

TABLE OF CONTENTS

Forward.....	x
1 Scope and General.....	1
1.1 Scope	1
1.2 Applications	1
1.3 Blade Pile Group Capability	1
1.4 Technical Report Outline.....	2
1.5 Notations	3
2 General Design Requirements	5
2.1 Design Standards & Documentations	5
2.2 Design Life	5
2.3 Other International Design Requirements	5
3 Blade Pile Group Products Summary.....	6
3.1 Blade Pile	6
3.1.1 Introduction	6
3.1.2 Blade Piles	6
3.1.3 Multiple Blades.....	8
3.2 Blade Pile Cap.....	9
3.3 Bracing Pile	10
3.4 Blade Pile Accessories.....	12
3.5 Blade Pile Cap Slab System	13
3.6 AirFormer Air Slab System – Patent Pending	14
4 The Edge over Competitors.....	16
4.1 Blade Pile Vs Alternative Piles	16
4.2 Blade Pile Cap Vs Alternative Support Methods	19
4.3 Bored Pier Replacement	22
4.4 Blade Fins Vs Spiral Pile	22
4.5 Environmental Considerations	24
5 Site Investigation	25
5.1 Site Classification	25
5.2 Regional Soil Suction	26
5.3 Blade Pile Depth & Testing Information	28
5.3.1 Testing Requirements	28
5.3.2 Piles in Reactive Clay	28

5.3.3	Pile Design for Trees.....	32
6	Structural Design Considerations	33
6.1	Structural Analysis & Member Capacities	33
6.2	Shaft Section Capacities	33
6.3	Connections	34
7	Design for Durability	35
7.1	Introduction.....	35
7.2	Pile Protection Method	36
7.3	Minimum pile specifications.....	37
8	Construction Applications	41
8.1	Bored Pier Replacement	41
8.2	Post Replacement	41
8.3	Piling for Adjacent Services.....	42
8.4	Retaining Wall	43
9	Pile Installation	44
9.1	Equipment & Torque	44
9.2	Pre Drilling.....	45
9.3	Safety	45
10	Blade Pile Testing	46
10.1	Compression	46
10.2	Uplift	48
10.3	Lateral	49
10.4	Compression or Tension Pile Testing Template Sheet	50
10.5	Lateral Pile Testing Template Sheet	51
11	References.....	52
Appendix A.	Design Guide to Blade Pile Manual & Load Tables.....	56
A1	Load Summary	58
A2	Internal Slab Design Loads	59
A3	Exterior or Interior Beam - Single Storey up to H2 Class	59
A4	Exterior Beam - Double Storey up to H2 Class	61
A5	Interior Beam - Double Storey up to H2 Class	65
A6	Raised Single Storey on Piles	66
Appendix B.	Slab Design Examples	67
B1	Blade Pile Cap Slab System – Waffle Example	67

