SENSE 600® TrenchMesh™

SENSE 600®
Design Guide for Residential Footings

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Building futures through sustainable steel

SENSE 600®

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Document: T07 V1.2
March 2024

Preface

The demand for sustainable construction has driven product manufacturers in Australia and around the world to conduct research and development into innovative products which offer improved environmental credentials. Given steel is already one of the most recycled materials in construction, and certainly the highest in terms of value, the logical progression is to look further up the waste hierarchy of – Reduce, Reuse and Recycle. The top of the hierarchy is obviously the best and this is where InfraBuild Steel has a significant focus. InfraBuild Steel has conducted extensive research and development in our own facilities and in collaboration with leading Universities in Australia, to produce higher strength grades of steel designed to reduce the mass of steel consumed, in the search for more sustainable construction solutions.

Changes to Australian Standards, that now recognise these higher strength grades, will facilitate adoption in design and construction using these steels. In 2018 changes to AS 3600 – *Concrete structures* and in 2019 changes to AS/NZS 4671 – *Steel for the reinforcement of concrete*, provided the reinforced concrete industry the opportunity to explore the benefits offered by higher strength, ductile reinforcing steels. Submissions have been made to Standards Australia to revise AS 2870 – *Residential slabs and footings*, to include higher grades of steel. However, a revision to an Australian Standard generally takes considerable time.

Significant sustainability benefits can be achieved using higher strength steels particularly in reinforced concrete elements that are governed predominately by strength, rather than serviceability. This publication was produced to assist designers to incorporate high strength steels into footing designs in order to take advantage of the sustainability benefits they offer. This publication is written to align with the current Australian Standard AS 2870 so that designers familiar with the Standard will be familiar with how this document should be used.

Importantly, this publication contains the designs which have a current CodeMark Certificate of Conformity. This means that the designs contained in this Guide are deemed-to-satisfy the provisions of the BCA Volume 2 of the National Construction Code and should be used just the same as the deemed-to-comply designs in AS 2870 Section 3.

Contents

1. Scope

This Design Guide provides information on the use InfraBuild's range of SENSE 600® TrenchMesh™ and bars in residential footings. The Trench Mesh is manufactured from SENSE 600® bar, a 600 MPa, Ductility Class N (Normal Ductility) bar, meeting the requirements of AS/NZS 4671. It considers the deemed-to-comply designs in Section 3 of AS 2780: 2011 and offers alternatives to the use of 500 MPa, Class L trench mesh and 500 MPa Class N bar, based on the National Construction Code's Performance Solution methodology. This means that the solutions presented with SENSE 600® TrenchMesh™ and bars have an equivalent level of performance to those in AS 2870. A CodeMark Certificate of Conformity from the Australian Building Code Board certified by Global-Mark means that these alternate designs are deemed-to-comply with the BCA Volume 2 of the National Construction Code.

The alternatives cover the following footing types:

- Stiffened raft slabs
- Footing slabs
- Waffle rafts
- Stiffened slab with deep edge beam
- Strip footings

Site classification is not covered in this Design Guide. Designers should refer to AS 2870 for guidance on the site classification.

Designers applying engineering principles to design footing should continue to refer to the guidance provided by AS 2870, the Standards Australia Handbook SAA HB28 – *The design of residential slabs and footings*, and any additional reference they would normally use. However, SENSE 600® TrenchMesh™ should be considered for use in those designs given its superior sustainability credentials and ductility.

Reference should also be made to AS 2870 for the detailing and construction requirements of the footings. However, where they differ from those required for 500 MPa trench mesh, they are specifically covered in this guide.

A full copy of the Certificate of Conformity for
SENSE 600® TrenchMesh™ and SENSE 600® Reinforcing Bar
for use in Residential Footings follows this page.
The Certificate of Conformity No. CM30155 Rev0
can be accessed here
www.infrabuildsensesolutions.com

Certificate of Conformity

global-mark

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

Tel: +61 2 9886 0222

www.Global-Mark.com.au

Certificate Holder:

InfraBuild Australia Pty Ltd
Level 28
88 Phillip Street
Sydney NSW 2304

Tel: 1800 178 335
www.infrabuild.com

Certificate number: CM30155 Rev0

THIS IS TO CERTIFY THAT

SENSE 600® TrenchMesh™ and SENSE 600® Steel Reinforcing Bar

Type and/or use of product:

SENSE 600® TrenchMesh™ and SENSE 600® Steel Reinforcing Bar are steel reinforcing products manufactured to AS/NZS 4671:2019 – Steel for the reinforcement of concrete, for use in residential footing systems designed to AS 2870:2011 – Residential slabs and footings.

