	1.0	1.0			Yes	1800	124	6522		80kN
2	1.0	1.0			Yes	1600	110	5797		80kN
3	1.0	1.0			Yes	1800	124	6522		80kN
4	1.0	1.0			Yes	2100	145	7609		80kN
5	1.0	1.0			Yes	1900	131	6884		80kN
6	1.0	1.0			Yes	1600	110	5797		80kN
7	1.0	1.0			Yes	1900	131	6884		80kN
8	1.0	1.0			Yes	2100	145	7609		80kN
9	1.0	1.0			Yes	1800	124	6522		80kN
10	1.0	1.0			Yes	2000	138	7246		80kN
11	1.0	1.0			Yes	1800	124	6522		80kN
12	1.0	1.0			Yes	2100	145	7609		80kN
13	1.0	1.0			Yes	2200	152	7971		80kN
14	1.0	1.0			Yes	1900	131	6884		80kN
15	1.0	1.0			Yes	1600	110	5797		80kN
16	1.0	1.0			Yes	1500	103	5435		80kN
17	1.0	1.0			Yes	1800	124	6522		80kN
18	1.0	1.0			Yes	1900	131	6884		80kN
19	1.0	1.0			Yes	1900	131	6884		80kN
20	1.0	1.0			Yes	2000	138	7246		80kN
21	1.0	1.0			Yes	2400	165	8696		80kN
22	1.0	1.0			Yes	2200	152	7971		80kN
23	1.0	1.0			Yes	1600	110	5797		80kN

Step 8: Inspect The Piles

- Conduct a final inspection before leaving the site. Katana is to review all installed piles to confirm the correct number, location, and final height, ensuring alignment with the structural and architectural plans provided.

Katana Screw Pile Installation Tolerances

➔ The maximum variation from the plan position, as indicated in the drawings, should **not exceed ± 25mm.**

➔ The installation of the Katana Screw Pile shaft must adhere to verticality standards, with a variation **not exceeding 4% from the vertical.**

On-Site Installation Issues

Torque

In contemporary piling practices, torque measurement is a key determinant of pile capacity. However, extensive installations reveal challenges in achieving the necessary torque, especially in cases of liquefaction in sandy soils, single-graded sand, wet silts, and saturated clay, despite good bearing capacity. Conversely, the introduction of fill can lead to exceptionally high torque readings, potentially leading to misinterpretations of sufficient capacity. These inconsistencies significantly impact the overall pile installation cost, often leading to pile extensions to meet torque requirements. To address this, Katana proposes confirming installation depth through an **on-site Uplift Load Test**, as mentioned above.

Refusal

Encountering very stiff/hard soils or weathered rock during pile installation can lead to refusal, presenting two issues:

1. Failure to **achieve the engineering-required** depth.
2. Inability to install the pile to the **required Reduced Level (RL).**

Where the minimum depth is not attained, the piling contractor must secure written confirmation from the engineer, either approving the situation or providing instructions on necessary actions. Despite common concerns about the pile being founded on rock, Katana believes this offers the best foundations, expressing confidence in the pile's ability to perform at its maximum capacity.

If the pile falls short of the required RL, the pile is trimmed to the desired RL, and a Katana Cut Drive Nut can be placed over the trimmed pile, either fixed in place by screws or welded.

Predrilling

Predrilling serves as a viable technique to facilitate the installation process in hard or dense ground conditions. It is important to adhere to the guidelines outlined in AS2870, ensuring the maximum pre-drill diameter is **limited to 90% of the maximum pile diameter.** This precaution is crucial to prevent surface water ingress into the foundation, mitigating the risk of corrosion in the pile. While there may be concerns about marginal ground disturbance during predrilling, it is also crucial to account for potential ground relaxation after installation, as this factor may impact the long-term capacity of the pile.

Differential Settlement

If a site is partially cut on one side and filled on the other, and the installation torques mirror this condition, there is a potential concern regarding how the home will settle and where cracks may occur.

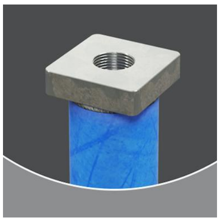
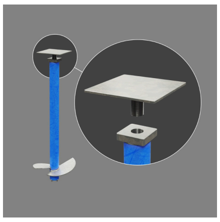
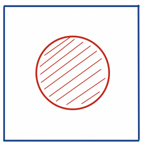
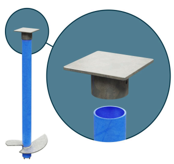
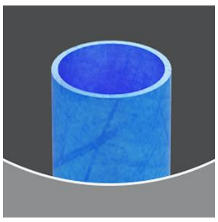
Certification

To obtain final certification for the Katana Screw Pile installation, the following information must be supplied:

1. Site photographic evidence.
2. Results of the initial Uplift Load Test, along with video footage or photographs that clearly capture the gauge read and the surrounding location.
3. Installation report containing comprehensive details such as pile number, final depth achieved for each pile, length, extensions, pressure, accessories and any cut increments.
4. Layout illustrating the location and assigned numbers of the installed screw piles.

