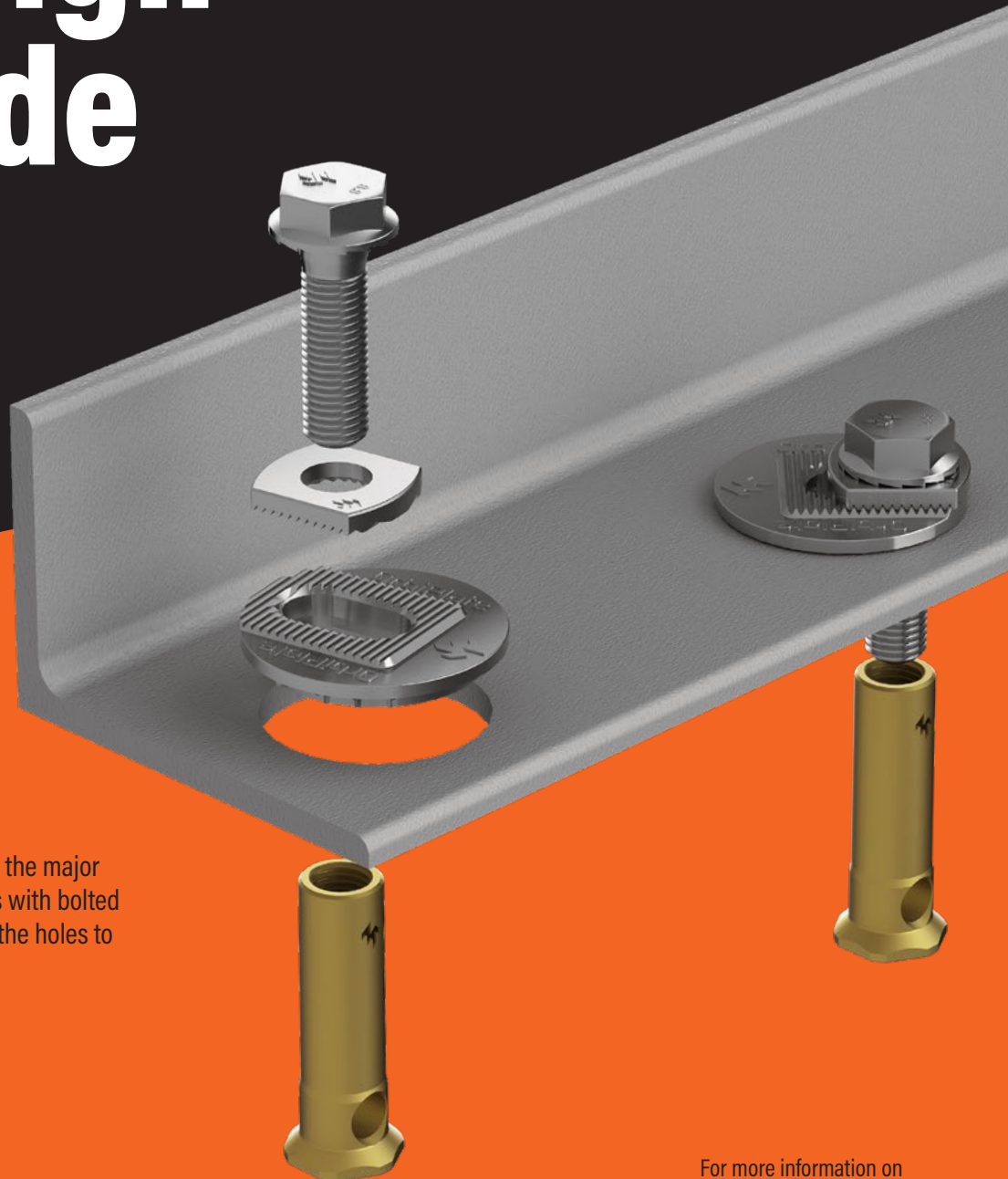


OrbiPlateTM

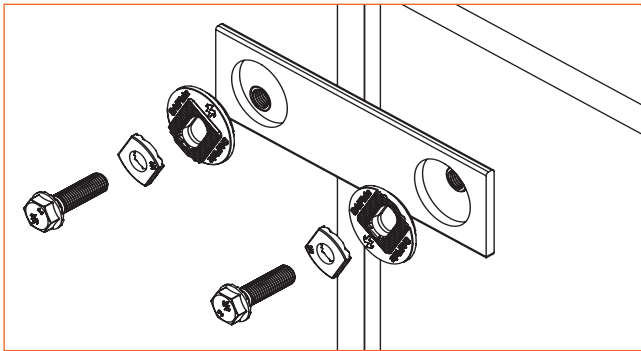
Design Guide



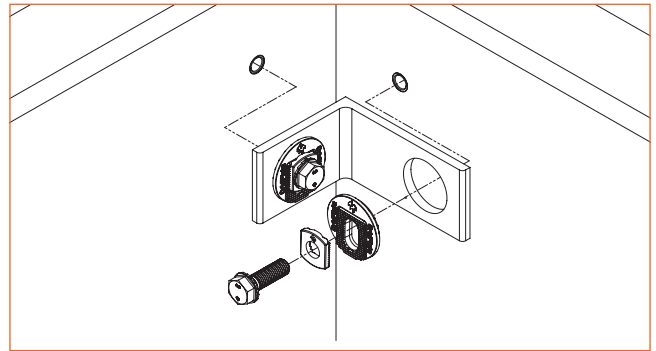
OrbiPlateTM overcomes the major headache that comes with bolted connections, getting the holes to line up!

For more information on
our products call
AU 1300 780 063
NZ 0800 726 738

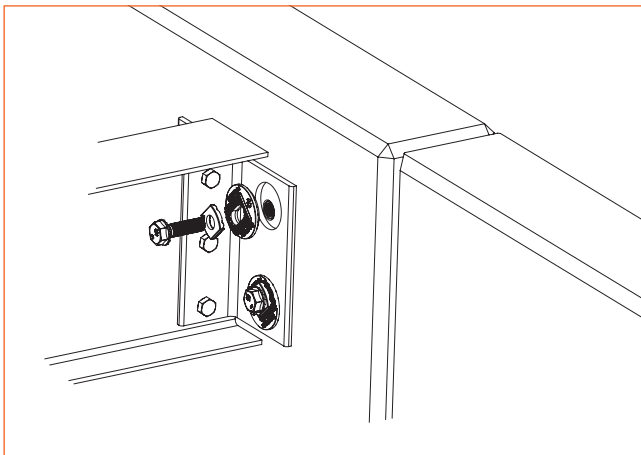
Applications



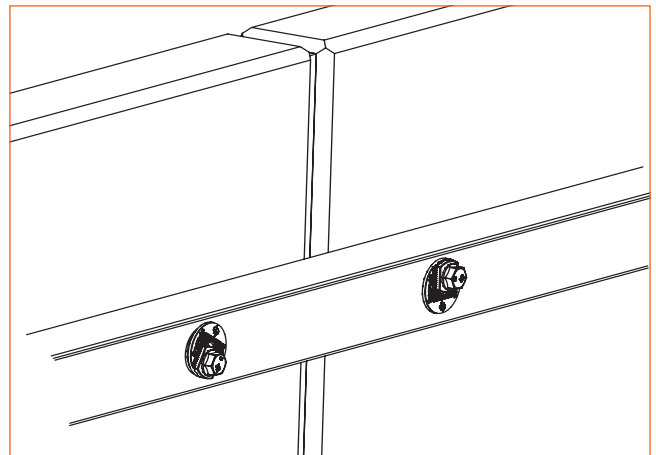
Straight panel to panel connection



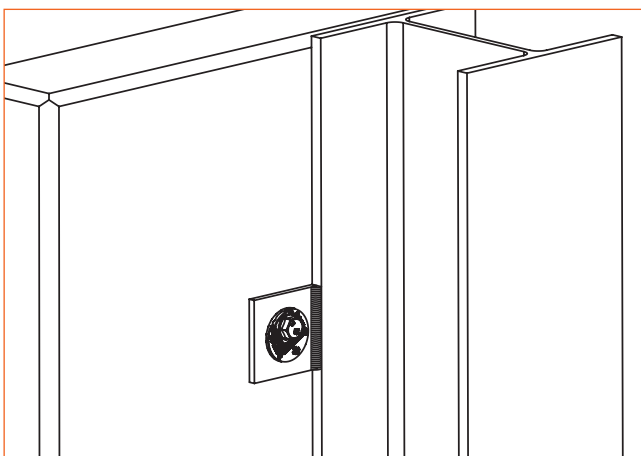
Corner panel to panel connection



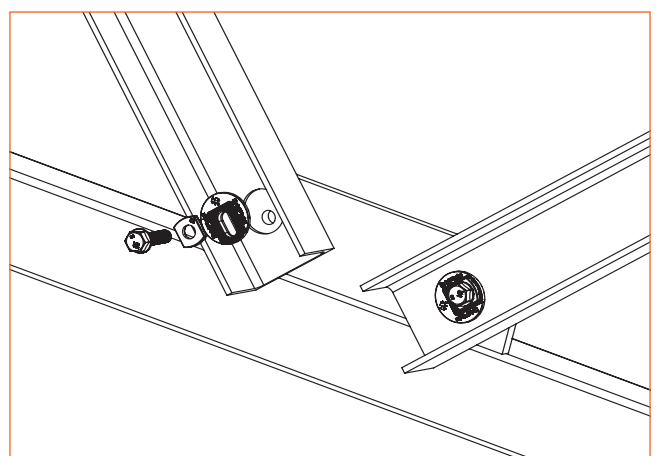
Roof beam to panel connection



Raker angle to panel connection



Column to panel connection



Steel to steel connection

OrbiPlate™ Design Guide

This Design Guide contains the information required by Specifiers, Engineers and Architects to design structural connections using Ramset™ OrbiPlate™. Selection is made using strength limit state approach on the basis of the design load case and influencing factors on the connection such as concrete substrate compressive strength and edge and spacing distances. The step-by-step method presented in this Design Guide will allow rapid design and verification of the connection, be it steel to concrete or steel to steel.

Cumulative tolerances in precast construction

OrbiPlate™ was invented by John Burke and Allan Walsh in recognition of the effects of tolerances that are prevalent within the precast concrete industry.

For example, when connecting two precast panels with cast in ferrules, the tolerances on the position of an individual insert within a group, the position of the group within the panel, the length of the panel and the site positioning of each panel results in a connection that is often impossible to bolt together with normal clearances.

According to AS 3850.2:2015 (+A1) section, 2.11: "The effects of cumulative tolerances shall be considered. The total accumulation of tolerances shall be not greater than 20 mm when related to set out grids and data".

Consequently it is the design Engineer's responsibility to make allowance for cumulative tolerances and OrbiPlate™ is an excellent solution.

NZS 3109:1997 section 5.3 provides similar guidance to AS 3850.2:2015 in regard to manufacturing tolerances for precast components.

The manufacturing tolerances contained in table 5.1 of NZS 3109:1997 for panel dimensions and positioning of fasteners and groups of fasteners exceed the equivalent within AS 3850.2:2015, making the effects of cumulative tolerances very important in New Zealand.

Seismic Design

While there is no clear protocol on how to test and assess the interlocking washers of OrbiPlate™ under seismic conditions, Swinburne University of Technology was commissioned by Ramset™ to carry out seismic testing of OrbiPlate™ sizes M16 (ORB2016BGH) and M20 (ORB2020BGH) with different configurations following the shear testing protocol of EOTA TR049 for Seismic Category C1. The purpose of the tests was to assess the performance of OrbiPlate's interlocking steel washers under cyclic shear loading to Seismic Category C1. The outcome of the above seismic test programme is embedded in this Design Guide.

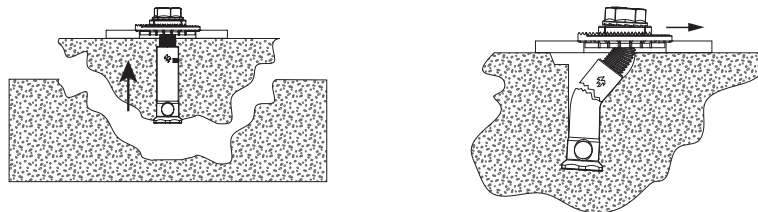
Scope

This Design Guide sets out the minimum requirements for the design of steel to concrete and steel to steel connections utilising Ramset™ OrbiPlate™ to design safe, serviceable and durable structures.

This guide is limited to using OrbiPlate™ as supplied with either a 50mm long M16 bolt or 60mm long M20 bolt respectively. This limits the fixture thicknesses that are specified in this guide. Where greater fixture thicknesses are required an alternate longer bolt can often be used but the application needs to be carefully considered as the capacities of the connection may be affected. Please contact your Ramset™ Engineer for guidance.

Steel to concrete

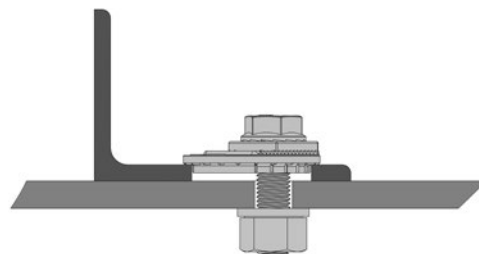
For the connection of steel to concrete, this guide is limited to the use of OrbiPlate™ when used in conjunction with the matching Reid™ footed ferrule. In all loading scenarios, the footed ferrule is the limiting factor when using OrbiPlate™ and the performance of the ferrule in shear varies with the fixture thickness. It is critical to design with OrbiPlate™ and the matching Reid™ footed ferrule as a system.



Steel to Steel

For the connection of steel to steel elements, this guide is limited to the use of 20mm OrbiPlate™ as supplied with a M20 x 60 set screw and a matching hex nut and washer supplied by others.

This may limit the thickness of the two steel plates to be connected. Where greater fixture thicknesses are required, contact your Ramset™ Engineer for guidance.



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Steel to Steel Connections	20
Anchoring Technology	22
Worked Example.....	30
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We have developed this set of easily recognisable icons to assist with product selection.

PERFORMANCE RELATED SYMBOLS

Indicates the suitability of product to specific types of performance related situations.



Has good resistance to cyclic and dynamic loading. Resists loosening under vibration.



Anchor has an effective pull-down feature, or is a stud anchor. It has the ability to clamp the fixture to the base material and provide high resistance to cyclic loading.



Suitable for use in seismic design.



Suitable for elevated temperate applications. Structural anchor components made from steel. Any plastic or non-ferrous parts make no contribution to holding power under elevated temperatures. To be used with appropriate fire protection coating.



May be used close to edges (or another anchor) without risk of splitting the concrete.



Steel Hot Dipped Galvanised to AS 4680:2006. For external applications.