SENSE 600® TrenchMesh™ and SENSE 600® Steel Reinforcing Bar are suitable for use in residential slabs and footings in Class 1 & Class 10 buildings.

Description of product:

SENSE 600® bar has minimum characteristic strength (f_{sy}) of 600 MPa and Ductility Class N (A_{gt} >5%) as defined in AS/NZS 4671:2019 – Steel for the reinforcement of concrete.

SENSE 600® TrenchMesh consist of a minimum of three to a maximum of six SENSE 600® longitudinal steel reinforcing bars welded into a mesh with cross wires to maintain the distance between bars.

COMPLIES WITH THE FOLLOWING BCA PROVISIONS AND STATE OR TERRITORY VARIATION(S) — **BCA 2022**

	Volume One		Volume Two including ABCB Housing Provisions	
Performance Requirement(s)			**H1P1**	Structural reliability and resistance
Deemed-to-Satisfy Provision(s):				
State or territory variation(s):				

Scope of certification: The CodeMark Scheme is a building product certification scheme. The rules of the Scheme are available at the ABCB website www.abcb.gov.au. This Certificate of Conformity is to confirm that the relevant requirements of the Building Code of Australia (BCA) as claimed against have been met. The responsibility for the product performance and its fitness for the intended use remain with the certificate holder. The certification is not transferrable to a manufacturer not listed on Appendix A of this certificate.

The purpose of Global-Mark **construction site audits** is to confirm the practicability of installing the product; and to confirm the appropriateness and accuracy of installation instructions

In placing **the CodeMark mark** on the product/system, the certificate holder makes a declaration of compliance with the certification standard(s) and confirms that the product is identical to the product certified herein. In issuing this Certificate of Approval Global-Mark has relied on the **expertise of external bodies** (laboratories, and technical experts).

Herve Michoux
Global-Mark Managing Director

Peter Gardner
Unrestricted Building Certifier

Date of Issue: 13/12/2023

Date of expiry: 13/12/2026

CodeMark Australia

Certificate of Conformity

SUBJECT TO THE FOLLOWING LIMITATIONS AND CONDITIONS AND THE PRODUCT TECHNICAL DATA IN APPENDIX A AND EVALUATION STATEMENTS IN APPENDIX B

Limitations and conditions:	Building classification/s:
1. Volume 2 – H1P1 Design and specification of SENSE 600® TrenchMesh™ and SENSE 600® Steel Reinforcing Bar shall be carried out by a Professional Engineer as defined in Schedule 1 of the BCA in accordance with InfraBuild SENSE 600® - Design Guide for Residential Footings 107 V1.0, October 2023.	**Class 1 & 10**
2. Volume 2 – H1P1 Installation must be carried out in accordance with: - the professional engineer's plans, and - AS 2870:2011 – Residential slabs and footings, with the exceptions of the substitution of 3 or 4 individual 500N bars by SENSE 600® TrenchMesh™ as detailed in Table 1	**Class 1 & 10**

Table 1

500N	SENSE 600® TrenchMesh™				
Designation	Designation	No. Bars	Diameter (mm)	Area (mm^2/bar)	Total Area (mm^2)
3N16	3S15TM	3	14.6	168	503
4N16	4S15TM	4	14.6	168	670

APPENDIX A – PRODUCT TECHNICAL DATA

A1 Type and intended use of product

Refer to page 1.

A2 Description of product

Equivalent Load Capacities – Steel Areas and Yield Strengths SENSE 600® TrenchMesh™ is given in Table 2a:

Table 2a:

500L Trench Mesh				SENSE 600® TrenchMesh™			
Designation	Total Area (mm2)	Grade fsy (MPa)	Load Capacity (kN)	Designation	Total Area (mm2)	Grade fsy (MPa)	Load Capacity (kN)
3-L11TM	270	500	135	3-S10TM	225	600	135
4-L11TM	360	500	180	4-S10TM	300	600	180
5-L11TM	450	500	225	5-S10TM	375	600	225
6-L11TM	540	500	270	6-S10TM	450	600	270
3-L12TM	330	500	167	3-S11TM	283	600	170
4-L12TM	440	500	222	4-S11TM	377	600	226
5-L12TM	550	500	278	5-S11TM	471	600	283
6-L12TM	660	500	334	6-S11TM	565	600	339
500N Trench Mesh				SENSE 600® TrenchMesh™			
3N16	603	500	302	3-S15TM	503	600	302
4N16	804	500	402	4-S15TM	670	600	402