B2	Blade Pile Cap Slab System – Conventional Example	69
B3	Blade Pile Slab System Example	71
Appendix C. Geotechnical Design Calculation.....		73
C1	Geotechnical Calculation Plan	73
C2	Geotechnical Values & Reduction Factor.....	84
C3	Design Calculation Examples.....	91
C4	Alternative Methods to Determine the Ultimate Geotechnical Strength	94
Appendix D. Blade Pile Capacity tables.....		95
D1	Design Ultimate Geotechnical Strength $R_{d,ug}$ for different Reduction factors ϕ_g	96
D2	Design Ultimate Geotechnical Strength $R_{d,ug}$ for different Reduction factors ϕ_g	97
D3	Design Ultimate Geotechnical Strength $R_{d,ug}$ for different Reduction factors ϕ_g	98
D4	Design Ultimate Geotechnical Strength $R_{d,ug}$ for different Reduction factors ϕ_g	99
D5	Ultimate Geotechnical Capacities in Homogeneous Stiff Clay [75kPa].....	100
D6	Ultimate Geotechnical Capacities in Homogeneous Stiff Clay [100kPa].....	101
D7	Ultimate Geotechnical Capacities in Homogeneous Very Stiff Clay [150kPa]	102
D8	Ultimate Geotechnical Capacities in Homogeneous Very Stiff Clay [200 kPa]	103
D9	Ultimate Geotechnical Capacities in Homogeneous Hard Clay [225 kPa]	104
D10	Ultimate Geotechnical Capacities in Homogeneous Hard Clay [250 kPa]	105
D11	Ultimate Geotechnical Capacities in Homogeneous Medium Dense Sand.....	106
D12	Ultimate Geotechnical Capacities in Homogeneous Medium Dense to Dense Sand	107
D13	Ultimate Geotechnical Capacities in Homogeneous Dense Sand	108
D14	Ultimate Geotechnical Capacities in Homogeneous Stiff Clay [75kPa] - Ground Water .	109
D15	Ultimate Geotechnical Capacities in Homogeneous Stiff Clay [100kPa] - Ground Water	110
D16	Ultimate Geotechnical Capacities in Homogeneous Very Stiff Clay [150kPa]- Ground Water	111
D17	Ultimate Geotechnical Capacities in Homogeneous Very Stiff Clay [200kPa]- Ground Water	112
D18	Ultimate Geotechnical Capacities in Homogeneous Hard Clay [225kPa] - Ground Water	113
D19	Ultimate Geotechnical Capacities in Homogeneous Hard Clay [250kPa] - Ground Water	114
D20	Ultimate Geotechnical Capacities in Medium Dense Sand - Ground Water	115
D21	Ultimate Geotechnical Capacities in Medium to Dense Sand - Ground Water	116
D22	Ultimate Geotechnical Capacities in Dense Sand - Ground Water	117

D23	Blade Piles vs Bored Piers comparison charts.....	118
D24	Blade pile vs bored piers – Stiff Clay (75kPa).....	119
D25	Blade pile vs bored piers – Stiff Clay (100kPa).....	122
D26	Blade pile vs bored piers – Very Stiff Clay (150kPa).....	125
D27	Blade pile vs bored piers – Very Stiff Clay (200kPa).....	128
D28	Blade pile vs bored piers – Hard Clay (225kPa).....	131
D29	Blade pile vs bored piers – Hard Clay (250kPa).....	134
D30	Blade pile vs bored piers – Medium Dense Sand.....	137
D31	Blade pile vs bored piers – Medium Dense to Dense Sand.....	140
D32	Blade pile vs bored piers – Dense Sand.....	143
D33	Blade pile vs bored piers – Stiff Clay (75kPa) & in Water Table.....	146
D34	Blade pile vs bored piers – Stiff Clay (100kPa) & in Water Table.....	149
D35	Blade pile vs bored piers – Very Stiff Clay (150kPa) & in Water Table.....	152
D36	Blade pile vs bored piers – Very Stiff Clay (200kPa) & in Water Table.....	155
D37	Blade pile vs bored piers – Hard Clay (225kPa) & in Water Table.....	158
D38	Blade pile vs bored piers – Hard Clay (250kPa) & in Water Table.....	161
D39	Blade pile vs bored piers – Medium Dense Sand & in Water Table.....	164
D40	Blade pile vs bored piers – Medium Dense to Dense Sand & in Water Table.....	167
D41	Blade pile vs bored piers –Dense Sand & in Water Table.....	170
Appendix E.	Engineering Certification.....	173
Appendix F.	Blade Pile Cap Test Report.....	177
Appendix G.	Blade Pile Testing & Results.....	189
G1	URS Testing.....	189
G2	Test Result – Recent Examples.....	195
G3	Testing Regime for the Geotechnical Strength of Blade Piles.....	200