Notations

GENERAL NOTATION

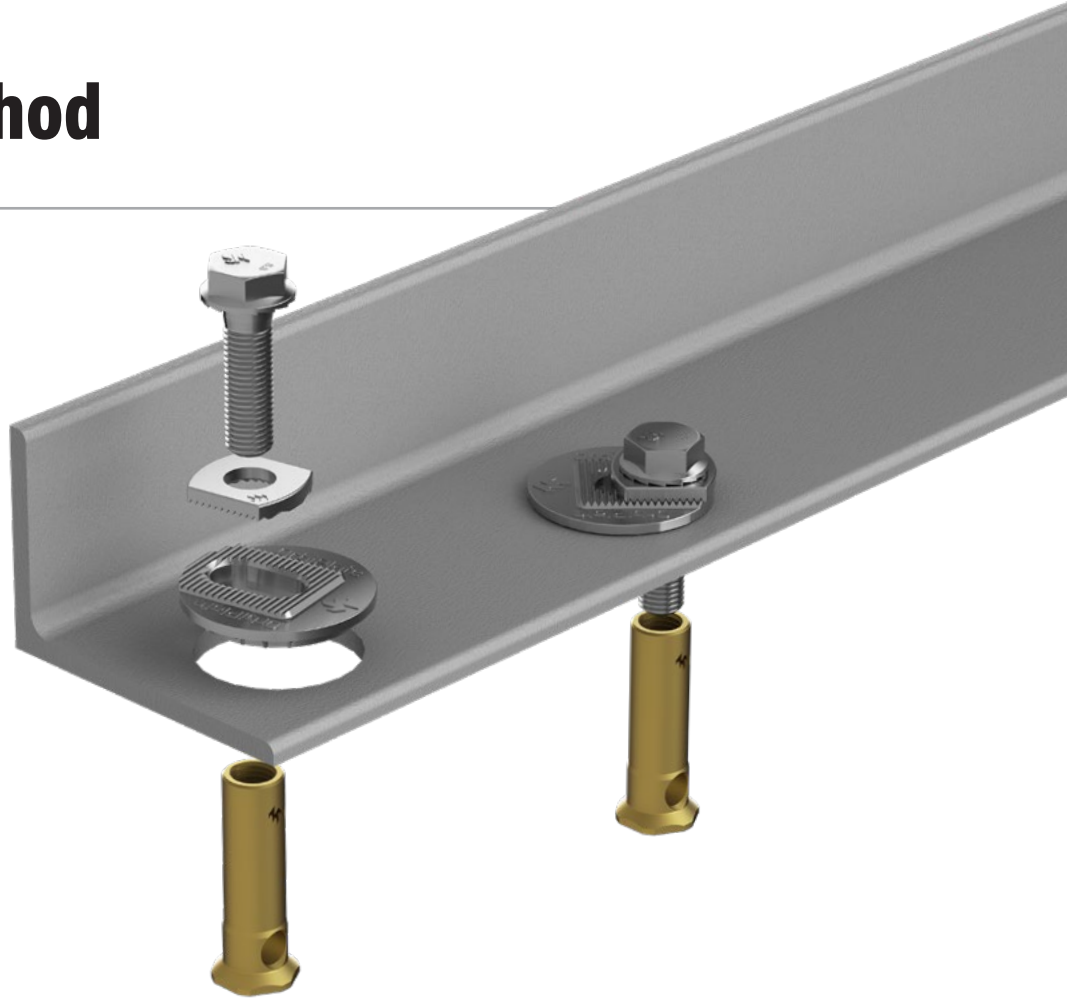
a = actual anchor spacing (mm)	k_1 = see AS 3600:2018	X_{nae} = anchor spacing effect, end of a row, tension
a_c = critical anchor spacing (mm)	k_2 = see AS 3600:2018	X_{nai} = anchor spacing effect, internal to a row, tension
a_m = absolute minimum anchor spacing (mm)	k_3 = see AS 3600:2018	X_{nc} = concrete compressive strength effect, tension
A_b = reinforcing bar stress area (mm ²)	L = anchor length (mm)	X_{ne} = edge distance effect, tension
A_s = stress area (mm ²)	L_e = anchor effective length (mm)	X_{uc} = characteristic ultimate capacity
A_{st} = stress area of reinforcing bar (mm ²)	L_{st} = length of reinforcing bar to develop tensile stress σ_{st} (mm)	X_{va} = anchor spacing effect, concrete edge shear
b_m = minimum substrate thickness (mm)	$L_{sy,t}$ = reinforcing bar length to develop steel yield in tension (mm)	X_{vc} = concrete compressive strength effect, shear
d_b = bolt diameter (mm)	$L_{sy,t(nom)}$ = length of reinforcing bar to develop full steel yield in 32 MPa concrete (mm)	X_{vd} = load direction effect, concrete edge shear
d_f = fixture hole diameter (mm)	L_t = thread length (mm)	X_{vn} = multiple anchors effect, concrete edge shear
d_h = drilled hole diameter (mm)	n = number of fixings in a group	X_{vs} = corner edge shear effect, shear
e = actual edge distance (mm)	N_{sy} = tensile steel yield load capacity	X_{vsc} = concrete compressive strength effect, combined concrete/steel shear
e_c = critical edge distance (mm)	N_{ub} = characteristic ultimate tensile adhesive bond capacity (kN)	X_{ns} = Cracked concrete service temperature limits effect
e_m = absolute minimum edge distance (mm)	P_L = long term, retained preload (kN)	Z = section modulus (mm ³)
f'_c = concrete cylinder characteristic compressive strength (MPa)	P_{Li} = initial preload (kN)	β = concrete cube characteristic compressive strength (N/mm ²)
f'_{cf} = concrete flexural tensile strength (MPa)	P_r = proof load (kN)	μ_T = torque co-efficient of sliding friction
f_{sy} = reinforcing bar steel yield strength (MPa)	t = total thickness of fastened material(s) (mm)	x_{-} = mean ultimate capacity
f_u = characteristic ultimate steel tensile strength (MPa)	T_r = assembly torque (Nm)	σ_{st} = steel tensile stress
f_y = characteristic steel yield strength (MPa)	X_e = edge distance effect, tension	$\sigma_{st(nom)}$ = steel tensile stress of reinforcing bar bonded into 32 MPa concrete
h = anchor effective depth (mm)	X_{na} = anchor spacing effect, tension	X_{nseis} = Seismic Cracked Concrete effect, tension
h_n = nominal effective depth (mm)		X_{vseis} = Seismic Cracked Concrete effect, shear
g = gap or non-structural thickness (mm)		

STRENGTH LIMIT STATE NOTATION

M^* = design bending action effect (kN.m)	N_{us} = characteristic ultimate steel tensile capacity (kN)	V_{usc} = characteristic ultimate combined concrete/steel shear capacity (kN)
M_u = characteristic ultimate moment capacity (kN.m)	N_{usr} = factored characteristic ultimate steel tensile capacity (kN)	ϕ = capacity reduction factor
N^* = design tensile action effect (kN)	R_u = characteristic ultimate capacity	ϕ_c = capacity reduction factor, concrete tension recommended as 0.6
N_{tf} = nominal ultimate bolt tensile capacity (kN)	V^* = design shear action effect (kN)	ϕ_m = capacity reduction factor, steel bending recommended as 0.8
N_u = characteristic ultimate tensile capacity (kN)	V_{st} = nominal ultimate bolt shear capacity (kN)	ϕ_n = capacity reduction factor, steel tension recommended as 0.8
N_{uc} = characteristic ultimate concrete tensile capacity (kN)	V_u = ultimate shear capacity (kN)	ϕ_q = capacity reduction factor, concrete edge shear recommended as 0.6
N_{up} = characteristic ultimate pull-through capacity (kN)	V_{uc} = characteristic ultimate concrete edge shear capacity (kN)	ϕ_v = capacity reduction factor, steel shear recommended as 0.8
N_{ucr} = factored characteristic ultimate concrete tensile capacity (kN)	V_{ur} = design ultimate shear capacity (kN)	ϕ_p = capacity reduction factor, pull-through recommended as 0.65
N_{ur} = design ultimate tensile capacity (kN)	V_{urc} = design ultimate concrete edge shear capacity (kN)	
N_{urc} = design ultimate concrete tensile capacity (kN)	V_{us} = characteristic ultimate steel shear capacity (kN)	
N_{urp} = design ultimate pull-through capacity (kN)	$N_{uc,seis}$ = seismic cracked concrete tensile capacity (kN)	
	$V_{usc,seis}$ = seismic steel shear capacity (kN)	

Capacity reduction factors are as per the applicable Australian Standards, i.e, AS 3600:2018 for concrete factors and AS 4100:2020 for steel factors

Design Method



This information is provided for the guidance of qualified structural engineers or other suitably skilled persons in the design of connections. It is the designer's responsibility to ensure compliance with the relevant standards, codes of practice, building regulations, workplace regulations and statutes as applicable.

This Design Guide allows the designer to determine load carrying capacities based on actual application and installation conditions, then select an appropriate connection to meet the required load case through the use of the simplified design process to arrive at recommendations in line with strength limit state design principles.

Ramset™ has developed this Simplified Design Approach to achieve strength limit state design, and to allow for rapid selection of a suitable connection and through systematic analysis, establish that it will meet the required design criteria under strength limit state principles. The necessary diagrams, tables etc. for each specific product are included in this Design Guide.

We have developed this design process to provide accurate anchor performance predictions and allow appropriate design solutions in an efficient manner.

Our experience over many years of anchor design has enabled us to develop this process which facilitates accurate and quick solutions without the need to work from first principles each time.

Preliminary Selection

Establish the design action effects, N^* and V^* (Tension and Shear) acting on each anchor being examined using the appropriate load combinations detailed in the AS 1170 series of Australian Standards and NZ S1170 series of New Zealand Standards.

STEP 1 Select the size OrbiPlate™ to be used

Refer to table 1a, 'Indicative combined loading – Interaction Diagram,' looking up N^* and V^* to check if the size and number of OrbiPlate™ fixings are likely to meet the design requirements.

Note that the Interaction Diagram is for a specific concrete compressive strength and does not consider edge distance and anchor spacing effects, it is a guide only and its use should not replace a complete design process.

ACTION: Note down the anchor size selected.

Having selected an anchor size, check that the design values for edge distance and anchor spacing comply with the absolute minima detailed in table 1b. If your design values do not comply, adjust the design layout.

ACTION: Note down the edge and spacing distances and the product part numbers referenced.

CHECK POINT 1

OrbiPlate™ and Reid™ footed ferrule combination selected ?
Absolute minima compliance achieved ?

STEP 2 Verify concrete tensile capacity - per anchorage

Referring to table 2a, determine the reduced characteristic ultimate concrete tensile capacity (ϕN_{uc}). This is the basic capacity, uninfluenced by edge distance or anchor spacing and is for the specific concrete compressive strength(s) noted.

ACTION: Note down the value for ϕN_{uc}

Calculate the concrete compressive strength effect, tension, X_{nc} by referring to table 2b. This multiplier considers the influence of the actual concrete compressive strength compared to that used in table 2a above.

ACTION: Note down the value for X_{nc}

If the concrete edge distance is close enough to the anchor being evaluated, that anchors tensile performance may be reduced. Use table 2c, edge distance effect, tension, X_{ne} to determine if the design edge distance influences the anchors tensile capacity.

ACTION: Note down the value for X_{ne}

For designs involving more than one anchor, consideration must be given to the influence of anchor spacing on tensile capacity. Use either of tables 2d or 2e to establish the anchor spacing effect, tension, X_{nae} or X_{nai} .

ACTION: Note down the value of X_{nae} or X_{nai}

CHECK POINT 2

Design reduced concrete tensile capacity, ϕN_{urc}
$$\phi N_{urc} = \phi N_{uc} * X_{nc} * X_{ne} * (X_{nae} \text{ or } X_{nai}) \text{ (kN)}$$

This calculation takes into consideration the influences of concrete compressive strength, edge distance and anchor spacing to arrive at the design reduced concrete tensile capacity.

ACTION: Note down the value of ϕN_{urc}

STEP 3 Verify anchor tensile capacity - per anchorage

Having calculated the concrete tensile capacity above (ϕN_{urc}), consideration must now be given to other tensile failure mechanisms.

Calculate the reduced characteristic ultimate steel tensile capacity (ϕN_{us}) from table(s) 3a.

ACTION: Note down the value of ϕN_{us}

Now that we have obtained capacity information for all tensile failure mechanisms, verify which one is controlling the design.

**CHECK
POINT 3**

Now that we have obtained capacity information for all tensile failure mechanisms, verify which one is controlling the design.

Design reduced ultimate tensile capacity, ϕN_{ur}

$\phi N_{ur} = \text{minimum of } \phi N_{urc}, \phi N_{us}$

Check $N^* / \phi N_{ur} \leq 1$,

if not satisfied return to step 1

This completes the tensile design process; we now look to verify that adequate shear capacity is available.

STEP 4 Verify concrete shear capacity - per anchorage

Referring to table 4a, determine the reduced characteristic ultimate concrete edge shear capacity (ϕV_{uc}). This is the basic capacity, uninfluenced by anchor spacings and is for the specific edge distance and concrete compressive strength(s) noted.

ACTION: Note down the value for ϕV_{uc}

Calculate the concrete compressive strength effect, shear, X_{vc} by referring to table 4b. This multiplier considers the influence of the actual concrete compressive strength compared to the nominal value used in table 4a above.

ACTION: Note down the value for X_{vc}

The angle of incidence of the shear load acting towards an edge is considered through the factor X_{vd} , load direction effect, shear.

Use table 4c to establish its value.

ACTION: Note down the value for X_{vd}

For a row of anchors located close to an edge, the influence of the anchor spacing on the concrete edge shear capacity is considered by the factor X_{va} , anchor spacing effect, concrete edge shear.

Note that this factor deals with a row of anchors parallel to the edge and assumes that all anchors are loaded equally.

If designing for a single anchor, $X_{va} = 1.0$

ACTION: Note down the value for X_{va}

In order to distribute the concrete edge shear evenly to all anchors within a row of anchors aligned parallel to an edge, calculate the multiple anchors effect, concrete edge shear, X_{vn} .

If designing for a single anchor, $X_{vn} = 1.0$

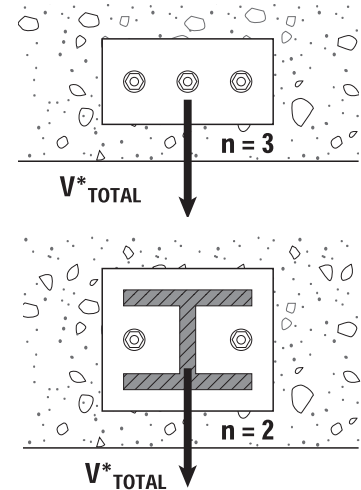
ACTION: Note down the value for X_{vn}

To allow for the combined effects of 2 concrete edges when anchoring near a corner, calculate the corner edge shear effect, shear, X_{vs} .