Equivalent Load Capacities – Steel Areas and Yield Strengths SENSE 600® Steel Reinforcing Bars is given in Table 2b:

Table 2b:

500N Bars				SENSE 600® Steel Reinforcing Bar			
Designation	Total Area (mm2)	Grade fsy (MPa)	Load Capacity (kN)	Designation	Total Area (mm2)	Grade fsy (MPa)	Load Capacity (kN)
N12	113	500	56.5	S11	94.2	600	56.5
N16	200	500	101	S15	168	600	102

A3 Product specification

SENSE 600® TrenchMesh™ and SENSE 600® Steel Reinforcing Bar shall be specified in accordance with the requirements of:

- AS 2870:2011 – Residential slabs and footings, and
- InfraBuild SENSE 600® - Design Guide for Residential Footings T07 V1.0, October 2023.

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A4 Manufacturer and manufacturing plant(s)

The Australian Steel Co. (Operations) Pty Ltd, 105-123 Dohertys Road, Laverton North, VIC, 3026
InfraBuild (Newcastle) Pty Ltd, Ingall Street, Mayfield, NSW, 2304
InfraBuild Reinforcing (Sunshine) 528 Ballarat Rd Sunshine VIC Australia 3020
InfraBuild (Acacia Ridge) 234 Bradman St Acacia Ridge QLD Australia 4110
InfraBuild (Revesby) Gate 3, Mons St Revesby NSW Australia 2212
InfraBuild Reinforcing 11 Carolyn Way Forrestfield WA Australia 6058

A5 Installation requirements

SENSE 600® TrenchMesh™ and SENSE 600® Steel Reinforcing Bar shall be installed in accordance with the requirements of AS 2870:2011 – Residential slabs and footings, and the professional engineer's plans.

A6 Other relevant technical data

Any referenced documents within the technical literature identified in Appendices A3 & A5.

The technical justification of substitution is provided in InfraBuild Performance Solution Report – SENSE 600® TrenchMesh™ v1.1, dated 5 December 2023.

APPENDIX B – EVALUATION STATEMENTS

B1 Evaluation methods

The following assessment methods have been used to determine compliance with BCA 2022:

Code Clause	Assessment Method(s)	Evidence of suitability	Evidence reference in B2
Volume Two H1P1	BCA Volume Two A2G2 (2)(a) & (c)	BCA Volume Two A5G3 (1)(e) Certificate or report from a professional engineer or other appropriately qualified person, and BCA Volume Two A5G3 (1)(f) Another form of documentary evidence (Product Design Guide)	Items 1, 2, 3, 4, 5, 6, 7, 8 & 9

B2 Reports

The following reports have been used as evidence to determine compliance with BCA 2022:

Ref	Author	Reference	Date	Description	NATA Registration
1	Australasian Certification Authority for Reinforcing and Structural Steels Ltd (ACRS)	Certificate Number: 311021	1 Nov 2003	CERTIFICATE OF APPROVAL - Product Conformity Certification Reinforcing Bar Manufactured in coil to AS/NZS 4671:2019	JAS-ANZ Accreditation Nos.: Z5221212AC
2	Australasian Certification Authority for Reinforcing and Structural Steels Ltd (ACRS)	Certificate Number: 31103	1 Nov 2003	CERTIFICATE OF APPROVAL - Product Conformity Certification Reinforcing Bar Manufactured in coil to AS/NZS 4671:2019	JAS-ANZ Accreditation Nos.: Z5221212AC
3	Australasian Certification Authority for Reinforcing and Structural Steels Ltd (ACRS)	Certificate Number: 31111	1 Nov 2003	CERTIFICATE OF APPROVAL - Product Conformity Certification Steel Reinforcing Mesh Manufacture to AS/NZS 4671:2019	JAS-ANZ Accreditation Nos.: Z5221212AC
4	Australasian Certification Authority for Reinforcing and Structural Steels Ltd (ACRS)	Certificate Number: 31106	1 Nov 2003	CERTIFICATE OF APPROVAL - Product Conformity Certification Steel Reinforcing Mesh Manufacture to AS/NZS 4671:2019	JAS-ANZ Accreditation Nos.: Z5221212AC
5	Australasian Certification Authority for Reinforcing and Structural Steels Ltd (ACRS)	Certificate Number: 31107	1 Nov 2022	CERTIFICATE OF APPROVAL - Product Conformity Certification Steel Reinforcing Mesh Manufacture to AS/NZS 4671:2019	JAS-ANZ Accreditation Nos.: Z5221212AC
6	Australasian Certification Authority for Reinforcing and Structural Steels Ltd (ACRS)	Certificate Number: 221101	22 Nov 2003	CERTIFICATE OF APPROVAL - Product Conformity Certification Steel Reinforcing Mesh Manufacture to AS/NZS 4671:2019	JAS-ANZ Accreditation Nos.: Z5221212AC
7*	Leigh D Appleyard (CPEng)	N/A	19 Oct 2023	Expert Opinion - Performance Solution Report - SENSE 600® TrenchMesh™ and SENSE 600® bars	N/A
8	Anthony Ng of InfraBuild	Performance solution report - SENSE 600® TrenchMesh™ v1.1	5 Dec 2023	Performance solution report - SENSE 600® TrenchMesh™	N/A
9	Anthony Ng & Graeme McGregor of InfraBuild	SENSE 600® - Design Guide for Residential Footings – T07 V1.0	Oct 2023	SENSE 600® - Design Guide for Residential Footings	N/A

* The Certificate Holder has chosen not to make the above identified evidence of compliance publicly available, due to the document(s) being considered commercial in confidence.

2. SENSE 600® TrenchMesh™

SENSE 600® TrenchMesh™ is manufactured utilising SENSE 600® bar which has a yield strength of 600 MPa and is Ductility Class N (A_{gt} ≥5%). The obvious benefits over 500L trench mesh are the additional strength and the superior ductility. The additional strength means that a smaller area of steel has the capacity to carry the same tensile load and the ductility means that there is greater opportunity for the redistribution of loads in the footing.

The range of SENSE 600® TrenchMesh™ products are manufactured in equivalent load capacity diameters with the same number of bars as the equivalent 500L trench mesh. The simplest way to explain this is by way of example:

Consider a 3-L11TM trench mesh, which has 3 x 10.7 mm 500 MPa, Ductility Class L bars.

Each bar has a calculated tensile load capacity equal to:

$\pi \times 10.7^2 / 4 \times 500 \times 10^{-3} = 45$ kN

3 bars provide a total tensile load capacity of 135 kN.

Now consider a 3-S10TM, the equivalent SENSE 600® TrenchMesh™ which has 3 x 9.8 mm 600 MPa, Ductility Class N bars.

Each bar has a calculated tensile load capacity equal to:

$\pi \times 9.8^2 / 4 \times 600 \times 10^{-3} = 45$ kN

3 bars provide a total tensile load capacity of 135 kN

Table 2.1 shows the details of the SENSE 600® TrenchMesh™ range compared to the standard 500L meshes and 500N (16 mm) bars.

Table 2.1: Details of SENSE 600® TrenchMesh™

500L (f_{sy} = 500 MPa)					SENSE 600® (f_{sy} = 600MPa)				
Trench mesh	d_b (mm)	Area (mm²/bar)	Total Area (mm²)	Load Capacity (kN)	TrenchMesh™	d_b (mm)	Area (mm²/bar)	Total Area (mm²)	Load Capacity (kN)
3-L11TM	10.7	89.9	270	135	3-S10TM	9.8	74.9	225	135
4-L11TM			360	180	4-S10TM			300	180
5-L11TM			450	225	5-S10TM			375	225
6-L11TM			540	270	6-S10TM			450	270
3-L12TM	11.9	111	330	167	3-S11TM	11.0	94.2	283	170
4-L12TM			440	222	4-S11TM			377	226
5-L12TM			550	278	5-S11TM			471	283
6-L12TM			660	334	6-S11TM			565	339
3-L16TM	16	201	603	302	3-S15TM	14.6	168	503	302
4-L16TM			804	402	4-S15TM			670	402
3N16	16	201	603	302	3S15	14.6	168	503	302
4N16			804	402	4S15			670	402

d_b – bar diameter

Table 2.2: Details of SENSE 600® Bars

500N (f_{sy} = 500 MPa)				SENSE 600® (f_{sy} = 600MPa)			
Designation	Diameter (mm)	Area (mm²)	Load Capacity (kN)	Designation	Diameter (mm)	Area (mm²)	Load Capacity (kN)
N12	12	113	56.5	S11	11.0	94.2	56.5
N16	16	201	101	S15	14.6	168	102