Appendix

Appendix A: Drive Nut Plate Vs. Other Slab Supports

Slab Support	Support Area	Shear Capacity	Bearing Load	Comments
 **Drive Nut Plate/ Square Drive Head**	76.1mm Dia. Shaft A=85 x 85 - π x $(18)^2$ A=**6,207mm^2**	**100kN** SWL at the CENTRE of the footing **80kN** SWL 75 mm AWAY from the centre	**13MPa** (80kN SWL)	Experimental testing conducted by the University of Melbourne regarding the smallest permissible footing size as per AS2870.
	88.9mm Dia. Shaft A = 110 x 110 - π x $(18)^2$ A =**11,082 mm^2**	**Varies based on the size of the footing**	**13.5MPa** (150kN SWL)	
 **Slab Plate**	A=π x $(60/2)^2$ A=**2,827 mm^2** 	**No empirical testing**	**28 MPa** (80kN SWL)	Assume providing support with an extra 12mm around the 36mm threaded rod, resulting in a **60mm diameter.**
 **Cut Off Plate**	A=π x $(52)^2$ A=**8,490 mm^2**	**> 100kN** SWL (centre of footing) **> 80kN** SWL 75mm from the centre	**10MPa** (80kN SWL)	Assume providing support with an extra 12mm around the 80mm CHS,, resulting in a **104mm diameter.**
 **Cut Pile**	A=π x $((38)^2 - (34)^2)$ A=**904 mm^2**	**No empirical testing**	**88MPa** (80kN SWL)	

Appendix B: Theoretical Torsion Capacity Calculation

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

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

For a 101mm 250MPa - 350 MPa high strength steel from a mill with QA (Ø = 0.9)

- Theoretical Torsion Capacity: **7600 Nm - 10700 Nm**

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

- Theoretical Torsion Capacity: **7300 Nm - 9200 Nm**

Appendix C: SWL vs. Torque

An estimate of the pile capacity can be derived from the empirical evidence provided below.However, it is essential to acknowledge that this calculation is an **approximation** due to numerous variables.

Qu = KT

- Qu = Ultimate Capacity
- K = Ratio (m-1 / ft-1)
    - The regression analysis, as illustrated by Perko, correlates K to pile diameter and differs between metric and imperial units.
- T = Torque

Examples:

- Assume a torque of 6kNm on a 76.1mm pipe , where K is 27, the ultimate capacity (Qu) would be 27 x 6kNm = 162kN
- Similarly, for an 88.9mm pipe with a torque of 13kNm, the calculated ultimate capacity is 23 x 13kNm = 300kN.

It is important to note that the governing factor is typically the bearing capacity of the soil.

However, there is a variable in K as depicted in the chart, influenced by factors such as:

- **Pile characteristics**: number, helix diameter, thickness, pitch, shaft shape, connection detail
- **Soil properties: type, strength, stiffness, water table**
- **Installation parameters:** rotation rate, advance rate, downforce
- **Testing considerations**: load rate, increments, waiting time, interpretations

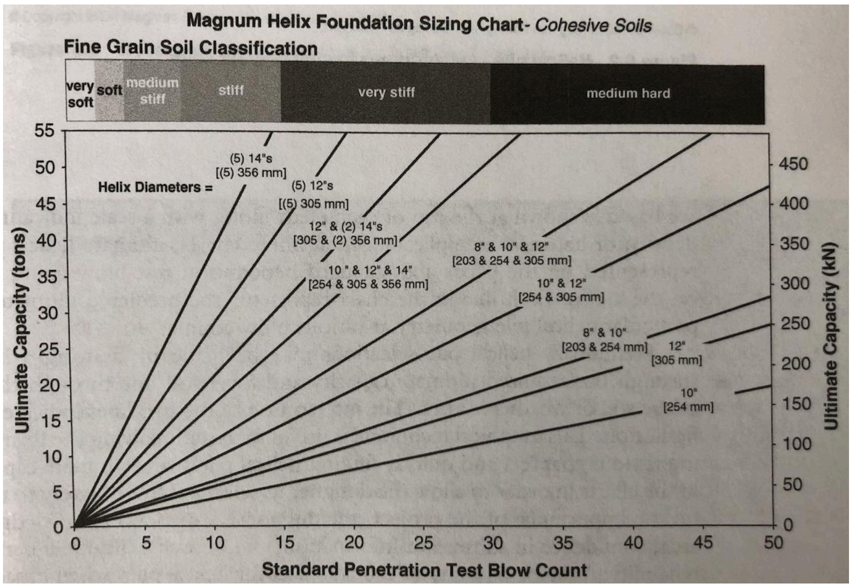
While K can be used to approximate the installed pile's capacity, it is advised to verify this through on-site testing. The table below provides an approximation of Torque (Nm) and the resulting pile capacity, emphasising the need for on-site verification.