If designing for a single edge, $X_{vs} = 1.0$

ACTION: Note down the value for X_{vs}

Examples



CHECK
POINT

4

Design reduced concrete shear capacity, ϕV_{urc}

$$\phi V_{urc} = \phi V_{uc} * X_{vc} * X_{vd} * X_{va} * X_{vn} * X_{vs} \text{ (kN)}$$

This calculation takes into consideration the influences of concrete compressive strength, edge distance and anchor spacing to arrive at the design reduced concrete shear capacity.

For a design involving two or more anchors in a row parallel to an edge, this value is the average capacity of each anchor assuming each is loaded equally.

ACTION: Note down the value of ϕV_{urc}

STEP 5 Verify anchor shear capacity - per OrbiPlate™ and Reid™ footed Ferrule Combination

Having calculated the concrete shear capacity above (ϕV_{urc}), consideration must now be given to other shear failure mechanisms.

Calculate the reduced characteristic ultimate steel shear capacity (ϕV_{usc}) from table(s) 5a (i).

ACTION: Note down the value for ϕV_{usc}

Calculate the concrete compressive strength effect, combined concrete/steel shear, X_{vsc} by referring to table 5a (ii). This multiplier considers the influence of the actual concrete compressive strength, compared to the nominal value in table 5a (i).

ACTION: Note down the value for X_{vsc}

Calculate ϕV_{us} by multiplying ϕV_{usc} and X_{vsc}

$$\phi V_{us} = \phi V_{usc} * X_{vsc}$$

CHECK POINT 5

Design reduced shear capacity, ϕV_{ur}

Now that we have obtained capacity information for all shear failure mechanisms, verify which one is controlling the design.

$$\phi V_{ur} = \text{minimum of } \phi V_{urc}, \phi V_{us}$$

$$\text{Check } V^* / \phi V_{ur} \leq 1,$$

if not satisfied return to step 1

This completes the shear design process. We now look to verify that adequate combined capacity is available for load cases having both shear and tensile components.

STEP 6 Combined loading and specification

For load cases having both tensile and shear components, verify that the relationship represented here is satisfied.

CHECK POINT 6

Check

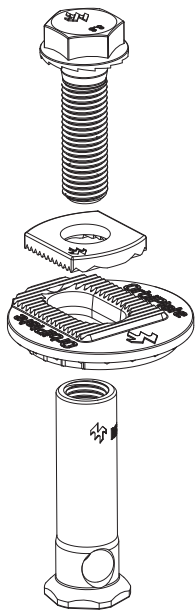
$$N^* / \phi N_{ur} + V^* / \phi V_{ur} \leq 1.2,$$

if not satisfied return to step 1

**Specify the product to be used
as detailed.**

Note: it is the Design Engineer's responsibility to ensure that the fixture plate is adequate for the design loads in accordance with AS 4100:2020 / NZS 3404:1997.

OrbiPlate™ & Reid™ Footed Ferrule Combination



OrbiPlate™ & Reid™
Elephant Foot™ Ferrule
(Aust)

General Information

Product

OrbiPlate™ overcomes the main headache that comes with bolted connections, getting the holes to line up!

Feature

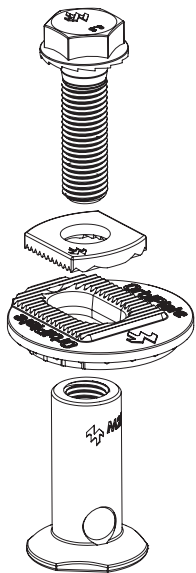
- A large washer with an elongated slot surrounded by teeth that lock the smaller washer in place, positioning the main structural bolt in alignment with the ferrule even with up to 20mm misalignment

Advantages

- Provides 20mm positional tolerance.
- Fine positional adjustment.
- No rotation under shear load.

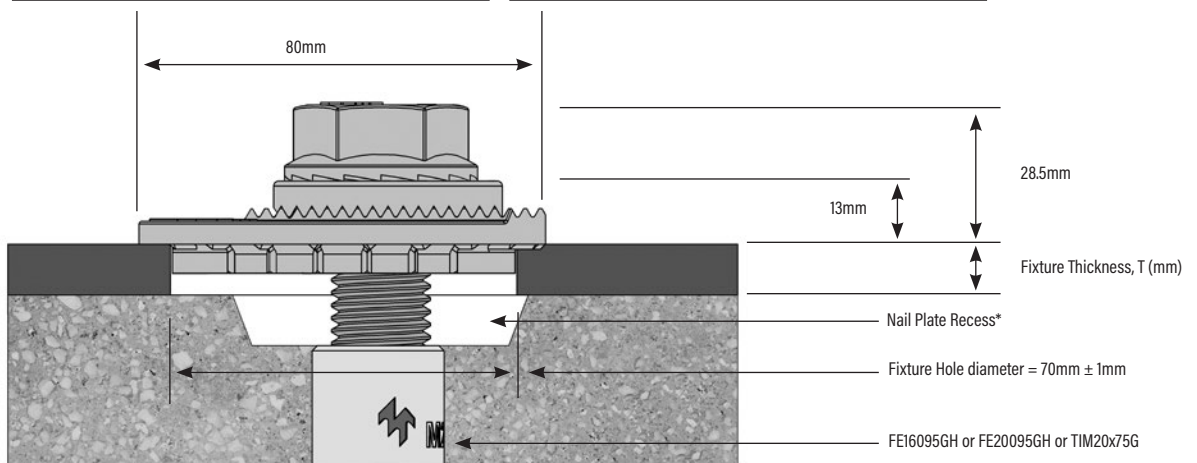
Benefits

- High structural capacity.
- Allows fine positional adjustment.
- Avoids misalignment delays and call outs.
- No hot work required on site.

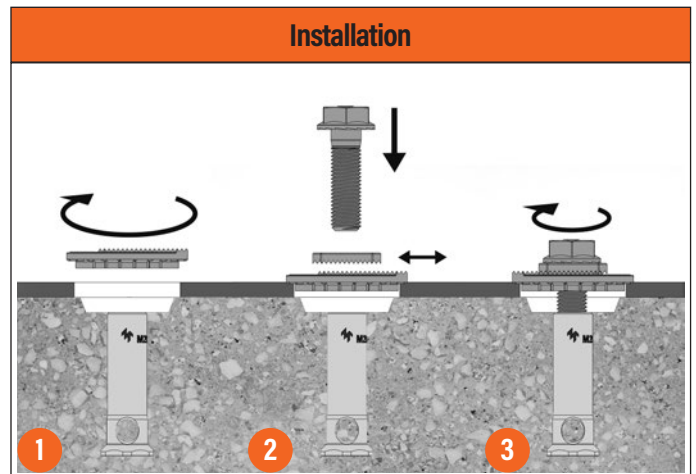


OrbiPlate™ & Reid™ TIM
Footed Ferrule
(NZ only)
installed with a nail plate,
NP20

Principal Applications
<ul style="list-style-type: none"> • Panel to panel fixing • Raker Angles • Roof beams to walls • Panels to steel columns



* Note that use with Reid™ TIM20x75G ferrules requires that a nail plate (part number NP20) be specified so that the ferrule is positioned below the concrete surface (as shown) with a recess above the ferrule. This ensures that the M20 class 8.8 bolt does not bottom out inside the ferrule. Reid™ FE Ferrules can be installed with either a nail plate (Part No. FM20N) or antenna cap (Part No. ANTAPM20) as they are slightly longer, and their performance data is not affected by the use of a nail plate.



Step 1 (TWIST IT)

Place the large washer in the 70mm fixture hole and rotate until the slot lines up with the ferrule.

Step 2 (SLIDE IT)

Move small washer along slot until it aligns with ferrule.

Step 3. (FIX IT)

Insert the bolt and tighten to specified torque.

Performance Related



*To be used with appropriate fire protection coating.

Material



Installation Related



OrbiPlate™ & Reid™ Footed Ferrule Combination

The following design information is for the OrbiPlate™ when used in combination with Reid™ Ferrules. This design information is not applicable if OrbiPlate™ is used with other ferrules as a reduction in capacity can be expected.

Installation and Performance Details

Anchor Size (mm)	OrbiPlate™ Part Number	Ferrule Part Number	Fixture hole dia (mm)	Tightening Torque, T (Nm)	Optimum dimensions *		Fixture thickness (mm)	Reduced Characteristic Capacity					
					Edge Distance, e _c (mm)	Anchor spacing, a _c (mm)		Shear, ϕV_{usc} (kN) ***			Tension , ϕN_{uc} (kN) **		
								Concrete compressive strength, f' _c			Concrete compressive strength, f' _c		
								20 MPa	32 MPa	40 MPa	20 MPa	32 MPa	40 MPa
M16	ORB2016BGH	FE16095GH	70 ± 1	94	135	270	6	33.2	39.0	42.1	33.9	42.9	48.0
							8	29.8	35.1	37.9			
							10	28.2	33.2	35.9			
							12	26.5	31.2	33.7			
M20	ORB2020BGH	FE20095GH	70 ± 1	180	135	270	6	34.8	40.9	44.2	37.9	48	53.8
							10	33.7	39.6	42.8			
							12	32.6	38.3	41.4			
							16	31.5	37.0	40			
M20	ORB2020BGH	TIM20x75G with nail plate (NZ Only)	70 ± 1	144	105	210	6	45.9	56.0	60.4	33.0	41.6	41.6
							8	42.5	50.0	54.0			
							12	35.7	42.0	45.3			
							16	31.5	37.0	39.9			

* Note: For shear loads acting towards an edge or where these optimal distances are not achievable, please use the simplified strength limit state design process to verify capacity.

** Note: Reduced characteristic ultimate tensile capacity = ϕN_{uc} where $\phi = 0.6$ and N_{uc} = Characteristic ultimate concrete tensile capacity.

*** Note: For Seismic Cracked Concrete Capacity tension $N_{uc,seis}$, Multiply ϕN_{uc} * X_{nseis} , in accordance with ACI 318M-19 Chapter 17, FE**095GH - $X_{nseis} = 0.52$, TIM20x75G - $X_{nseis} = 0.42$

*** Note: For Seismic steel shear, $V_{usc,seis}$, where $\phi = 0.6$ refer to table below,

Anchor size (mm)	OrbiPlate™ Part Number	Ferrule Part Number	Fixtures (mm)	Shear $\phi V_{usc,seis}$
				15 MPa to 50 MPa
M16	ORB2016BGH	FE16095GH	6-12	20.7
M20	ORB2020BGH	FE20095GH	6-16	27.7
M20	ORB2020BGH	TIM20 x 75G with nail plate (NZ Only)	6-16	27.7

Description And Part Numbers

OrbiPlate™

Ferrule size, d_b	Washer OD (mm)	Fixture Hole ϕ (mm)	Bolt	Hex Head AF (mm)	Part No.
					Gal
M16	80	70 ± 1	M16 x 50	30	ORB2016BGH
M20	80	70 ± 1	M20 x 60	30	ORB2020BGH

Ferrules

Ferrule size, d_b	Ferrule OD (mm)	Ferrule length, L (mm)	Effective depth, h (mm)	Thread length, L_t (mm)	Cross hole to suit	Part No.
						Gal
M16	22	95	91	32	N12	FE16095GH
M20	26	95	91	38	N12	FE20095GH
M20	30	75	70	32	N12	TIM20x75G (NZ Only)

Effective depth, h (mm). Read value from "Description and Part Numbers" table.

Engineering Properties

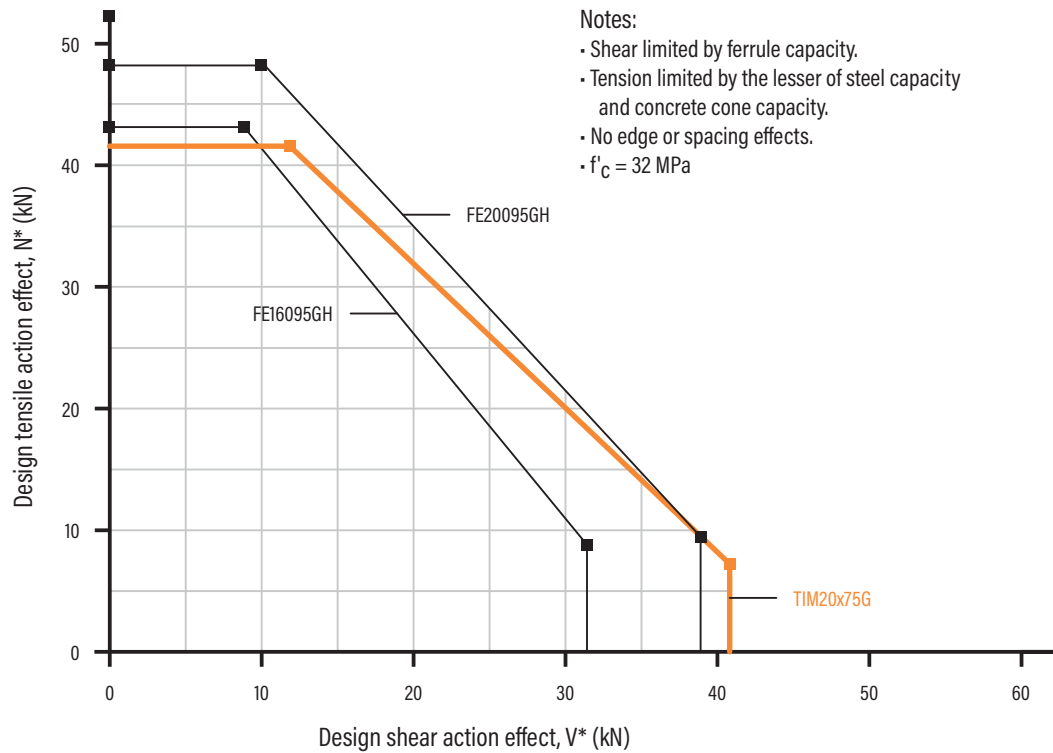
OrbiPlate™

Size	Bolt Stress area (mm ²)	Yield Strength, f_y (MPa)	Ult Strength, f_u (MPa)	Hex Head A/F (mm)	Section Modulus, Z (mm ³)
M16	157	664	830	30	277.5
M20	245	664	830	30	540.9

Reid™ Footed Ferrules

Part Number	Ferrule size, d_b	Stress area threaded section, A_s (mm ²)	Carbon Steel		Section modulus, Z (mm ³)
			Yield strength, f_y (MPa)	Ult Strength f_u (MPa)	
FE16095GH	M16	158.0	400	500	692.8
FE20095GH	M20	242.0	400	500	1034.0
TIM20x75G (NZ Only)	M20	263.4	240	400	3174.0