3. How to use this Guide

The designs in this Guide have a CodeMark Certificate of Conformity which is evidence of suitability recognised by the National Construction Code, specifically the Building Code of Australia, that the product, and form of design is fit for their intended purpose to achieve the relevant requirements of the NCC. Refer to Figure 3.1

A5G3 **Evidence of suitability — Volumes One and Two (BCA)**

[2019: A5.2]

(1) Subject to A5G5, A5G6, A5G7 and A5G9, evidence to support that the use of a material, product, form of construction or design meets a *Performance Requirement* or a *Deemed-to-Satisfy Provision* may be in the form of any one, or any combination of the following:

(a) A current CodeMark Australia or CodeMark *Certificate of Conformity*.

(b) A current *Certificate of Accreditation*.

(c) A current certificate, other than a certificate described in (a) and (b), issued by a *certification body* stating that the properties and performance of a material, product, form of construction or design fulfil specific requirements of the BCA.

(d) A report issued by an *Accredited Testing Laboratory* that—

(i) demonstrates that a material, product or form of construction fulfils specific requirements of the BCA; and

(ii) sets out the tests the material, product or form of construction has been subjected to and the results of those tests and any other relevant information that has been relied upon to demonstrate it fulfils specific requirements of the BCA.

(e) A certificate or report from a *professional engineer* or other *appropriately qualified person* that—

(i) certifies that a material, product, form of construction or design fulfils specific requirements of the BCA; and

(ii) sets out the basis on which it is given and the extent to which relevant standards, specifications, rules, codes of practice or other publications have been relied upon to demonstrate it fulfils specific requirements of the BCA.

Figure 3.1 – Extract from NCC BCA Volume 2

The following design examples demonstrate how the CodeMark Certificate of Conformity designs in Section 5 of this Guide can be used.

3.1 Design Example 1

Consider a single storey residential building with the following design criteria:

Footing Type: Waffle Raft

Site Class: Class M - D

Type of Construction: Articulated Masonry Veneer

Design:

The appropriate design table is from Section 5 – Alternative SENSE 600® and Standard Design Table 5.3 Waffle Raft Designs with SENSE 600® TrenchMesh™

Table 5.3: Waffle Raft Designs with SENSE 600® TrenchMesh™: refer to Figure 5.3								
Site class	Type of Construction	Depth [D] (mm)	Bottom Reinforcement				Slab Mesh	
			Edge Beam Alternatives Bottom		Internal Beam Alternatives Top and Bottom		Slab Length (m)	
			500 MPa	SENSE 600®	500 MPa	SENSE 600®	<20	≥20 - <30
	Clad frame	310	3-L11TM	3-S10TM	1N12	1S11	SL72	SL82
	Articulated masonry veneer	310	3-L11TM	3-S10TM	1N12	1S11	SL72	SL82
Class M	Masonry veneer	310	3-L11TM	3-S10TM	1N12	1S11	SL72	SL82
	Articulated full masonry	610	2 x 3-L11TM	2x3-S10TM	1N16	1S15	SL72	SL82
	Full masonry	-	-	-	-	-	-	-
	Clad frame	310	3-L11TM	3-S10TM	1N12	1S11	SL72	SL92
	Articulated masonry veneer	310	3-L11TM	3-S10TM	1N12	1S11	SL72	SL92
Class M-D	Masonry veneer	385	2x3-L11TM	2x3-S10TM	1N16	1S15	SL72	SL92
	Articulated full masonry	610	2x3-L11TM	2x3-S10TM	1N16	1S15	SL72	SL92
	Full masonry	-	-	-	-	-	-	-
	Clad frame	310	3-L11TM	3-S10TM	1N12	1S11	SL82	SL92
	Articulated masonry veneer	385	3-L11TM	3-S10TM	1N12	1S11	SL82	SL92
Class H1	Masonry veneer	460	2 x 3-L11TM	2x3-S10TM	1N16	1S15	SL82	SL92
	Articulated full masonry	610	2 x 3-L11TM	2x3-S10TM	1N16	1S15	SL82	SL92
	Full masonry	-	-	-	-	-	-	-
	Clad frame	310	3-L11TM	3-S10TM	1N12	1S11	SL82	SL92
	Articulated masonry veneer	385	3-L11TM	3-S10TM	1N12	1S11	SL82	SL92
Class H1-D	Masonry veneer	460	2 x 3-L11TM	2x3-S10TM	1N16	1S15	SL82	SL92
	Articulated full masonry	-	-	-	-	-	-	-
	Full masonry	-	-	-	-	-	-	-
	Clad frame	310	3-L11TM	3-S10TM	2N12	1S11	SL82	SL92
	Articulated masonry veneer	385	2 x 3-L11TM	2x3-S10TM	2N16	1S15	SL82	SL92
Class H2	Masonry veneer	-	-	-	-	-	-	-
	Articulated full masonry	-	-	-	-	-	-	-
	Full masonry	-	-	-	-	-	-	-
	Clad frame	385	2 x 3-L11TM	2x3-S10TM	1N16	1S15	SL82	SL92
	Articulated masonry veneer	460	2 x 3-L11TM	2x3-S10TM	1N16	1S15	SL82	SL92
Class H2-D	Masonry veneer	-	-	-	-	-	-	-
	Articulated full masonry	-	-	-	-	-	-	-
	Full masonry	-	-	-	-	-	-	-