TABLE OF FIGURES

Figure 1 – Large blades in soft plasticine clay6

Figure 2 - Dual Blade Pile8

Figure 3 - Piles caps installed on site9

Figure 4 – Examples of Customised Bracing Piles10

Figure 5 - Bearing Assembly12

Figure 6 - Corner Blade Plate14

Figure 7 – Preliminary Edge Beam Detail.....14

Figure 8 - Air Pod ready for testing.....14

Figure 9 - Isometric views of the Air Pods to form the AirFormer Slab System15

Figure 10 - Assembly of Air Pods and Blade Plates to form the AirFormer Air Slab System15

Figure 11 - Design geotechnical capacity comparison of bored piers, screw piles and blade piles in clay17

Figure 12 - Design geotechnical capacity comparison of bored piers, screw piles and blade piles in sand17

Figure 13 - Design geotechnical capacity comparison of bored piers and blade piles in stiff clay ..18

Figure 14 - Blade Piles Vs Screw Piles23

Figure 15 - Screw Helix Vs Twin Blades.....23

Figure 16 - Effect of bedrock or water table on design suction change profiles (AS2870-2011).....27

Figure 17 - Bored Piers in Shrinking Clay Soil.....30

Figure 18 - Bored Piers in Heaving Clay Soil31

Figure 19 - Weld capacity strong enough to withstand large forces to incur significant deflection..34

Figure 20 - Effective length factors for idealized conditions of end restraint (AS4100-1998).....39

Figure 21 - Blade piles founded to very dense/stiff natural material with lower bearing material or with long term differential41

Figure 22 - Post Replacement Examples42

Figure 23 - Piling for Adjacent Services or trees42

Figure 24 - Example of piles for a retaining wall.....43

Figure 25 - Compression testing rig.....47

Figure 26 – (Left) Incorrect method where reaction piles are less than the greater of 2.5m or 5 times the pile diameter (Right) Blade Pile uplift testing rig48

Figure 27 (a) Compression Loading Forces and (b) Tension Loading Forces Acting on a Multi-Helix Screw Pile (HPS 2010)73

Figure 28 - Bearing Capacity factor N_q for pile base capacity (Knappet & Craig 2012 after Berezantsev et al. 1961).....77

Figure 29 - Variation of Breakout Factor with Embedment Depth for Deep Anchor Conditions based on Mitsch and Clemence's Theory after Das, 1990 (Stephenson 1997)	78
Figure 30 - Variation of Breakout Factor with Embedment Depth for Shallow Anchor Conditions based on Mitsch and Clemence's Theory after Das, 1990 (Stephenson 1997).....	79
Figure 31 - Effect of the spacing between Inter-Helix (Narasimha et al 1991)	82
Figure 32 - Methods to determine the ultimate geotechnical strength of a pile (Uno 2015)	94
Figure 33 - Single & Multi-Blade Piles Embedment Depth for Blade Pile Capacity Tables	95