Capacity	76 pipe (Nm) K_1=27m^{-1}	88 pipe (Nm) K_1=23m^{-1}	101 pipe (Nm) K_1=20.5m^{-1} (Approx)	114 pipe (Nm) K_1=18m^{-1}
40kN	**1500**	**1750**	**2000**	**2500**
60kN	**2300**	**2600**	**3000**	**3400**
80kN	**3000**	**3500**	**3900**	**4500**
100kN	**3700**	**4300**	**4900**	**5600**
120kN	**4500**	**5200**	**5900**	**6700**
140kN	**5200**	**6100**	**6800**	**7800**

150kN	**5600**	**6500**	**7300**	**8400**
160kN	**6000**	**7000**	**7800**	**8900**
180kN	**6700**	**7800**	**8800**	**10000**
200kN	**7400**	**8700**	**9800**	**11100**
250kN	**9300**	**10900**	**12200**	**13900**
300kN	**11200**	**13100**	**14700**	**16700**

Helical Blade Sizing Method

Several empirical methods also exist that establish a correlation between helical blade area, soil strength, and ultimate capacity, as indicated in Perko's graph below.



Appendix D: Capacity of Edge Beam Connector

Some builder's engineers may recommend reinforcing through a hole towards the top of the pile, typically a length of 29D for full embedment into the concrete. Katana, however, utilises **a 250mm N16 Adjustable Edge Beam Connector embedded into the concrete footing.**

Through testing, the Katana Screw Pile, with an Edge Beam Connector, has demonstrated an ultimate failure load of 55kN per pile or 110kN for two piles, resulting in a **SWL of 27.5kN per pile**. This makes it particularly well-suited for residential applications.

Test Results

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

The Katana Screw Piles, set at an 80kN SWL and spaced 3m apart at a depth of 2.0m, were installed. The installation included the use of the **16 Adjustable Edge Beam Connector,** steel cages and slab mesh. Given that this was a destructive test conducted for both Lateral and Uplift modes and considering the Katana Screw Pile configuration, the following observations can me made:

- In uplift mode, Katana asserts that the load pressures were distributed over the three piles, with the middle pile withstanding a minimum of 50% of the load. Given that this conclusion is based on a single test, a Factor of Safety (FOS) of 2.0 was applied.
- In the lateral mode, Katana contends that the load distribution was equal across the three Katana Screw Piles, and so a FOS of 3.0 was applied.

Calculations:

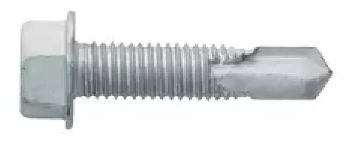
Uplift: 110kN / 2.0 FOS = **27.5 kN/pile**

Lateral: 110kN / 3.0 = **18.3 kN/ pile**

Capacity of the Edge Beam Connector:

Capacity of Threaded Rod: Dia. = 31 mm Area = 754 mm² Fy = 800 MPa (rod) F (Ultimate) = Fy x Area = 603.8 kN FOS = 2.0 **F (SWL) = 301.9kN**	**Capacity of the Weld:** Fillet weld size = 8 mm Length = 20mm x 2 (sides) = 40 mm Area = 320 mm² Fy = 480 MPa (weld) F (Ultimate) = Fy x Area = 92.2 kN FOS = 2.0 **F (SWL) = 46.1 kN**	**Shear Capacity of N16 bBar:** Dia. = 16mm Area = 201 mm² Fy = 500 MPa (bar) F (Ultimate) = 0.62 x Fy x Area = 99.7 kN FOS = 2.0 **F (SWL) = 49.9 kN**

Appendix E: Screw Capacity for Uplift Loads

Tri-Fixx M8 Heavy Duty Self Drilling Screws Specification Sheet 	**Buildex Hex Head Screws** Specification Sheet 	**Bunnings Zenith Screws** DO NOT USE 