Figure 3.1.1 – Table 5.3 Extract for Design Example 1

Using Table 5.3 select Class M-D and then Articulated Masonry Veneer, then reading across gives the CodeMark Certified design.

Depth of Waffle Raft: 310 mm

Reinforcement for External Beam: 3-S10TM

Reinforcement for Internal Ribs: Either 1N12 top and bottom or 1S11 top and bottom.

3.2 Example 2

Consider the same residential building as in Example 1. However, in this case the waffle raft has already been designed with 500 MPa using the deemed-to-comply designs from Section 3 of AS 2870. That is, the design has:

Depth of Waffle Raft: 310 mm

Reinforcement for External Beam: 3-L11TM

Reinforcement for Internal Ribs: 1N12 top

One way to execute the redesign is to use the same process as in Design Example 1

Alternatively as the original design used the deemed-to-comply designs from Section 3 of AS 2870 to specify the 500 MPa reinforcing steel, the SENSE 600® alternatives can be simply read from Tables 2.1 and 2.2 as appropriate.

Table 2.1: Details of SENSE 600® TrenchMesh™

500L (f_{sy} = 500 MPa)					SENSE 600® (f_{sy} = 600MPa)				
Trench mesh/ Bar	d_b (mm)	Area (mm²/bar)	Total Area (mm²)	Load Capacity (kN)	TrenchMesh™	d_b (mm)	Area (mm²/bar)	Total Area (mm²)	Load Capacity (kN)
3-L11TM	10.7	89.9	270	135	3-S10TM	9.8	74.9	225	135
4-L11TM			360	180	4-S10TM			300	180
5-L11TM			450	225	5-S10TM			375	225
6-L11TM			540	270	6-S10TM			450	270
3-L12TM	11.9	111	330	167	3-S11TM	11.0	94.2	283	170
4-L12TM			440	222	4-S11TM			377	226
5-L12TM			550	278	5-S11TM			471	283
6-L12TM			660	334	6-S11TM			565	339
3-L16TM	16	201	603	302	3-S15TM	14.6	168	503	302
4-L16TM			804	402	4-S15TM			670	402
3N16	16	201	603	302	3N15	14.6	168	503	302
4N16			804	402	4N15			670	402

d_b – bar diameter

Figure 3.2.1 – Table 2.1 Extract for Design Example 2

The 3-L11TM reinforcement for external beams can be substituted with SENSE 600® TrenchMesh™ 3-S10TM.

Table 2.2 can be used if the design requires that the reinforcement for internal ribs also be SENSE 600®. This table shows that the N12 bar top and bottom for internal ribs can be substituted with a SENSE 600® S11 bar top and bottom.