Strength Limit State Design / OrbiPlate™ & Reid™ Footed Ferrules

STEP 1**Select anchor to be evaluated****Table 1a - Indicative combined loading - interaction diagram****Table 1b - Absolute minimum edge distance and anchor spacing values, e_m and a_m (mm)**

Ferrule size, d_b	M16	M20
e_m	48	60
a_m	90	90

**CHECK
POINT****1****Anchor size determined, absolute minima compliance achieved.**

Strength Limit State Design / OrbiPlate™ & Reid™ Footed Ferrules

STEP 2

Verify concrete tensile capacity - per anchor

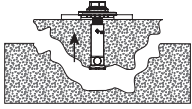


Table 2a - Reduced characteristic ultimate concrete tensile capacity, ϕN_{uc} (kN), $\phi_c = 0.6$, $f'_c = 32$ MPa

	h (mm)	e_c (mm)	M16	M20
FE**095GH	91	136.5	42.9	48
TIM20x75G (NZ only)	70	105		41.6

Table 2a-1 - Seismic Cracked Concrete effect, tension, X_{nseis}

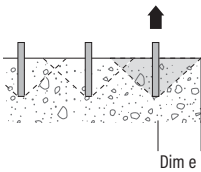
Condition	Seismic Cracked Concrete	Non-Cracked Concrete
FE**095GH - X_{nseis}	0.52	1
TIM20x75G - X_{nseis}	0.42	1

Note: For Seismic Capacity in accordance with ACI 318M-19 Chapter 17

Table 2b - Concrete compressive strength effect, tension, X_{nc}

f'_c (MPa)	15	20	25	32	40	50
FE**095GH - X_{nc}	0.68	0.79	0.88	1.00	1.12	1.25
TIM20x75G - X_{nc}	0.68	0.79	0.88	1.00	1.00	1.00

Table 2c - Edge distance effect, tension, X_{ne}

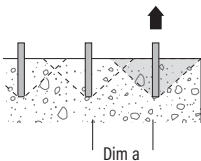


	h_{EF}	e_c	60	65	70	75	80	90	100	120	140
FE**095GH	91	136.5		0.63	0.66	0.68	0.71	0.76	0.81	0.92	1.02
TIM20x75G (NZ only)	70	105	0.70	0.73	0.77	0.8	0.83	0.9	0.97	1.00	1.00

Note: For applications with two edges, apply the X_{ne} factor twice for the corresponding edges.

Table 2d - Anchor spacing effect, end of a row, tension, X_{nae}

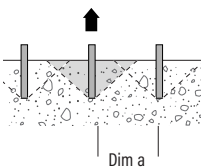
Note: For single anchor designs, $X_{nae} = 1.0$



	h	a_c	60	70	85	100	125	150	200	250	300
FE**095GH	91	273	0.61	0.63	0.66	0.68	0.73	0.77	0.87	0.96	1
TIM20x75G (NZ only)	70	210	0.64	0.67	0.7	0.74	0.8	0.86	1	1	1

Table 2e - Anchor spacing effect, internal to a row, tension, X_{nai}

Note: for single anchor designs, $X_{nai} = 1.0$



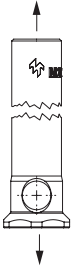
	h	a_c	60	70	85	100	125	150	200	250	300
FE**095GH	91	273	0.22	0.26	0.31	0.37	0.46	0.55	0.73	0.92	1
TIM20x75G (NZ only)	70	210	0.29	0.33	0.4	0.48	0.6	0.71	0.95	1	1

CHECK POINT 2

Design reduced ultimate concrete tensile capacity, ϕN_{urc}

$$\phi N_{urc} = \phi N_{uc} * X_{nseis} * X_{nc} * X_{ne} * (X_{nae} \text{ or } X_{nai})$$

Strength Limit State Design / OrbiPlate™ & Reid™ Footed™ Ferrules

STEP 3**Verify anchor tensile capacity - per anchor****Table 3a** - Reduced characteristic ultimate steel tensile capacity, ϕN_{us} (kN), $\phi_n = 0.8$

	M16	M20
FE**095GH	63.2	96.8
TIM20x75G (NZ only)		84.3

Note: The Ramset™ OrbiPlate™ bolts exceed the steel strength of the ferrule, hence need not be considered.

CHECK POINT 3

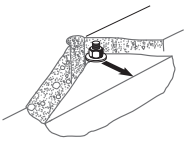
Design reduced ultimate tensile capacity, ϕN_{ur}

$\phi N_{ur} = \text{minimum of } \phi N_{urc}, \phi N_{us}$

Check $N^* / \phi N_{ur} \leq 1$,

if not satisfied return to step 1

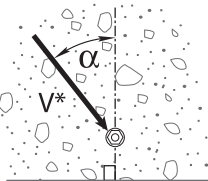
Strength Limit State Design / OrbiPlate™ & Reid™ Footed Ferrules

STEP 4**Verify concrete shear capacity - per anchor****Table 4a - Reduced characteristic ultimate concrete edge shear capacity, ϕV_{uc} (kN), $\phi_q = 0.6$, $f_c = 32$ MPa**


Ferrule size, d_b	M16	M20
Edge distance, e (mm)		
50	8.7	
60	11.3	12.3
70	14.4	15.6
100	24.4	26.6
200	69.2	75.2
300	127.1	138.2
400	195.8	212.8
500		297.5

Table 4a-1 - Seismic Cracked Concrete effect, shear, X_{vseis}

Condition	Seismic Cracked Concrete	Non-Cracked Concrete
X_{vseis}	0.65	1

Table 4b - Concrete compressive strength effect, concrete edge shear, X_{vc}


f_c (MPa)	15	20	25	32	40	50
X_{vc}	0.68	0.79	0.88	1.00	1.12	1.25

Table 4c - Load direction effect, concrete edge shear, X_{vd}

Load direction effect, conc. edge shear, X_{vd}

Angle, α°	0	10	20	30	40	50	60	70	80	90 - 180
X_{vd}	1.00	1.04	1.16	1.32	1.50	1.66	1.80	1.91	1.98	2.00

Table 4d - Anchor spacing effect, concrete edge shear, X_{va} Note: For single anchor designs, $X_{va} = 1.0$

Edge distance, e (mm)	50	60	70	100	200	300	400	500	600
Anchor spacing, a (mm)									
90	0.86	0.80	0.76	0.68	0.59	0.56	0.55	0.54	0.53
100	0.90	0.83	0.79	0.70	0.60	0.57	0.55	0.54	0.53
125	1.00	0.92	0.86	0.75	0.63	0.58	0.56	0.55	0.54
150		1.00	0.93	0.80	0.65	0.60	0.58	0.56	0.55
200			1.00	0.90	0.70	0.63	0.60	0.58	0.57
300				1.00	0.80	0.70	0.65	0.62	0.60
450					0.95	0.80	0.73	0.68	0.65
600					1.00	0.90	0.80	0.74	0.70
750						1.00	0.88	0.80	0.75
1000							1.00	0.90	0.83
1250								1.00	0.92
1500									1.00

Strength Limit State Design / OrbiPlate™ & Reid™ Footed Ferrules

STEP 4

continued

Table 4e - Multiple anchors effect, concrete edge shear, X_{vn}

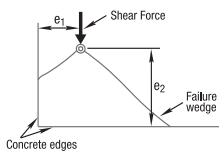
Note: For single anchor designs, $X_{vn} = 1.0$

Anchor spacing / Edge distance, a / e	0.20	0.40	0.60	0.80	1.00	1.20	1.40	1.60	1.80	2.00	2.25	2.50
Number of anchors, n												
2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3	0.72	0.76	0.80	0.83	0.86	0.88	0.91	0.93	0.95	0.96	0.98	1.00
4	0.57	0.64	0.69	0.74	0.79	0.82	0.86	0.89	0.92	0.94	0.97	1.00
5	0.49	0.57	0.63	0.69	0.74	0.79	0.83	0.87	0.90	0.93	0.97	1.00
6	0.43	0.52	0.59	0.66	0.71	0.77	0.81	0.85	0.89	0.93	0.96	1.00
7	0.39	0.48	0.56	0.63	0.69	0.75	0.80	0.84	0.88	0.92	0.96	1.00
8	0.36	0.46	0.54	0.61	0.68	0.74	0.79	0.84	0.88	0.92	0.96	1.00
9	0.34	0.44	0.52	0.60	0.67	0.73	0.78	0.83	0.87	0.91	0.96	1.00
10	0.32	0.42	0.51	0.59	0.66	0.72	0.77	0.82	0.87	0.91	0.96	1.00
15	0.26	0.37	0.47	0.55	0.63	0.70	0.76	0.81	0.86	0.90	0.95	1.00
20	0.23	0.35	0.45	0.54	0.61	0.68	0.75	0.80	0.85	0.90	0.95	1.00

Table 4f - Anchor at a corner effect, concrete edge shear, X_{vs}

Note: For $e_1/e_2 > 1.25$, $X_{vs} = 1.0$

Edge distance, e_2 (mm)	50	60	75	125	200	300	400	600	900
Edge distance, e_1 (mm)									
50	0.86	0.77	0.67	0.52	0.44	0.39	0.37	0.35	0.33
60	0.97	0.86	0.75	0.57	0.47	0.41	0.38	0.36	0.34
75	1.00	1.00	0.86	0.64	0.51	0.44	0.41	0.37	0.35
125	1.00	1.00	1.00	0.86	0.65	0.53	0.48	0.42	0.38
200	1.00	1.00	1.00	1.00	0.86	0.67	0.58	0.49	0.42
300	1.00	1.00	1.00	1.00	1.00	0.86	0.72	0.58	0.49
400	1.00	1.00	1.00	1.00	1.00	1.00	0.86	0.67	0.55
500	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.77	0.61
600	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.86	0.67
900	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.86



CHECK POINT **4**

Design reduced ultimate concrete edge shear capacity, ϕV_{urc}

$$\phi V_{urc} = \phi V_{uc} * X_{vseis} * X_{vc} * X_{vd} * X_{va} * X_{vn} * X_{vs}$$

STEP 5

Verify anchor shear capacity - per anchor

Table 5a - Reduced characteristic ultimate steel shear capacity, ϕV_{us} (kN), $\phi_v = 0.6$, $f'_c = 32$ MPa

(i) ϕV_{usc} Reduced characteristic ultimate combined concrete/steel shear capacity

Ferrule	OrbiPlate™	Non-Cracked Concrete V_{usc}				Seismic Cracked $\phi V_{usc,seis}$	
		Fixture Thickness (mm)				Fixture Thickness (mm)	
		6	8	12	16	6-12	16
FE16095GH	ORB2016BGH	39.0	35.1	31.2	-	20.7	-
FE20095GH	ORB2020BGH	40.9	39.6	38.3	37.0	27.7	27.7
TIM20x75G (NZ only)	ORB2020BGH	56.0	50.0	42.0	37.0		

Note: Seismic steel shear data is based on testing in accordance with ACI 355.2

(ii) X_{vsc} Concrete compressive strength effect, combined concrete/steel shear

f'_c (MPa)		15	20	25	32	40	50
Non-Cracked Concrete	X_{vsc}	0.77	0.85	0.92	1.00	1.08	1.16
Seismic Cracked	$X_{vsc,seis}$	0.77	0.85	0.92	1.00	1.00	1.00

Non-Cracked Concrete	$\phi V_{us} = \phi V_{usc} * X_{vsc}$	Seismic Cracked Concrete	$\phi V_{us} = \phi V_{usc,seis} * X_{vsc,seis}$
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Strength Limit State Design / OrbiPlate™ & Reid™ Footed Ferrules

CHECK
POINT**5**Design reduced ultimate shear capacity, ϕV_{ur} $\phi V_{ur} = \text{minimum of } \phi V_{urc}, \phi V_{usr}$ Check $V^* / \phi V_{ur} \leq 1$,

if not satisfied return to step 1

STEP 6**Combined loading and specification**CHECK
POINT**6**

Check

 $N^* / \phi N_{ur} + V^* / \phi V_{ur} \leq 1.2$,

if not satisfied return to step 1

HOW TO SPECIFY

Ramset™ OrbiPlate™

(Thread size & Finish (Part Number))

Reid™ Elephant Foot™ Ferrule (AU), or Reid™ TIM Ferrule (NZ)

(Ferrule Size x Length) (Part Number)

EXAMPLE

Ramset™ OrbiPlate™

M20 HDG (ORB2020BGH)

Australia

Reid™ Elephant Foot™ Ferrule, Gal

M20 x 95 (FE20095GH).

New Zealand

Reid™ TIM Ferrule, Gal

M20 x 75 (TIM20x75G)

installed with a nail plate, (NP20)

Please refer to Reid™ product guides for the range of accessories, (nailing plates, antenna caps, chairing solutions. etc.) that are available.

Note: It is the Design Engineer's responsibility to ensure that the fixture plate is adequate for the design loads in accordance with AS 4100:2020 / NZS 3404:1997

OrbiPlate™

General Information

Product

The patented OrbiPlate™ system is used when connecting steel to steel elements and delivers connection tolerances of up to 20mm where the ability to achieve fine locational accuracy when positioning each steel member is required.

Feature

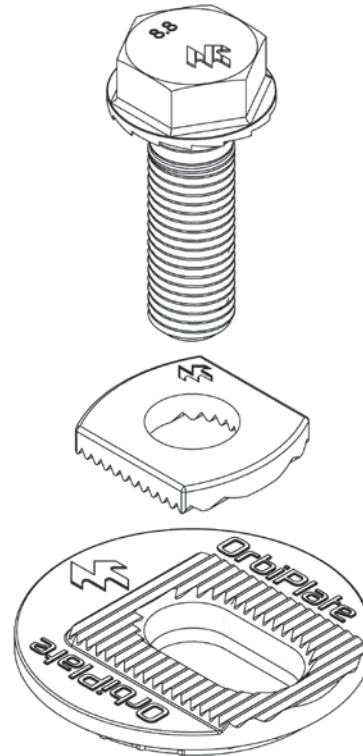
- A large washer with an elongated slot surrounded by teeth that locks the smaller washer in place, allowing positioning of the main structural bolt even with up to 20mm of misalignment.

Advantages

- Provides 20mm positional tolerance.
- Fine positional adjustment.