TABLE OF TABLES

Table 1 - Notations	4
Table 2 - Site Classification	25
Table 3 - P Class Classification Reasons.....	26
Table 4 - Relationship between H _s values for climatic regions around Australia	27
Table 5 - Minimum testing requirement for each H _s Value	28
Table 6 - Minimum depth of piles used in reactive clay for each H _s value.....	28
Table 7 – Maximum Design Drying Depth - H _t	32
Table 8 - Section capacity of the shaft according to AS4100 with no loss due to corrosion.....	33
Table 9 - Exposure Classification based on Soil Acidity/Alkalinity, Soil Chlorides, Resistivity (Standards Australia 2009)	35
Table 10 - Exposure Classification for steel piles in water (Standards Australia 1009).....	36
Table 11 - Exposure Classification and their related Corrosion.....	36
Table 12 - Minimum pile specification based on Exposure Class & the section capacities of the shaft according to AS4100 for the given design life & with a C350 Steel Grade.	37
Table 13 - Minimum pile specifications for a given effective length to AS4100 – Above Ground Applications	40
Table 14 - Critical Embedment Ratio, (H/D) _{cr} for Circular Piles (Meyerhof & Adam 1968).....	77
Table 15 - Recommended average values of K (Das 2007).....	80
Table 16 - K _u , coefficient of lateral earth pressure (after Mitsch & Clemence 1985 & HPS 2010)..	81
Table 17 - Sensitivity of Clays (A.B. Chance Company 2003)	83
Table 18 - End bearing reduction factors for multiple bearing plates in cohesionless soils (Lutenegger 2015)	83
Table 19 - Weighting Factors and Individual Risk Ratings for Risk Factors (AS2159-2009 Table 4.3.2 (A)).....	85
Table 20 - Individual Risk Rating (AS2159-2009 Table 4.3.2(B)).....	86
Table 21 - Basic Geotechnical Strength Reduction Factor for Average Risk Rating (AS2159-2009 Table 4.3.2(C)).....	86
Table 22 - Unit Weights of soil (Standards Australia 2002)	87
Table 23 - UCS & bearing capacity for clay (Standards Australia 1993)	88
Table 24 - Soil Friction Angle (Peck, Hanson & Thornburn 1974).....	88
Table 25 - Friction Angle used in Capacity Tables	88
Table 26 – Typical in-situ soil test relationship with different sand consistencies (Liddell n.d.).....	89
Table 27 - SPT for different types of sand (A.B. Chance Company, 2003)	89
Table 28 - Typical in-situ soil test relationships with different clay consistencies (Liddell n.d.).....	89
Table 29 - Additional in-situ soil test relationships with different clay consistencies (Look 2007) ...	90

TABLE OF EQUATIONS

Equation 1 - Geotechnical Design Strength.....	73
Equation 2 - Bearing capacity for shallow foundations	74
Equation 3 - Base resistance for compression in cohesive soil.....	74
Equation 4 - Base resistance for uplift in cohesive soils	74
Equation 5 - Shaft resistance in cohesive soils	75
Equation 6 - Base resistance for compression in cohesionless soils	76
Equation 7 - Base resistance for uplift in deep condition in cohesionless soil.....	77
Equation 8 - Base resistance for uplift in shallow conditions in cohesionless soil	77
Equation 9 - Shaft resistance for compression in cohesionless soils	79
Equation 10 – Effective Earth Pressure.....	80
Equation 11 - Shaft resistance for uplift in cohesionless soils	81
Equation 12 - Cylindrical Shear	82

FORWARD

The Blade Pile Group consists of a group of companies working together to provide piling and foundation systems, technology and services, for the benefit of the Australian and international property development, civil construction and building industries.

The extensive team of Blade Pile Group are now recognised as a world leader in steel screw in piling technology and foundation systems. The inventions and patents owned and operated within the group represent 'World First' foundation technology.

The Blade Pile Group mission is simple. We aim to innovate and produce the highest quality, best performing foundation products, systems and services available.



Brent Shorter
General Manager of Blade Pile Group

1 SCOPE AND GENERAL

1.1 Scope

This Technical Manual provides general guidance for the use of **Blade Pile Group** products and as a “design tool” to specify **Blade Pile Group** products. It covers the design and installation requirements for the use of **Blade Pile Group** products.

The manual also includes a review of the **Blade Pile Group** product range, conducted by Structerre Consulting Engineers, to assist building designers, engineers, installers and associated industry professionals. This includes design tables, design requirements, design procedures and product data to provide cost effective solutions.

Note that the information contained within this technical manual is generic in nature and is not intended to provide specific design. “Site specific” engineering and certification is essential for any pile design and installation certification.

1.2 Applications

This manual is recommended as a design tool for residential, commercial or industrial applications as defined in AS2870-2011 “Residential Slabs and Footings – Construction” and AS2159-2009 – “Piling – Design and Installation”.

1.3 Blade Pile Group Capability

Blade Pile Group has the capability and industry knowledge to cater for "site specific" design and applications outside the scope of this manual. Specific pile designs and solutions may be provided for mono directional loadings, combinational loadings, angled installation or high serviceability requirements to name a few.