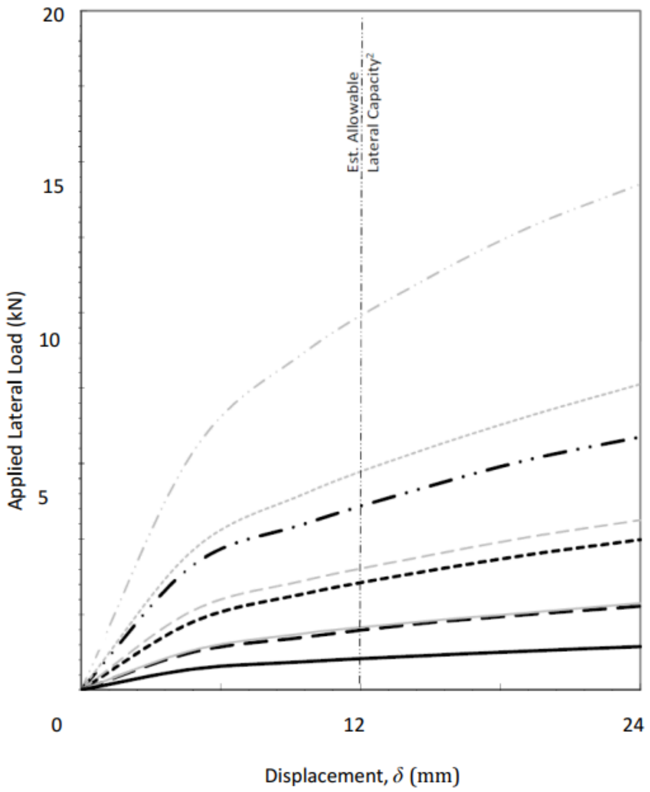
Appendix F: Katana Screw Lateral Capacity Graphs

Katana Pile - 80kN

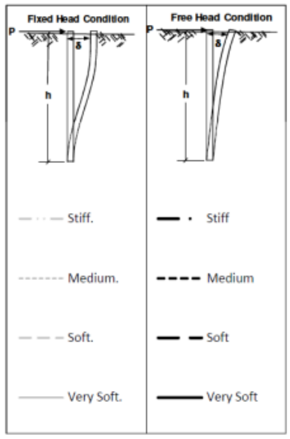
Lateral Performance in Clay

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.)

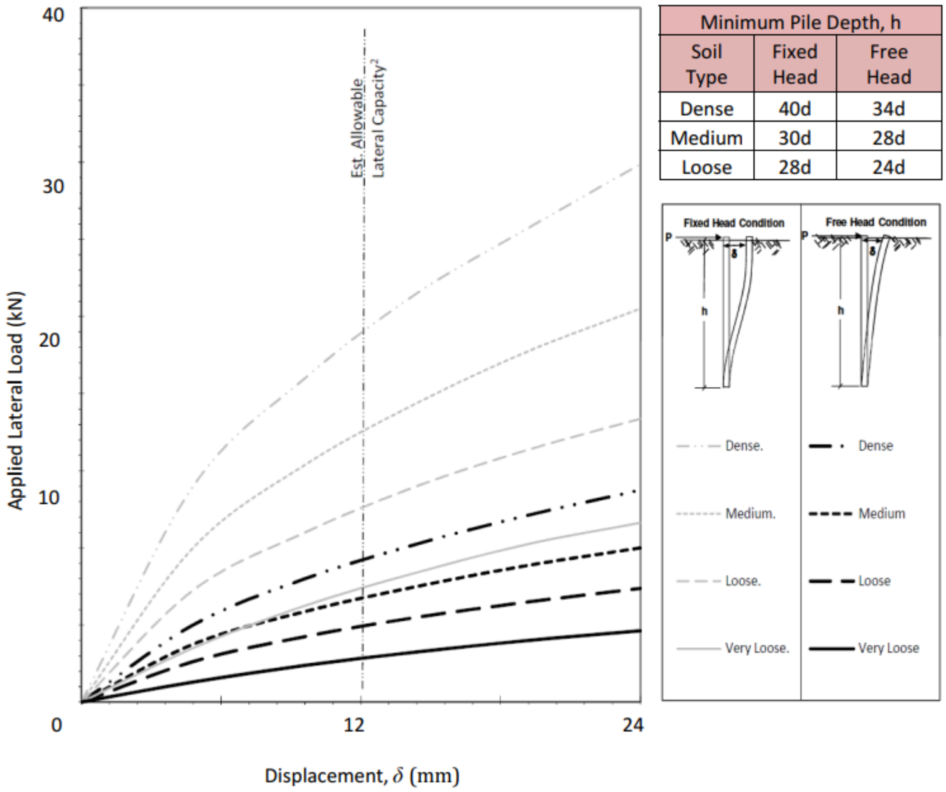
AS2159 - 2009, states that the allowable lateral capacity of a pile is half load causing a 25mm of displacement. Many practitioners take this to be nearly the same as the lateral load predicated at 12mm displacement. The graph presented here can be used to evaluate capacity for either condition as well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

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.