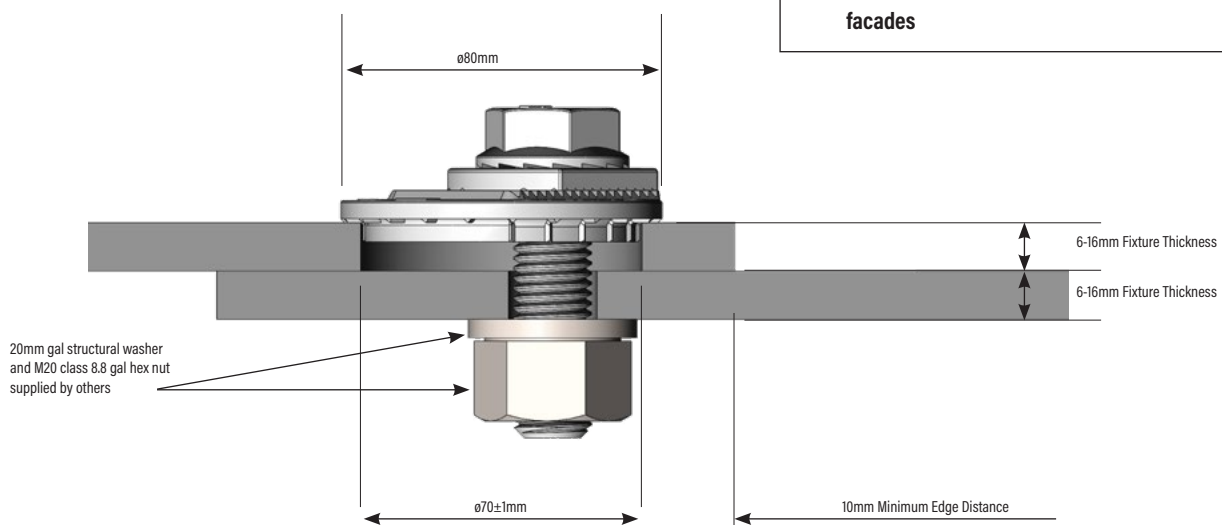
Benefits

- High structural capacity.
- Allows fine positional adjustment.
- Avoids misalignment delays and call outs.
- No hot work required on site.



Principal Applications

- Connecting steel elements where joint positional tolerance or adjustment is required without hot work such as complex facades



Strength Limit State Design / Steel to Steel Connection (through bolted)

STEP 1 Select anchor to be evaluated

Table 1a - Indicative combined loading - interaction diagram

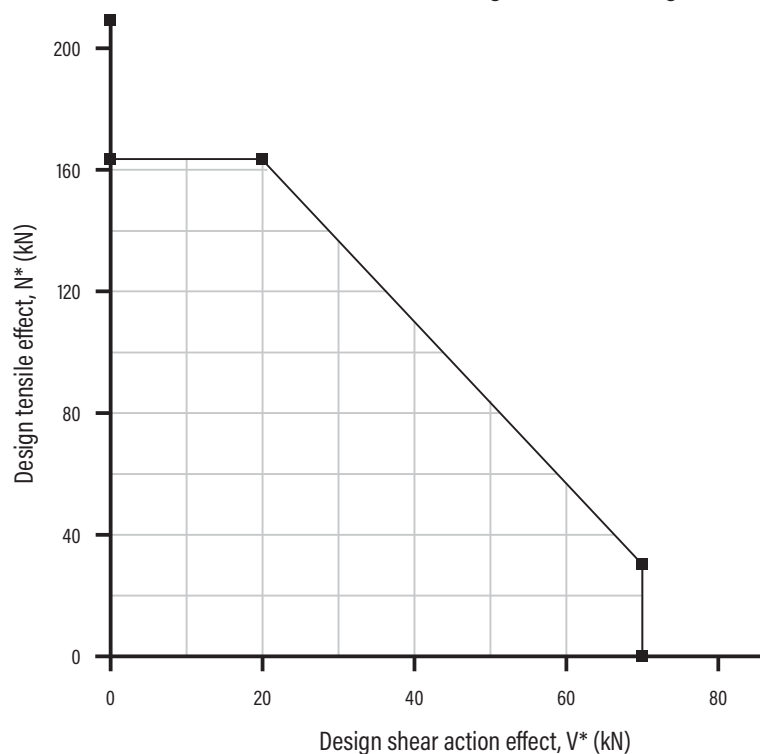


Table 1b - ϕN_{US} (kN), Reduced characteristic ultimate OrbiPlate™ steel tensile capacity, ϕN_{US} (kN), $\phi_N = 0.8$

OrbiPlate™	
ORB2020BGH	162.7

Step 1c - ϕV_{US} (kN), Reduced characteristic ultimate steel shear capacity, ϕV_{US} (kN), $\phi_V = 0.8$

OrbiPlate™	Fixture Thickness, T (mm)	
	6 - 16	
	Standard Design	70.0
ORB2020BGH	Seismic Design	36.9

CHECK
POINT

1

Check $N^* / \phi N_{US} \leq 1$, if not satisfied return to step 1

Check $V^* / \phi V_{US} \leq 1$, if not satisfied return to step 1

Check $N^* / \phi N_{US} + V^* / \phi V_{US} \leq 1.0$,

Note: It is the Design Engineer's responsibility to ensure that the fixture plate is adequate for the design loads in accordance with AS 4100:2020 / NZS 3404:1997



Derivation Of Capacity

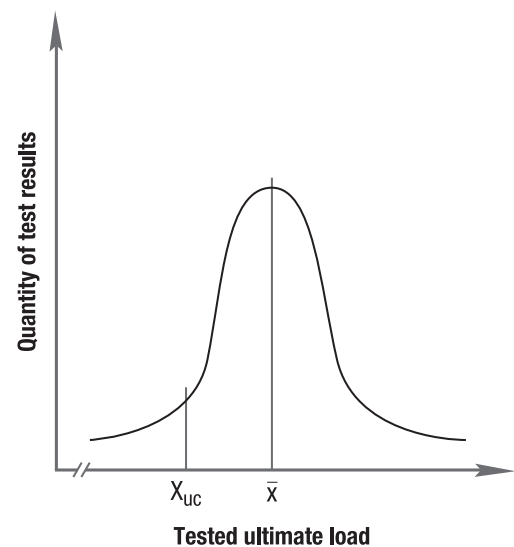
Internationally, design standards are becoming more probabilistic in nature and require sound engineering assessment of both load case information and component capacity data to ensure safety as well as economy. Published capacity data for Ramset™ anchoring products are derived from Characteristic Ultimate Capacities. From a series of controlled performance tests, Ultimate Failure Loads are established for a product.

Obviously, the value obtained in each test will vary slightly, and after obtaining a sufficient quantity of test samples, the Ultimate Failure Loads are able to be plotted on a chart.

Test values will typically centre about a mean value.

Once the mean Failure Load is established, a statistically sound derivation is carried out to establish the Characteristic Ultimate Capacity which allows for the variance in results as well as mean values.

The Characteristic Value chosen is that which ensures that a 90% confidence is obtained that 95% of all test results will fall above this value. From this value, and dependent on local design requirements, the design professional may then undertake either a strength limit state or working load design assessment of the application at hand, confident that they are working with state of the art capacity information.



\bar{x} = Mean Ultimate Capacity

X_{uc} = Characteristic Ultimate Capacity

Anchoring Principles

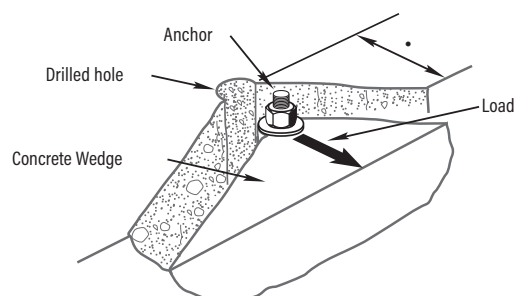
Reid™ footed ferrules are high quality, precision made fixings designed to give optimal performance.

Resistance to tensile loads is provided by engagement of the foot of the ferrule, deep in the concrete.

Generally, shear load resistance mechanisms are more uniform amongst anchors, and comprise these elements:

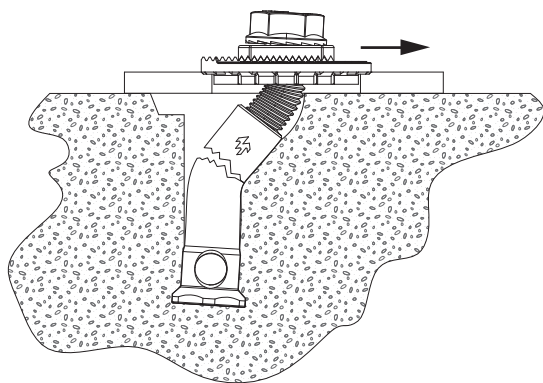
- the bolt or stud, and the body of the ferrule.
- the ability of the ferrule to resist the bending moment induced by the shear force.
- the compressive strength of the concrete.
- the shear and tensile strength of the concrete at the surface of the potential concrete failure wedge.

When loaded to failure in concrete shear, an anchor located near an edge breaks a triangular wedge away from the concrete.



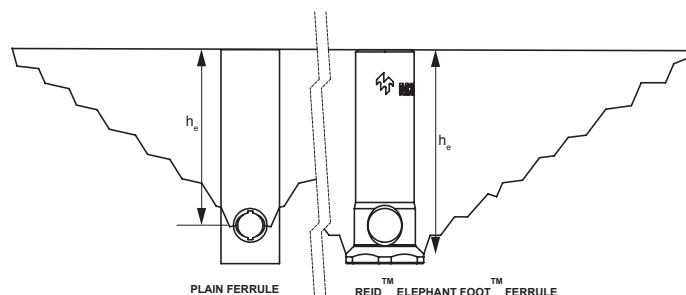
CONCRETE WEDGE FAILURE MODE

When loaded to failure in concrete shear, a cast in anchor located away from an edge in normal strength concrete often fails below the surface of the concrete in a concrete / steel failure.



Footed Ferrules Vs Plain Ferrules

Reid™ footed ferrules offer the design Engineer far superior performance and features over a conventional plain ferrule.



Performance Features

- The patented integral footed design yields the maximum effective depth, hence optimizes concrete cone capacity of the ferrule.
- A cross bar is not required to achieve concrete capacity. The cross hole is provided to enable the ferrule to be used with a cross bar tied to the reinforcing mesh to hold it in position during casting and to comply with NZ S3101 4.8.4 (b) when required.
- Premium grade, carbon steel gives the highest possible steel capacity while maintaining good ductility and toughness.

Because Reid™ footed ferrules offer such significant advantages over plain ferrules, Ramset™ only recommend them for use in combination with OrbiPlate™

Applications as per 4.8 of NZS 3101

For applications on external walls or wall panels that could collapse inward or outward due to fire, the following considerations apply:

- OrbiPlate™ is not a fire rated connection system.
- The cast-in insert (TIM20x75G) is not fire rated and 4.8.4 (b) applies.

Base Material Suitability

Ramset™ cast-in ferrules can be used in plain or in reinforced concrete. It is recommended that the cutting of reinforcement be avoided. The specified characteristic compressive strength " f_c " will not automatically be appropriate at the particular location of the anchor. The designer should assess the strength of the concrete at the location of the anchor making due allowance for degree of compaction, age of the concrete, and curing conditions.

Particular care should be taken in assessing strength near edges and corners, because of the increased risk of poor compaction and curing. Where the anchor is to be placed effectively in the cover zone of closely spaced reinforcement, the designer should take account of the risk of separation under load of the cover concrete from the reinforcement.

Concrete strength " f_c " determined by standard cylinders, is used directly in the equations. Where strength is expressed in concrete cubes, a conversion is given in the following table:

Cube Strength β (N/mm ²)	20	30	40	50	60
Cylinder Strength f_c (MPa)	15	24	33	42	51

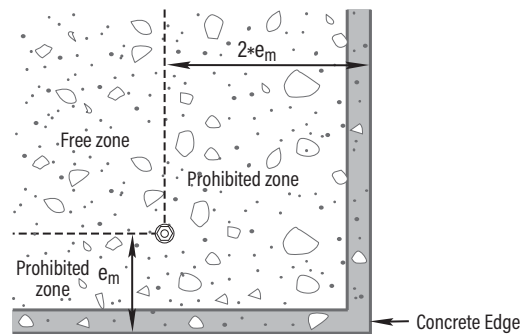
The design engineer is responsible for the overall design and dimensioning of the structural element to resist the service loads applied to it by the anchor.

Absolute Minimum Dimensions

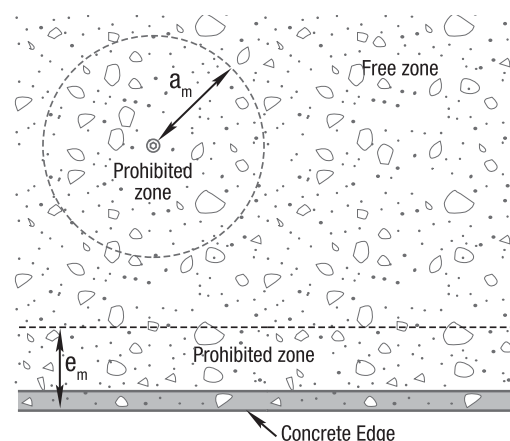
Spacings, edge distances, and concrete thicknesses are limited to absolute minima, in order to avoid risks of splitting or spalling of the concrete cast-in anchors are defined on the basis of notional limits, which take account of the practicalities of anchor placement.

Absolute minima spacing " a_m " and absolute minimum edge distance " e_m " define prohibited zones where no anchor should be placed. The prohibited spacing zone around an anchor has a radius equal to the absolute minimum spacing. The prohibited zone at an edge has a width equal to the absolute minimum edge distance.

Where a cast-in anchor is placed at a corner, there is less resistance to splitting, because of the smaller bulk of concrete around the anchor. In order to protect the concrete, the minimum distance from one of the edges is increased to twice the absolute minimum.



PROHIBITED ZONES AT CORNER FOR CAST-IN ANCHORS



PROHIBITED ZONES FOR SPACINGS AND EDGES

Strength Limit State Design

Designers are advised to adopt the limit state design approach which takes account of stability, strength, serviceability, durability, fire resistance, and any other requirements, in determining the suitability of the fixing. Explanations of this approach are found in the design standards for structural steel and concrete. When designing for strength the anchor is to comply with the following:

$$\phi R_u \geq S^*$$

where:

ϕ = capacity reduction factor

R_u = characteristic ultimate load carrying capacity

S^* = design action effect

ϕR_u = design strength

Design action effects are the forces, moments, and other effects, produced by agents such as loads, which act on a structure. They include axial forces (N^*), shear forces (V^*), and moments (M^*), which are established from the appropriate combinations of factored loads as detailed in the **AS/NSZ 1170 : 2002** "Minimum Design Load on Structures" series of Australian/New Zealand Standards.

Capacity reduction factors are given below, these typically comply with those detailed in **AS 4100:2020 & NZS 3404.1: 1997** - "Steel Structures" and **AS 3600:2018 & NZS 3101.1:2006** - "Concrete Structures". The following capacity reduction factors are considered typical:

ϕ_c = capacity reduction factor, concrete tension
= 0.6

ϕ_q = capacity reduction factor, concrete shear
= 0.6

ϕ_n = capacity reduction factor, steel tension
= 0.8

ϕ_v = capacity reduction factor, steel shear
= 0.8

ϕ_m = capacity reduction factor, steel bending
= 0.8

Whilst these values are used throughout this document, other values may be used by making the adjustment for ϕ as required.

NZ3101 Capacity reduction factors

For designing in New Zealand, the capacity reduction factors used in this guide will result in slightly conservative capacities than using those prescribed in NZS 3101.1:2006.

The steel tension reduction factor of 0.8 is the only non conservative exception, however the cast in ferrules specified within this guide are not limited by steel capacity up to the concrete strengths in the design tables.

Steel Tension

The characteristic ultimate tensile capacity for the steel of an anchor is obtained from:

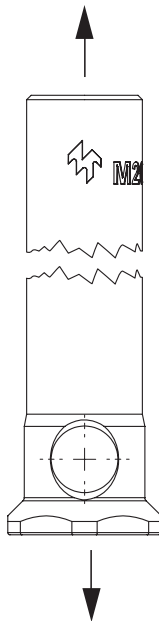
$$N_{US} = A_s f_u$$

where:

N_{US} = characteristic ultimate steel tensile capacity (N)

A_s = tensile area (mm²)
= stress area for threaded sections (mm²)

f_u = characteristic ultimate tensile strength (MPa)



Note that the strength of the OrbiPlate™ washers and class 8.8 bolt exceed the steel strength of the ferrule.

Concrete Cone

Characteristic ultimate tensile capacities for cast-in anchors vary in a predictable manner with the relationship between:

- effective depth (h), and
- concrete compressive strength (f'_c)

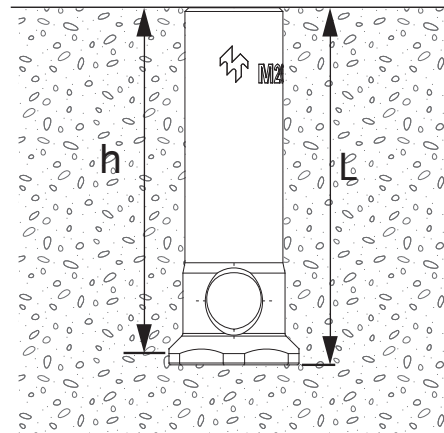
within a limited range of effective depths, h.

This is typically expressed by a formula such as:

$$N_{uc} = \text{factor} * d_b^{\text{factor}} * h^{1.5} * \sqrt{f'_c}$$

Anchors may have constraints that apply to the effective depth of the anchor or the maximum or minimum concrete strength applicable.

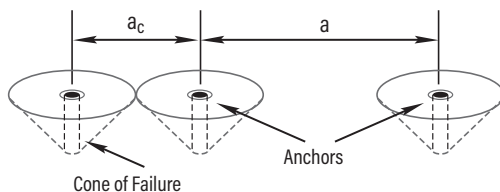
Anchor effective depth (h) is taken from the surface of the substrate to the point where the concrete cone is generated.



The appropriate concrete compressive strength " f'_c " is the actual strength at the location of the anchor, making due allowance for site conditions, such as degree of compaction, age of concrete, and curing method.

Critical Spacing Tension

In a group of cast-in anchors loaded in tension, the spacing at which the cone shaped zones of concrete failure just begin to overlap at the surface of the concrete, is termed the critical spacing, a_c .

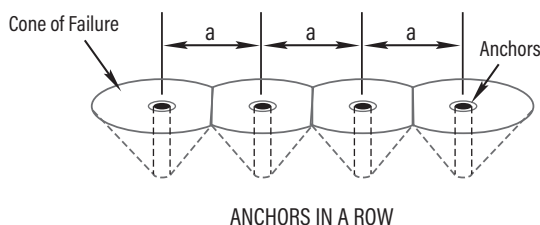


At the critical spacing, the capacity of one anchor is on the point of being reduced by the zone of influence of the other anchor. **Reid**™ cast-in anchors placed at or greater than critical spacings are able to develop their full tensile capacity, as limited by concrete cone bond capacity. Anchors at spacings less than critical are subject to reduction in allowable concrete tensile capacity.

Both ultimate and working loads on anchors spaced between the critical and the absolute minimum, are subject to a reduction factor " X_{na} ", the value of which depends upon the position of the anchor within the row:

$$N_{ucr} = X_{na} * N_{uc}$$

for strength limit state design.



ANCHORS IN A ROW

For anchors influenced by the cones of two other anchors, as a result for example, of location internal to a row:

$$X_{na} = a / a_c \leq 1$$

Unequal distances (" a_1 " and " a_2 ", both $< a_c$) from two adjacent anchors, are averaged for an anchor internal to a row:

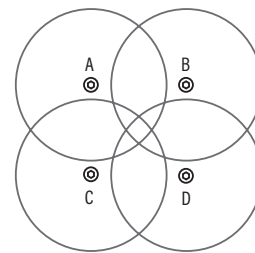
$$X_{na} = 0.5 (a_1 + a_2) / a_c$$

If the anchors are at the ends of a row, each influenced by the cone of only one other anchor:

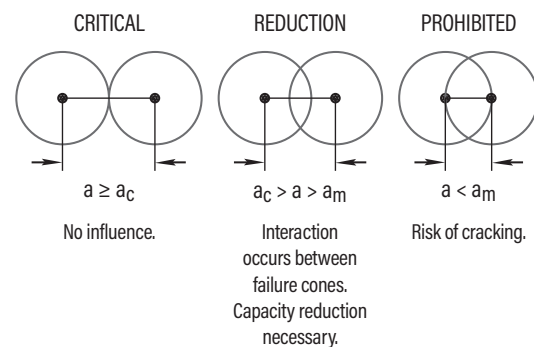
$$X_{na} = 0.5 (1 + a/a_c) \leq 1$$

The cone of anchor A is influenced by the cones of anchors B and C, but not additionally by the cone of anchor D. " X_{na} " is the appropriate reduction factor as a conservative solution.

Critical spacing (a_c) defines a critical zone around a given anchor, for the placement of further anchors. The critical spacing zone has a radius equal to the critical spacing. The concrete tensile strengths of anchors falling within the critical zone are reduced. For clarity, the figure includes the prohibited zone as well as the critical zone.



ANCHOR GROUP INTERACTION



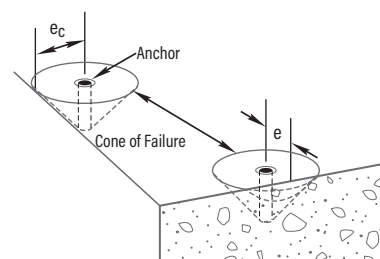
Critical Edge Distance Tension

At the critical edge distance for anchors loaded in tension, reduction in tensile capacity just commences, due to interference of the edge with the zone of influence of the anchor.

Cast-in Anchors

The critical edge distance (e_c) for cast-in anchors is taken as one and a half times effective depth:

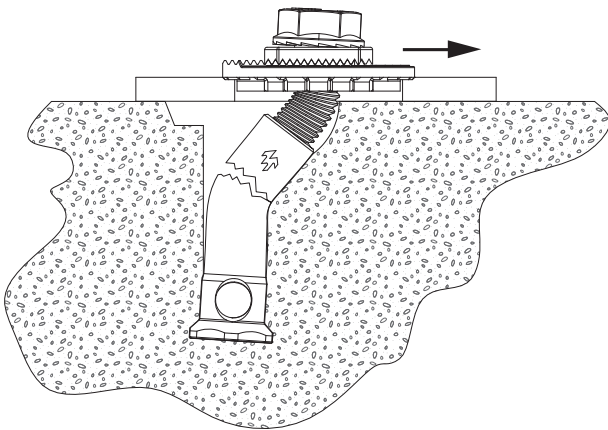
$$e_c = 1.5 * h$$



Cast-In Anchor Steel Shear

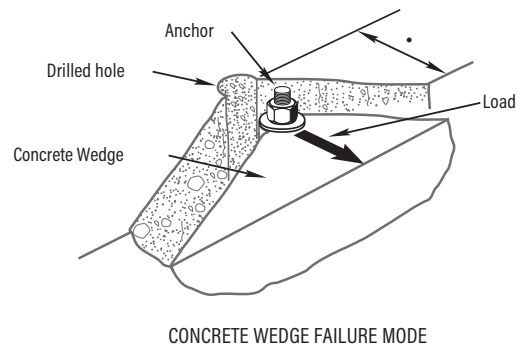
For an anchor not located close to another anchor nor to a free concrete edge, the ultimate shear load will be determined by the steel shear strength of the anchor.

Foot™ Ferrule



Concrete Edge Shear

Where load is directed either towards or parallel to an edge, and the anchor is located in the proximity of the edge, failure may occur in the concrete.



OrbiPlate™ minimum edge distances for steel fixtures

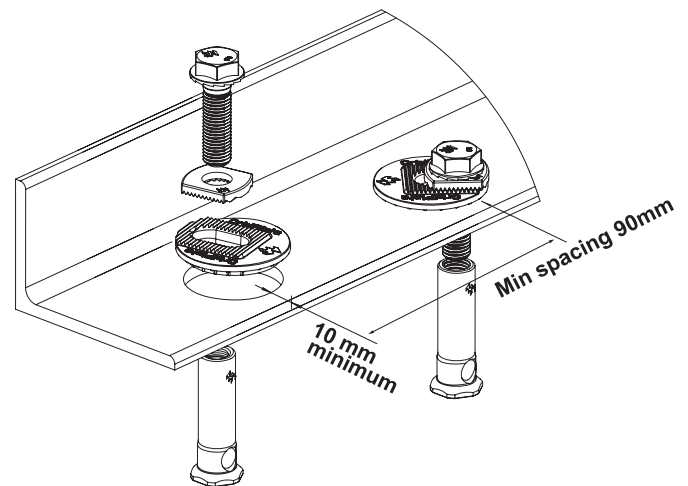
The minimum edge distance of 10mm from the edge of the fixture hole to a single edge of the fixture contained within this Design Guide is conservative yet is well below that detailed within AS 4100:2020 section 9.5.2.

OrbiPlate™ is able to be used much closer to an edge than a standard bolted connection because in shear, the much larger hole and bearing area of the large washer resists the "ply in bearing force" as defined in AS 4100:2020 section 9.2.2.4 & NZS 3404.1:1997 9.3.2.4.

AS 4100:2020 section 1.5.1 states that "This standard shall not be interpreted so as to prevent the use of materials or methods of design or construction not specifically referred to herein, provided the requirements of section 3 are complied with".

NZS 3404 part 1-1997 section 1.5 covers the use of alternate materials or methods. It states "designing using methods and/or materials not covered in the standard shall be permitted provided the requirements of section 3 are complied with".

Therefore the minimum edge distance of 10mm is appropriate to either cut or formed edges and is more than sufficient to prevent tear out or ply in bearing failure.



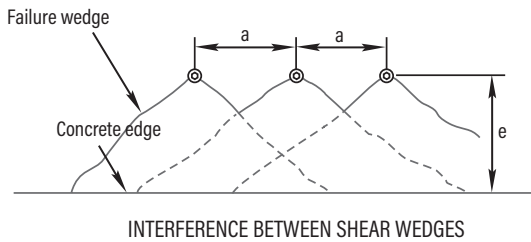
Applications as per 4.8 of NZS 3101

For applications on external walls or wall panels that could collapse inward or outward due to fire, the following considerations apply:

- OrbiPlate™ is not a fire rated connection system.
- The cast-in insert (TIM20x75G) is not fire rated and 4.8.4 (b) applies.

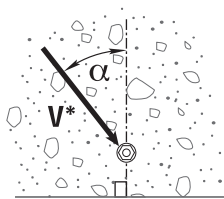
Spacing Under Concrete Shear

At a spacing of at least 2.5 times edge distance, there is no interference between adjacent failure wedges. Where anchor spacing is less than 2.5 times edge distance, the shear load capacities in the concrete are subject to a reduction factor " X_{va} ".

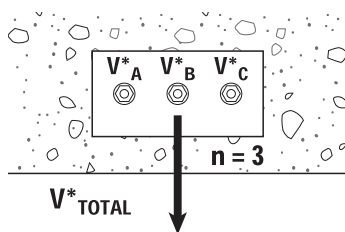


$$X_{va} = 0.5 (1 + a / (2.5 * e)) \leq 1$$

The direction of the shear load towards an edge will influence the concrete edge shear capacity. This is accounted for with the factor X_{vd} .



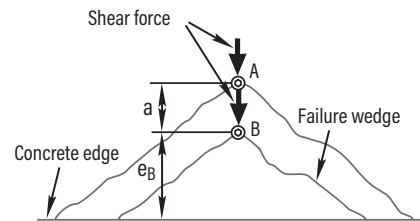
When a row of anchors is subject to a shear load acting towards an edge, the distribution of each anchor's capacity in the anchor group is derived by using the factor X_{vn} .



$$V_A^* = V_B^* = V_C^*$$

$$\phi V_{ur} \geq V_A^*, V_B^*, V_C^*$$

Two anchors installed on a line normal to the edge, and loaded in shear towards the edge, are treated as a special case. Where the anchors are loaded simultaneously by the same fixture, the ultimate or the concrete edge shear capacity for each anchor will be influenced by the other anchor. Where the spacing " a " between anchors A and B is less than or equal to " e_B " the edge distance of anchor B, the ultimate edge shear for anchor A is equal to anchor B, despite the longer edge distance of anchor A:



ANCHORS IN LINE TOWARDS AN EDGE

For an anchor located at a corner and where the second edge is parallel to the applied shear, interference by the second edge upon the shear wedge is taken into account by the following reduction factor:

$$X_{vs} = 0.30 + 0.56 * e_1 / e_2 \leq 1$$

An anchor is considered to be at a corner if the ratio of the edge distance parallel to the direction of shear to the edge distance in the direction of shear is less than 1.25.

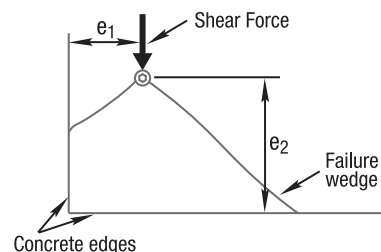
If:

$$\frac{e_1}{e_2} < 1.25$$

then apply reduction factor X_{vs} shown above

$$\frac{e_1}{e_2} > 1.25$$

acceptable $X_{vs} = 1.00$

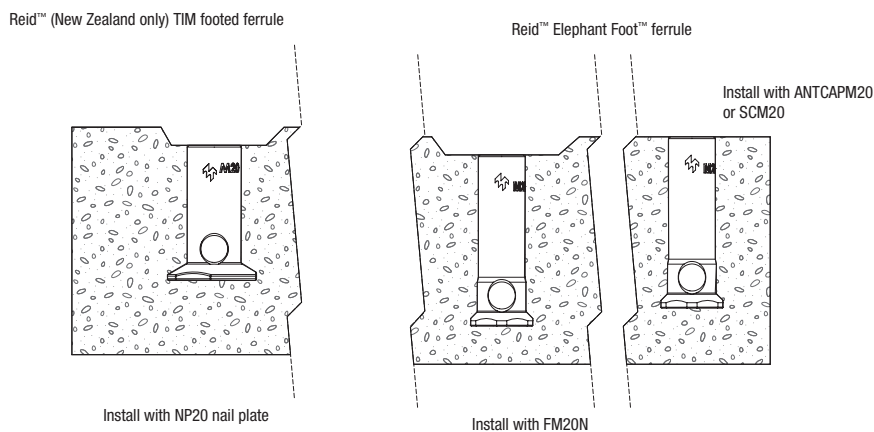


ANCHOR AT A CORNER

The following worked example is based on the use of OrbiPlate™ with Elephant Foot™ ferrules. The same approach is used for New Zealand except for the ferrule selected.