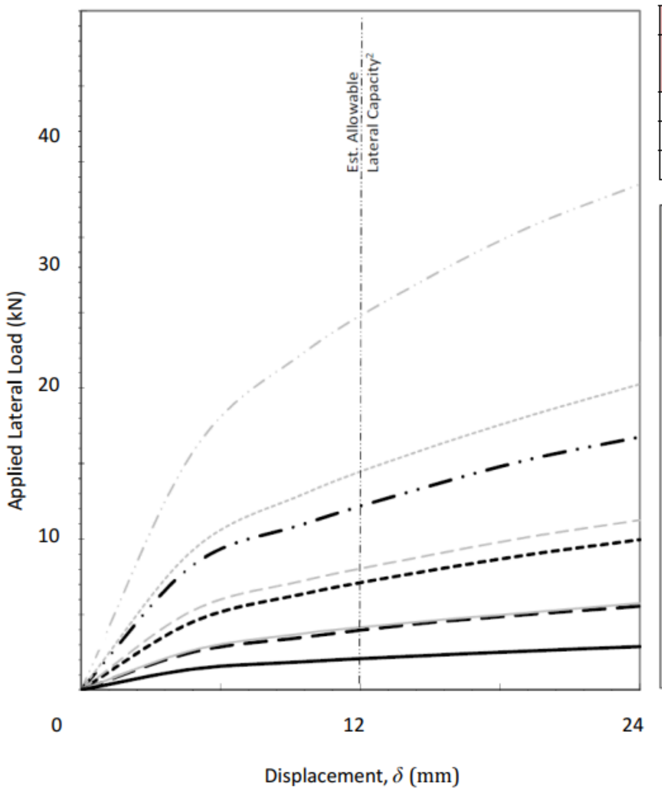
Katana Pile - 150kN

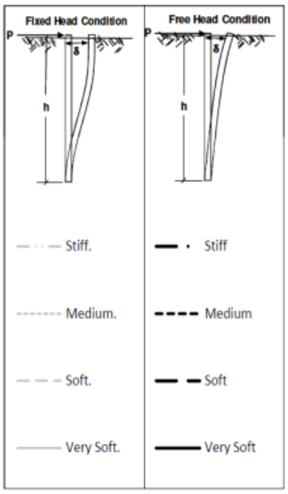
Lateral Performance in Clay

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





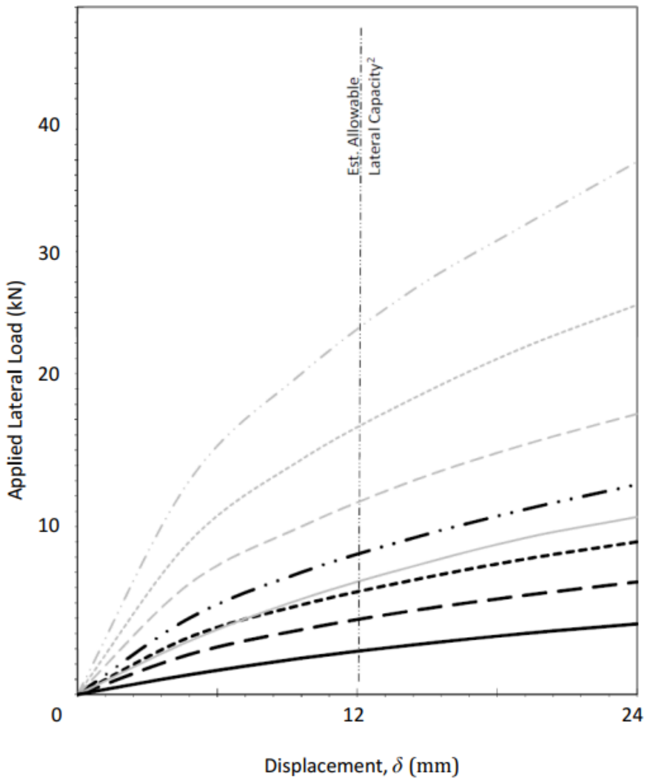
These charts are for Katana Piles only as lateral performance is highly dependent on the connections rigidity and shaft properties. It is Katana's opinion that these graphs represent a reasonable approximation of the average performance of th Katana Pile in the indexed soils. Using the average performance 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.

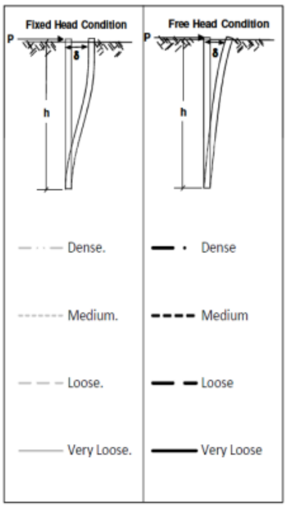
Katana Pile - 150kN
Lateral Performance in Sand

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.

Appendix G: Explanation of Corrosivity Factors

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 µg/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 µg/m^3 to 30 µg/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 µg/m^3 to 90 µg/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 µg/m^3 to 250 µg/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 µg/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.			

Corrosivity category	Comparative corrosion rates for steel and zinc from ISO 9223 r_{corr}		
	Unit	Carbon steel	Zinc
C1	g/(m^2·a)	$r_{corr} \leq 10$	$r_{corr} \leq 0.7$
	µm/a	$r_{corr} \leq 1.3$	$r_{corr} \leq 0.1$
C2	g/(m^2·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/(m^2·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/(m^2·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/(m^2·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/(m^2·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/(m^2·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].			

Appendix H: Calculation of Building Loads

Ultimate Load Transmitted to Edge Beam, kN/m

Using typical dead loads (G), live loads (Q), and ultimate limit state loads (U) transmitted to the edge beam, the following line loads can be calculated:

- ➔ 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).
- ➔ 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).
- ➔ 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).
- ➔ 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)

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)	28.1kN/m	25.27kN/m

Controlling line load (ULS) = 1.2G + 1.5Q = 28.1kN/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)	24.5kN/m	21.22kN/m

Controlling line load (ULS) = 1.2G + 1.5Q = 24.5kN/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)	46.9kN/m	38.80kN/m

Controlling line load (ULS) = 1.2G + 1.5Q = 46.9kN/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)	43.3kN/m	34.75kN/m

Controlling line load (ULS) = 1.2G + 1.5Q = 43.3kN/m.

After determining the line loads, the pile loads can be calculated based on the potential spacing of the piles.

SWL of piles with FOS = 1.5 based on the above ULS building load table * assuming the pile carries all the load and no load is distributed to the surrounding soil:

			Pile Spacing C/C			
Residential Types	**ULS Load (kN/m)**	**SWL Load (kN/m)**	**1.5m SWL (kN)**	**2.0m SWL (kN)**	**2.5m SWL (kN)**	**3.0m SWL (kN)**
Single Story, Brick Veneer, Metal Roof	24.5	16.3	24.5	32.6	40.8	48.9
Single Story, Brick Veneer, Tile Roof	28.1	18.7	28.1	37.4	46.8	56.1
Double Story, Brick Veneer, Metal Roof	43.3	28.9	43.4	57.8	72.3	86.7
Double Story Brick Veneer Tile Roof	46.9	31.3	47.0	62.6	78.3	93.9

Appendix I: Serviceability Limit State (SLS) vs Ultimate Limit State (ULS)

Katana Screw Pile

Katana has a comprehensive understanding of their product at the SWL. Builder's engineers are encouraged to explicitly specify the SWL on their drawings to eliminate the need to make assumptions regarding the FOS of the ULS.

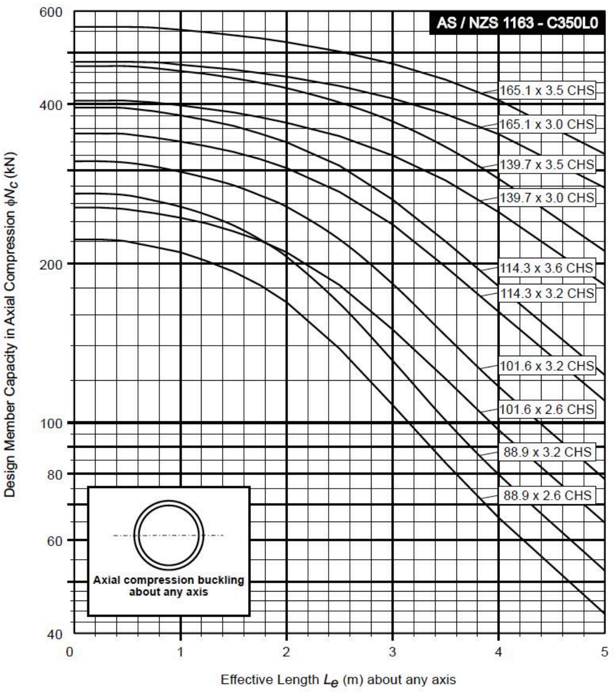
	76.1 x 4.0 250 x 8 (kN)	76.1 x 4.0 300 x 8 (kN)	88.9 x 5.5 350 x 10 (kN)	88.9 x 5.5 2 No 350 x 10 (kN)
Serviceability Limit State	7 - 200kN	10 - 200kN	14 - 230kN	41 - 300kN
Ultimate Limit State (SLS x 1.5 FOS)	10 - 300kN	15 - 300kN	21 - 345kN	61 - 450kN
Approx. SLS for an 8m pile in ***very loose soil***	40kN	50kN	75kN	100kN
Approx.. Tension Load depending on depth	1m - 5kN	2m - 35kN	3m - 118kN	4m - 280kN