Please note that use with Reid™ TIM20x75G ferrules requires that a nail plate (part number NP20) be specified so that the ferrule is positioned below the concrete surface (as shown) with a recess above the ferrule. This ensures that the M20 class 8.8 bolt does not bottom out inside the ferrule.

Reid™ Elephant Foot™ ferrules can be installed either with or without nail plates as they are slightly longer, and their performance data is not affected by the use of a nail plate.



Verify capacity of the anchors detailed below:

Given data:

Concrete compressive strength	f_c	40 MPa
Design tensile action effect	N^*_{TOTAL}	45 kN
Design shear action effect	V^*_{TOTAL}	75 kN
Edge distance	e	100 mm
Anchor spacing	a	150 mm
Fixture plate	t	12 mm
No. of anchors in shear	n	3

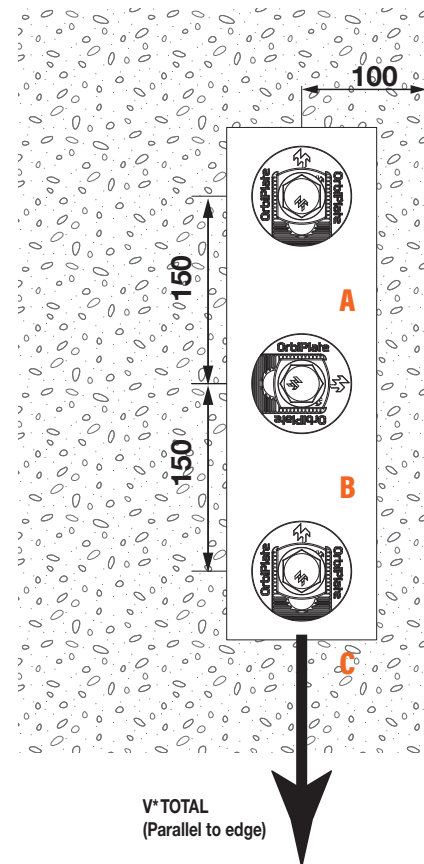
As the design process considers design action effects PER anchor, distribute the total load case to each anchor as is deemed appropriate.

In this case, equal load distribution is considered appropriate hence:

Design tensile action effect (per anchor)	N^*	15 kN
Design shear action effect (per anchor)	V^*	25 kN

Given that the 'interior' anchor is influenced by two adjacent anchors, verify capacity for anchor 'B' in this case.

Having completed the preliminary selection component of the design process, commence the Strength Limit State Design process.



Select anchor to be evaluated

Refer to table 1a, 'Indicative combined loading – interaction diagram' on page 20. Applying both the N^* value and V^* value to the interaction, it can be seen that the intersection of the two values falls within the M16 & M20 bands.

ACTION: M20 anchor size selected.

Confirm that absolute minima requirements are met.

From table 1b (page 20) for M20, it is required that edge distance, $e > 60$ mm. and that anchor spacing, $a > 80$ mm.

The design values of $e = 100$ mm and $a = 150$ mm comply with these minima, hence continue to step 1c.

Anchor size selected ?	M20
Absolute minimum compliance achieved ?	Yes

STEP 2 Verify concrete tensile capacity - per anchor

Referring to table 2a, consider the value obtained for an M20 OrbiPlate™.

ACTION: $\phi N_{uc} = 48.0$ kN

Verify the concrete compressive strength effect, tension, X_{nc} value from table 2b.

ACTION: $X_{nc} = 1.12$

Verify the edge distance effect, tension, X_{ne} value from table 2c.

ACTION: $X_{ne} = 0.81$

As we are considering anchor 'B' for this example, use table 2e on page 21 to verify the anchor spacing effect, internal to a row, tension, X_{nai} value. If we were inspecting anchors 'A' or 'C' we would use table 2d for anchors at the end of a row.

ACTION: $X_{nai} = 0.55$

CHECK POINT 2

Design reduced concrete tensile capacity, ϕN_{urc}

$$\begin{aligned}
 \phi N_{urc} &= \phi N_{uc} * X_{nc} * X_{ne} * X_{nai} && \text{(kN)} \\
 &= 48.0 * 1.12 * 0.81 * 0.55 \\
 &= 23.9 \text{ kN}
 \end{aligned}$$

ACTION: $\phi N_{urc} = 23.9$ kN

STEP 3 Verify anchor tensile capacity - per anchor

From table 3a, verify the reduced characteristic ultimate steel tensile capacity, ϕN_{us} .
For an M20 OrbiPlate™ & FE20095 Ferrule $\phi N_{us} = 96.8$ kN.

ACTION: $\phi N_{us} = 96.8$ kN

CHECK POINT 3

$\phi N_{ur} = \text{minimum of } \phi N_{urc}, \phi N_{us}$

In this case $\phi N_{ur} = 23.9$ kN (governed by concrete capacity).

Check $N^* / \phi N_{ur} \leq 1$,

$15 / 23.9 = 0.63 \leq 1$ Tensile design criteria satisfied, proceed to Step 4.

STEP 4 Verify concrete shear capacity - per anchor

Referring to table 4a, consider the value obtained for an M20 anchor at $e = 100$ mm.

ACTION: $\phi V_{uc} = 26.6$ kN

Verify the concrete compressive strength effect, tension, X_{vc} value from table 4b.

ACTION: $X_{vc} = 1.12$

Verify the load direction effect, concrete edge shear, X_{vd} value using table 4c.

ACTION: $X_{vd} = 2.00$ for angle of 90 degrees to normal.

Verify the anchor spacing effect, concrete edge shear, X_{va} value using table 4d.

ACTION: $X_{va} = 0.80$

In order to distribute the shear load evenly to all anchors in the group, the multiple anchors effect, concrete edge shear, X_{vn} value is retrieved from table 4e.

The ratio of (a / e) for this design case is $150 / 100 = 1.5$.

ACTION: $X_{vn} = \frac{0.91 + 0.93}{2} = 0.92$

Verify anchor at a corner effect, concrete edge shear, X_{vs}

ACTION: $X_{vs} = 1.00$

CHECK POINT 4

Design reduced concrete shear capacity, ϕV_{urc}

$$\begin{aligned}\phi V_{urc} &= \phi V_{uc} * X_{vc} * X_{vd} * X_{va} * X_{vn} * X_{vs} \text{ (kN)} \\ &= 26.6 * 1.12 * 2.0 * 0.80 * 0.92 * 1.00 \\ &= 43.8 \text{ kN}\end{aligned}$$

ACTION: $\phi V_{urc} = 43.8$ kN

STEP 5 Verify anchor shear capacity - per anchor

From table 5a, (i) verify the reduced characteristic ultimate steel shear capacity, ϕV_{usc} M20 & t = 12mm

ACTION: $\phi V_{usc} = 38.3 \text{ kN}$

From table 5a, (ii) verify the concrete compressive strength effect, shear, X_{vsc}

ACTION: $X_{vsc} = 1.08$

$$\begin{aligned}\phi V_{us} &= \phi V_{usc} \times X_{vsc} \\ &= 38.3 \times 1.08 \\ &= 41.4 \text{ kN}\end{aligned}$$

CHECK POINT 5

$\phi V_{ur} = \text{minimum of } \phi V_{usc}, \phi V_{us}$

In this case $\phi V_{ur} = 41.4 \text{ kN}$ (governed by steel capacity).

Check $V^* / \phi V_{ur} \leq 1$,

$$25 / 41.4 = 0.60 \leq 1$$

Shear design criteria satisfied, proceed to Step 6.

STEP 6 Combined loading and specification

CHECK POINT 6

Check that the combined loading relationship is satisfied:

$$N^*/\phi N_{ur} + V^*/\phi V_{ur} \leq 1.2,$$

$$15.0 / 23.9 + 25 / 41.5 = 1.23 > 1.2$$

Combined loading criteria **FAILED**.

Review the design process and examine the critical factors influencing the overall anchor capacity.

For tension (governed by concrete failure),

$$\phi N_{uc} = 48.0 \text{ kN}$$

$$X_{nc} = 1.12$$

$$X_{ne} = 0.81$$

$$X_{nai} = 0.55$$

From the above values while the concrete compressive strength effect, X_{nc} improves the design ultimate tensile capacity, the anchor spacing effect, X_{nai} significantly reduces design ultimate tensile capacity.

Possible solution: Increase anchor spacing to raise the value of X_{nai} .

For shear (governed by concrete failure),

$$\phi V_{uc} = 26.6 \text{ kN}$$

$$X_{vc} = 1.12$$

$$X_{vd} = 2.0$$

$$X_{va} = 0.8$$

$$X_{vn} = 0.92$$

$$X_{vs} = 1.00$$

Again, the concrete compressive strength effect, X_{vc} improves the design ultimate shear capacity. Anchor spacing effect, X_{va} reduces the design ultimate shear capacity.

Possible solution: Increase anchor spacing to raise the value of X_{va} .

Note that increasing the anchor spacing for this design will improve X_{nai} , X_{va} and X_{vn} .

Re-consider the design using the adjusted values with anchor spacing, "a" set at 200 mm.

$$\phi N_{uc} = 48.0 \text{ kN}$$

$$X_{nc} = 1.12$$

$$X_{ne} = 0.81$$

$$X_{nai} = 0.73$$

Hence $\phi N_{urc} = 31.8 \text{ kN}$ (at $a = 200 \text{ mm}$).

$$\phi V_{uc} = 26.6 \text{ kN}$$

$$X_{vc} = 1.12$$

$$X_{vd} = 2.0$$

$$X_{va} = 0.9$$

$$X_{vn} = 0.96 \text{ (at } a = 200 \text{ mm, hence } a / e = 2.0)$$

$$X_{vs} = 1.00$$

Therefore $\phi V_{urc} = 41.5 \text{ kN}$ (still limited by steel shear).

Now -

$$N^*/\phi N_{ur} + V^*/\phi V_{ur} \leq 1.2,$$

$$15 / 31.8 + 25/41.5 = 1.07 < 1.2$$

Combined loading criteria **PASSES**.

Specify

Ramset™ OrbiPlate™
M20 HDG (ORB2020BGH)

Reid™ Elephant Foot™ Ferrules
M20 x 95 HDG (FE20095GH)

Note: It is the Design Engineer's responsibility to ensure that the fixture plate is adequate for the design loads in accordance with AS 4100:2020 / NZS 3404:1997.

OrbiPlate™ and ReidBrace™

Orams Marine Facility, Auckland, New Zealand

The Project

Project: Orams Marine

Product: 20mm OrbiPlate™

Main Contractor: MacRennie Construction

Structural Engineer: Strata Group Consulting Engineers Ltd

Steel fabricator: Culham Engineering

Precast Fabricator: ConcreTec NZ

Crane company: Hi Lift

OrbiPlate™ and ReidBrace™ added strength and stability to this prestigious commercial construction project, saving time and money for the builders

For every glamorous activity, there is some hard work behind the scenes – something that makes everything work seamlessly and look easy. This is the case with the new Orams Marine Facility in Auckland.

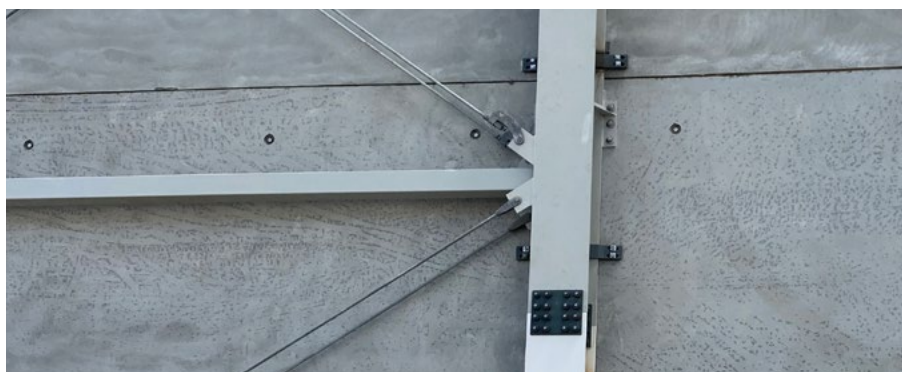
This huge new marine workshop is being constructed to provide increased maintenance facilities for Auckland's ferries, fishing vessels and commercial vessels – and the occasional superyacht. It's a large project, even involving a 110-tonne travelator to move the boats around. It's due to be handed over on the first week of March 2023.

Why OrbiPlate™ was chosen

Main contractor of the project, **MacRennie Construction**, chose 20mm OrbiPlate™ connectors to connect the steel to the precast panels.

Working with steel fabricator, **Culham Engineering**, and precast fabricator **ConcreTec NZ**, the OrbiPlate™ connectors were essential to the efficiency of the build.

"We piled first, then we added footings, structural steel, then precast," explains site manager Tony Watson of MacRennie Construction. "And our services are going on now."



OrbiPlate™ and ReidBrace™

Orams Marine Facility, Auckland, New Zealand

MacRennie Construction discussed the precast panel installation process with Luke Price, the design engineer from **Strata Group Consulting Engineers Ltd**, because they wanted the maximum tolerance they could get at the connection point of the structural steel and precast panels.

Price recommended OrbiPlate™ connectors, which are made of high tensile steel. The OrbiPlate™ system delivers 360 degrees connection tolerances of up to 20mm in structural connections. Quick and easy to install, it delivers fine locational accuracy when positioning steel members.

The OrbiPlate™ system streamlined the install process, reducing crane time and potential delays caused by misaligned connection points having to be remediated onsite while large panels were hanging on a crane.

This was the first time that MacRennie used the OrbiPlate™ system and after installing over #1000 units of them on this project, Watson said they were happy with the product and felt it was a good system.

"It was really effective," he says. "Once the precasts were made, it was pretty straightforward."

ReidBrace™ in action

MacRennie also used Ramset's ReidBrace™ on the project, which is one of their favourite and most-used Ramset™ products.