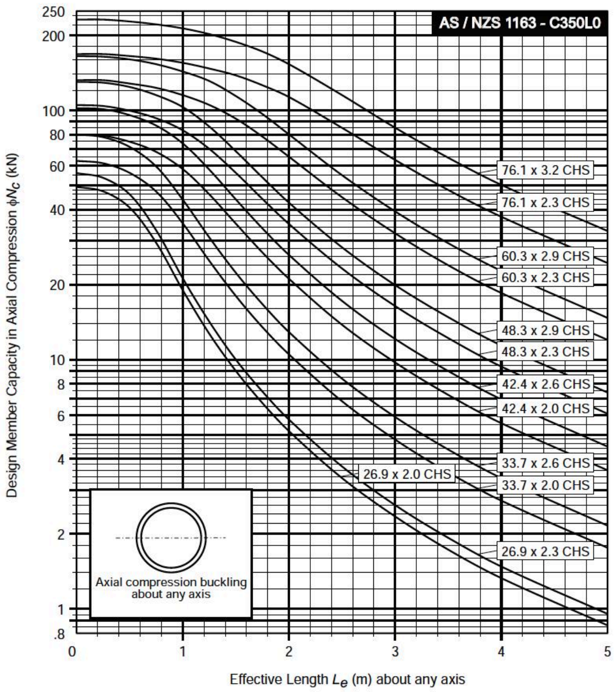
- Wet sandy soil can exhibit a significantly low tension capacity.
- The concern of buckling on piles longer than 8m may arise, especially considering that soft soil can provide some support to the pile.

Steel Capacity

All values are min based on 400 MPa.	76.1 x 4.0	76.1 x 4.0	88.9 x 5.5	88.9 x 5.5	114.3 x 5.4	114.3 x 5.4
SWL vs. ULS	SWL	ULS	SWL	ULS	SWL	ULS
Compression (Short Pile) 0.9 Fy (350MPa) A	190kN	285kN	302.7kN	454kN	428.7kN	643kN
Compression (8m Freestanding Column)	12kN	18kN	22.5kN	33.7kN	52.8kN	79.2kN
Tension	190kN	285kN	302.7kN	454kN	428.7kN	643kN
Bending Moment 0.9 Fy (430MPa) Z	4.1kNm	6.1kNm	8.1kNm	12.1kNm	14.8kNm	22.2kNm
Shear	61.3kN	92kN	98kN	147kN	138.7kN	208kN
Torsion	7 - 8kNm	-	12.5 - 13.5kNm	-	19 - 20kNm	-

The chart below illustrates the reduction in axial capacity with increased length of the pile. Katana must ensure that the axial strength is confirmed by the builder's engineer.





The Helical Plates

A fundamental plate bending analysis was conducted, with both plates contributing 4kN of SWL, primarily at the leading edge. Ultimate load testing was subsequently performed on different soil types, and the helixes were examined for any bending. In loose or soft soils, the strength of the plate/helix will consistently surpass that of the founding soil. In the case of dense or hard soils, over time, the soil above the helix consolidates, and the helix predominately acts in shear along the shaft rather than in bending.

Appendix J: Calculating Load Capacity

There are various theories for calculating the load capacity of screw piles, and one example is outlined below. It is important to note that different theories may yield different results, and these calculations should be verified through testing.

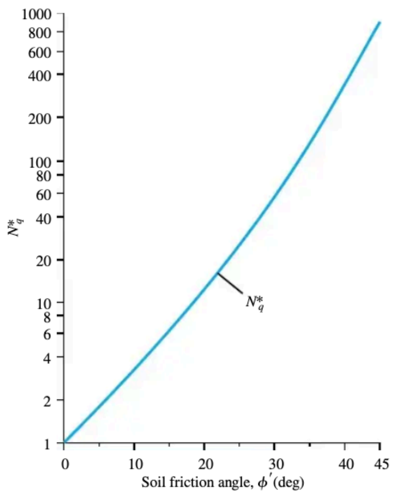
Referring to Donald Calyton's Basic Helical Screw Pile Design, the formula for capacity is given as follows:

Capacity = Sum of Areas of Helical Plates x (qNq or cNc) ~~+ skin friction~~

General guidelines to follow:

- In loose soils where piles are relatively long (as indicated by Penetrometer tests showing loose material), it's important to take into account the reduced buckling capacity.
- Screw pile helices are individually effective when spaced more than three helix diameters apart.

Then, capacity of cohesionless sand = (area of helix) x (overburden) x Nq (where phi is related to Nq)



Soil friction angle, ϕ (deg)	N_q^*
20	12.4
21	13.8
22	15.5
23	17.9
24	21.4
25	26.0
26	29.5
27	34.0
28	39.7
29	46.5
30	56.7
31	68.2
32	81.0
33	96.0
34	115.0
35	143.0
36	168.0
37	194.0
38	231.0
39	276.0
40	346.0

Example: for a plate with a diameter of 250mm, depth of pile 3m, and sand with a density of 16kN/m³ and phi = 32 deg, Nq = 81, then: **Capacity = 0.0446 x (16 x 3) x 81 = 173/1.5 = 115**

From above, the following guide capacity table has been developed:

Assumptions & Considerations:

- Pile in sand
- Single helix
- Depth of pile 3m
- FOS 1.5

- Pipe torsion will not be a limiting factor

Soil Type	Density (kN/m3) - phi	76.1 x 4.0 250 x 8 (kN)	76.1 x 4.0 300 x 8 (kN)	88.9 x 5.5 350 x 10 (kN)	88.9 x 5.5 2 No 350 x 10 (kN)	114.3 x 5.4 450 x 12 (kN)	114.3 x 5.4 2 No 450 x 12 (kN)
Loose	15 - 28	53	79	107	179	177	354
Medium	16 - 32	**115**	171	*230	*300	*350	*400
Dense	17 - 36	*200	*200	*230	*300	*350	*400
Gravel w/ some Sand	17 - 40	*200	*200	*230	*300	*350	*400
Silts	16 - 30	81	120	*230	*300	270	*400

Then, capacity of a **cohesive clay** = (area of helix) x (shear strength) x Nc

Example: for a plate with a diameter of 250mm, depth of pile 3m, and clay with a shear strength of 100kPa and phi = 0 deg, Nc = 9, then: **Capacity = 0.0446 x 100 x 9 = 40.5/1.5 = 27kN**

From above, the following guide capacity table has been developed:

Assumptions & Considerations:

- Pile in clay
- Single helix
- Depth of pile 3m
- FOS 1.5
- Pipe torsion will not be a limiting factor

Soil Type	Undrained Shear Strength (kPa)	76.1 x 4.0 250 x 8 (kN)	76.1 x 4.0 300 x 8 (kN)	88.9 x 5.5 350 x 10 (kN)	88.9 x 5.5 2 No 350 x 10 (kN)	114.3 x 5.4 450 x 12 (kN)	114.3 x 5.4 2 No 450 x 12 (kN)
Soft	25	7	10	14	27	22	45
Firm	50	13	20	27	54	45	89
Stiff	100	27	40	54	108	89	179
Very Stiff	200	53	79	108	216	179	*350
Hard	>200	>53	>79	>108	>216	>179	>*350

Soil Type	**76.1 x 4.0 250 x 8 (kN)**	**76.1 x 4.0 300 x 8 (kN)**	**88.9 x 5.5 350 x 10 (kN)**	**88.9 x 5.5 2 No 350 x 10 (kN)**	**114.3 x 5.4 450 x 12 (kN)**	**114.3 x 5.4 2 No 450 x 12 (kN)**
Soft - Loose	7 - 53	10 - 79	14 - 107	27 - 179	22 - 177	45 - 354
Firm - Medium	13 - 115	20 -171	27 - *230	54 - *300	45 - *350	89 - *400
Stiff - Dense	27 - *200	40 - *200	54 - *230	108 - *300	89 - *350	179 - *400
Very Stiff Clay	53	79	108	216	179 - *350	*350 - *400
Silts	81	120	*230	*300	270	*400

Appendix K: Questions to Demonstrate Proficiency in Katana Products

Q: Under typical conditions, what torque (Nm) or hydraulic pressure (psi) is necessary to attain a minimum load of 80kN on a Katana Screw Pile with a 76.1 x 4.0mm shaft, 250 x 8mm helix?

A: ____

Q: What advantages does the use of a Torque Hub on an excavator offer when installing piles?

A: ____

Q: At what depth, specifically in loose soils, would you begin to express concerns about the decrease in buckling capacity for a 76.1 x 4.0mm pile?

A: ____

Q: What is the recommended approach when encountering a site with fill material?

A: ____

Q: Which test method is most effective in showcasing the load capacity of a screw pile?

A: ____

Q: What are four factors that determine the exposure classification according to AS2159?

A: ____

Q: What is the default coating system for screw piles that are above ground?

A: ____

Q: What considerations should be taken into account when cutting a Katana Screw Pile in a Raised Floor System?

A: ____

Q: What is the maximum load capacity on a Katana Raised Floor System?

A: ____

Q: What must be installed on each pile within the Katana Raised Floor System?

A: ____

Q: Who is responsible for the setout and verification of pile positions once they are installed for a raised floor?

A: ____

Q: Who should perform the design of the Katana Raised Floor System bracing and verify the suitability of Katana bearer plates, L-Brackets, etc, to carry the required loads?

A: ____

Installer Certification

This serves as a certification of Certified Katana Installer on behalf of Katana Foundations Pty Ltd.

I, the **Certified Katana Installer**, have thoroughly read and comprehended the contents of the Performance Guide for the installation of Katana Screw Piles.

Date____

Name:____

Position:____

Signature: ____

I, an **approved Katana Foundations Representative**, confirm that I have provided a thorough explanation of the contents of the Performance Guide for the proper installation of Katana Screw Piles. I hereby certify the Katana Installer to conduct installations on behalf of Katana Foundations Pty Ltd.

Date____

Name:____

Position:____

Signature: ____