ReidBrace™ is an off-the-shelf system that provides design engineers and constructors with an economic solution for tension bracing of structures, tie-back applications and temporary works bracing.

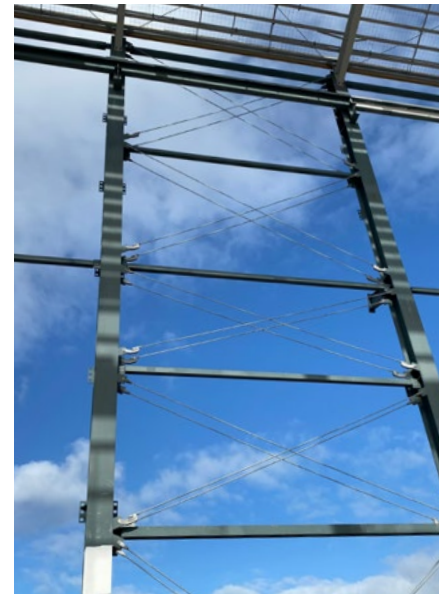
"We use this product on 99% of our jobs and don't have any issues with it," says Watson.

Boost for Health and Safety

Because the team was working at heights throughout the build, having a faster and smoother install not only reduced costs, but it also reduced exposure to health and safety issues.

The site has more than 30 people working at most times of the day, so safety is a big challenge.

"It's all up high," says Watson. "It's all on boom machines - there are 10 boom machines on site. Working at heights is the biggest challenge for us, as well as the fact that everyone is in a small, confined area."



About OrbiPlate™

Ramset's patented OrbiPlate™ system delivers orbital connection tolerances of up to 20mm in structural connections. OrbiPlate™ is quick and easy to install, delivering fine locational accuracy when positioning steel members.

About ReidBrace™

ReidBrace™ is an off the shelf, out of the box system that provides design engineers and constructors with an economic solution for tension bracing of structures, tie-back applications, retrofits and temporary works bracing.

ReidBrace™ utilises ReidBar™, a user friendly continuously threaded 500 grade reinforcing bar as the tension member. ReidBrace™ is a unique system that is as easy as screwing on a thread to install, minimising fabrication time.

For more information,



Watch this video



OrbiPlate™ Web page

OrbiPlate™

Abian Apartments- Brisbane CBD



The Project

Sunland Group have designed and constructed a number of architecturally defying projects across Australia. G James Glass and Aluminium were challenged to implement the conception of the fascinating glass façade around Abian Apartments. The challenge of soffit connections in addition to the millimeter accuracy required, pointed to only one option, the "OrbiPlate™ system".

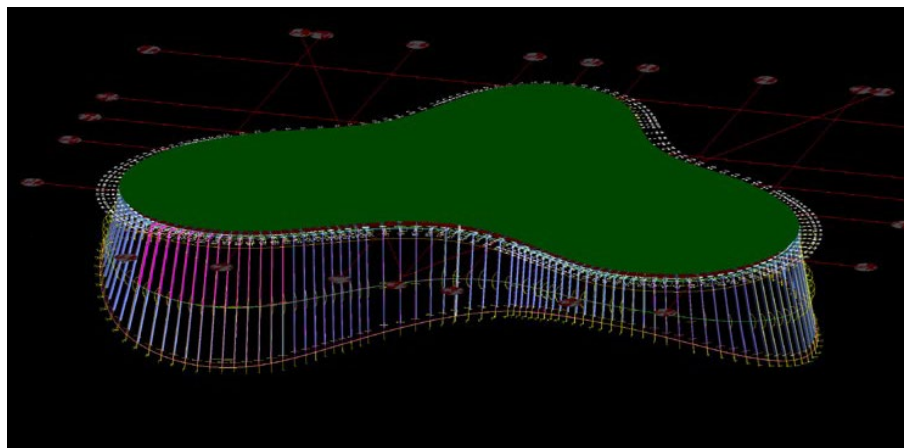
G James Glass and Aluminium approached Ramset™ for assistance, technical literature and CAD Blocks to create tolerance with Elephant Foot™ ferrule connections. OrbiPlate™ allowed 20mm tolerance and eliminated the pain of marking out and installation of post installed anchors.

The placement of each steel member needed to be millimetre perfect to marry up with regular surveyor checks in order to fit the glass panels.

"I believe using the OrbiPlate™ fixing option was at least 30% quicker than our original design"

"OrbiPlate™ provided tolerance in every direction and allowed fabrication of steel to be done without a site measure of the Elephant Foot ferrule™ locations."

Testimonial from Darshan Naik, G James Glass and Aluminium Project Manager

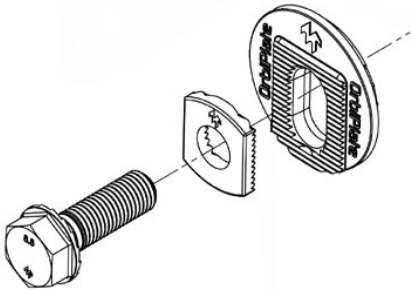


OrbiPlate™

Abian Apartments- Brisbane CBD

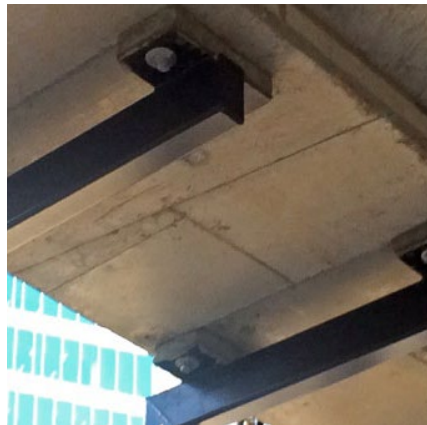
Beenleigh Steel Fabrication PTY LTD

were responsible for the fabrication & erection of the steelwork, and this was their first exposure to OrbiPlate™



"OrbiPlate™ is the best system for use with cast-in ferrules as the location of ferrules is always an issue".

Testimonial from Darshan Naik, G James Glass and Aluminium Project Manager



OrbiPlate™

The patented OrbiPlate™ system delivers connection tolerances of 20mm in any direction to position the main structural M20 bolt. It is comprised of an 80mm main circular washer with an elongated slot surrounded by serrated teeth that provide the effective mechanical lock with a secondary, smaller washer used to position the main structural M20 bolt as required.

For more information,



Watch this video



OrbiPlate™ Web page

OrbiPlate™

Jaques Apartments Richmond Victoria



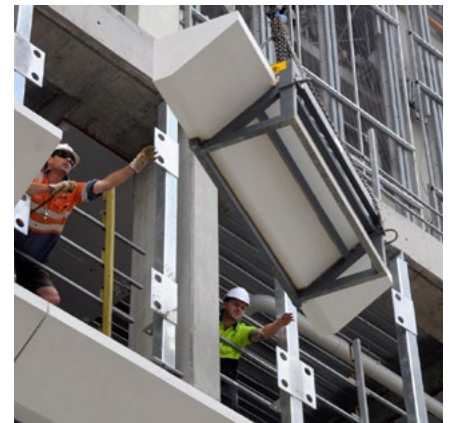
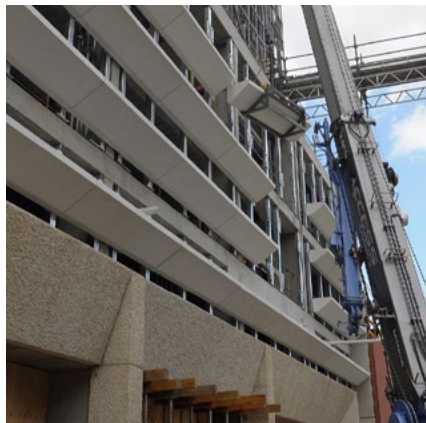
The Project

The Jaques apartment project in Coppin st Richmond features exterior facades surrounding the car parking on the lower levels. GRC Environments were responsible for the manufacture and erection of the light weight hollow composite panels.

OrbiPlate™ was used to fix each of the panels to the outside of the galvanised steel structural members that will later have crash barriers fitted internally. OrbiPlate™ provided sufficient connection tolerance to enable the facade panels to be quickly bolted into place, dramatically reducing crane time while providing a high strength structural connection.

OrbiPlate™

The patented OrbiPlate™ system delivers connection tolerances of 20mm in any direction to position the main structural M20 bolt. It is comprised of an 80mm main circular washer with an elongated slot surrounded by serrated teeth that provide the effective mechanical lock with a secondary, smaller washer used to position the main structural M20 bolt as required.



For more information,



Watch this video



OrbiPlate™ Web page

OrbiPlate™

Applecross Senior High School, WA.



The Project

OrbiPlate was specified by design engineers to connect concrete spandrel facade panels.



OrbiPlate™

Applecross Senior High School, WA.



OrbiPlate™

The patented OrbiPlate™ system delivers connection tolerances of 20mm in any direction to position the main structural M20 bolt. It is comprised of an 80mm main circular washer with an elongated slot surrounded by serrated teeth that provide the effective mechanical lock with a secondary, smaller washer used to position the main structural M20 bolt as required.

For more information,



Watch this video



OrbiPlate™ Web page

OrbiPlate™

Bendigo carpark architectural screen fixing solution



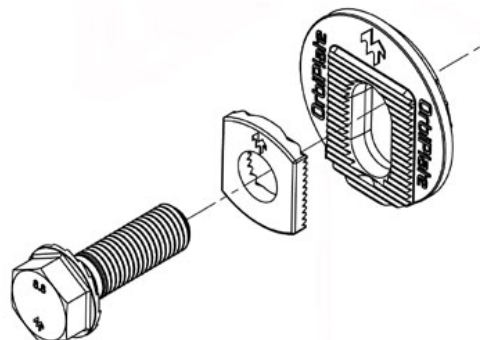
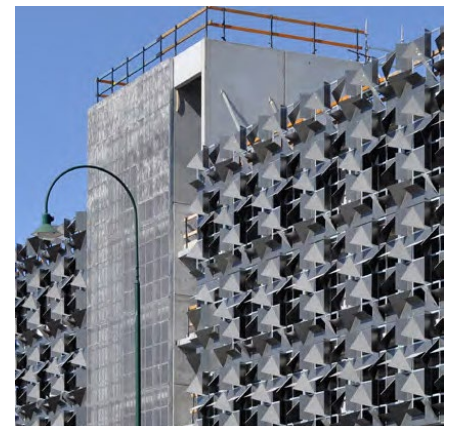
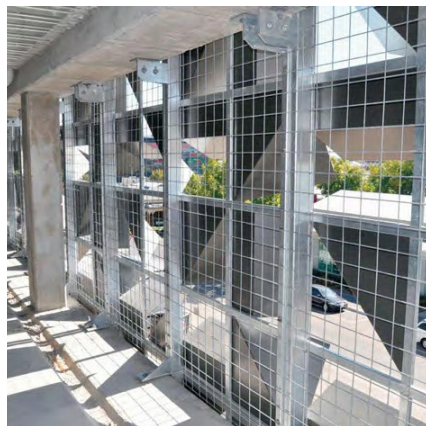
The Project

When leading, locally based Builder/Developer H. Troon began planning their multi storey carpark project in Bendigo, located in north-western Victoria, they could foresee some unique construction challenges ahead.

James Troon (H Troon) enlisted the services of Dale Baldi and his team at Statewide Panels in Shepparton.

Both James and Dale identified the key construction challenge as the fixing of the steel architectural screens to the exterior with little, if no margin for misalignment. How could this be achieved quickly and as cost effectively as possible?

The importance of speed and efficiency in connection was keeping the crane time down to an absolute minimum and limiting the disruption to traffic flow and its potential impact on businesses in the heart of Bendigo's CBD. Furthermore, the crane would be blocking the main access to a busy shopping centre. With post installed anchors to be used on this project, the concern was the potentially significant idle crane time whilst the holes are drilled and the anchors set for each of the architectural screens.



OrbiPlate™

Bendigo carpark architectural screen fixing solution

OrbiPlate™

On the recommendation from Statewide Panels, James Troonput a call into Darren Metzke (Reid Account Manager) based in Shepparton, to discuss the project and the connection challenges it presented. In consultation with Reid's Victorian Sales Engineer, Vas Haitas, the solution to the connection challenge was obvious:

The Reid OrbiPlate! Having relayed the features and benefits of the OrbiPlate solution to James, Darren promptly arranged copies of the technical literature for the design team at H Troon. Upon a quick review of the technical documents, the Reid OrbiPlate was almost instantly specified as the connection system of choice for the multi storey carpark.

The solution was to employ Reid OrbiPlates and Ramset TruBolts on the upper brackets and Reid OrbiPlates and Ramset Chemset 502 and threaded studs on the lower brackets. The holes for the anchors were predrilled, then, when the panels arrived, the crane lifted them into place and they could be quickly secured with the TruBolts top and dry studs below, allowing the crane to move onto the next. Only after the crane's services were no longer required and the road cleared for traffic once again, were the panel's alignment finalised and the ancorages completed.

Paul Grech (H Troon – Site Foreman) stated **"Hats off to the OrbiPlate! This product has not only simplified the installation of the safety screens but saved us up to 40% in time (with the crane onsite)"**.

Paul went on to add that "this site is in the centre of Bendigo's bustling CBD, and we needed to consider the needs of local traders and the community, so we aimed to minimise road closures and traffic disruption. By using the OrbiPlate, we were able to install the screens much quicker, allowing us to clear the trucks and crane quickly, which definitely made the locals happy."

Based on a concept originally developed by independent NSW engineers John Burke and Alan Walsh, the patented OrbiPlate™ assembly provides a quick and effective, fully rated, structural connection. OrbiPlate overcomes the challenge regularly faced in concrete construction – accurately locating connection points in the concrete.

Paul Grech agrees, stating that "the OrbiPlate would be considered in other projects and applications. On this occasion, The patented OrbiPlate™ system delivers connection tolerances of 20mm in any direction. It is comprised of an 80mm main circular washer with an elongated slot surrounded by serrated teeth that provide the effective mechanical lock with a secondary, smaller washer used to position the main structural M20 bolt as required main access to a busy shopping centre. With post installed anchors to be used on this project, the concern was the potentially significant idle crane time whilst the holes are drilled and the anchors set for each of the architectural screens.



Upper connection: Reid OrbiPlate and Ramset TruBolts



Lower Connection: Reid OrbiPlate and Ramset ChemSet 502

For more information,



Watch this video



OrbiPlate™ Web page

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Sales, Orders and Enquiries

Tel: 1300 780 063

Email: enquiry@ramset.com.au

Web: www.ramset.com.au

Ramset™ New Zealand

Sales, Orders and Enquiries

Tel: 0800 RAMSET (726738)

Email: info@ramset.co.nz

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Ramset™ 1 Ramset Drive, Chirnside Park 3116

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