Table 2.2: Details of SENSE 600® Bars

500N (f_{sy} = 500 MPa)				SENSE 600® (f_{sy} = 600MPa)			
Designation	Diameter (mm)	Area (mm^2)	Load Capacity (kN)	Designation	Diameter (mm)	Area (mm^2)	Load Capacity (kN)
N12	12	113	56.5	S11	11.0	94.2	56.5
N16	16	201	101	S15	14.6	168	102

Figure 3.2.2 – Table 2.2 Extract for Design Example 2

4. Structural design

The design requirements for the footing systems in AS 2870 are generally consistent with those in AS 3600. However, it is clearly noted in AS 2870 that the design provision of AS 2870 should take precedence over AS 3600 where they are not consistent. The guidance in this document follows this same principle.

The structural design aspects that are relevant when considering a change to the reinforcement of a footing design are:

1) The ultimate moment capacity – M_u
2) The ductility of the steel and the footing
3) The stiffness of the footing

Each of these factors were assessed to produce the alternate designs in Section 4 of this Guide. The approach followed was to substitute the equivalent load capacity SENSE 600® TrenchMesh™ for the equivalent 500L trench mesh or 500N bar for the deemed-to-comply designs in AS 2870 and determine what impact the substitution had on the 3 structural design aspects noted above.

4.1 Ultimate Strength of a Footing

The ultimate strength of a footing can be calculated using well known formulae found in most textbooks as well as in SAA HB28 – 1997 commonly known as the 1997 Commentary to AS 2870. The Commentary indicates that the designs in AS 2870 consider the strip footings and stiffening beams as singularly reinforced rather than doubly reinforced with compression and tension reinforcement, so this simplifies the comparison even further.

Consider Figure 4.1 below for a sagging mode (or positive moment). The ultimate moment can be determined using the formula:

$$M_u = A_{st} \times f_{sy} \times L$$

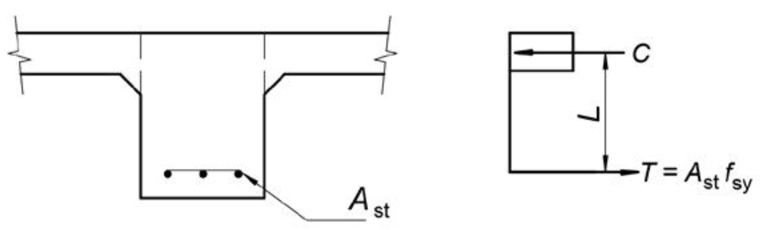


Figure 4.1 – Ultimate Moment Capacity – M_u

However, if equivalent load capacity SENSE 600® TrenchMesh™ is used in place of 500L trench mesh then

$$A_{st} \times f_{sy\ (SENSE\ 600^{®})} = A_{st} \times f_{sy\ (500L)}$$

and the ultimate moment capacity (M_u) is essentially the same. The lever arm (L) is slightly longer for the SENSE 600® TrenchMesh™ as the bar is smaller in diameter and hence the ultimate moment is slightly higher. Appendix A contains detailed calculations for the generic case showing the moments are essentially the same.

For a hogging mode (or negative moment) in a stiffened raft the mesh in the slab is in tension and the trench mesh is ignored. The alternative deemed-to-comply solutions in Section 4 of this Guide leaves the slab mesh unchanged from the designs in AS 2870 and therefore the negative moment capacity remains the same.

For strip footings the top and bottom steel is the same and therefore the negative moment capacity is the same as the positive moment capacity.

In summary, substituting SENSE 600® TrenchMesh™ for the 500L trench mesh in the deemed-to-comply designs in AS 2870 does not have a negative impact on the ultimate strength of the footing.

4.2 Ductility

A ductile steel means that a load in a cracked zone has a greater capacity of being transferred to a stiffer uncracked zone. Therefore, the performance of a beam is generally improved if a ductile steel is used in place of a low ductility steel. SENSE 600® TrenchMesh™ is a Ductility Class N steel and therefore has superior ductility to 500L trench mesh.

Member ductility is important when the cracking moment (M_{cr}) of the section is exceeded, as the reinforcement in the design should be sufficient to carry the load. The deemed-to-comply designs in AS 2870 have ultimate moment (M_u) capacities that meet the ductility requirement, that is:

$$M_u > 1.2\ M_{cr}$$

It is clear from Section 3.1 the substitution of equivalent capacity SENSE 600® TrenchMesh™ for 500L trench mesh does not substantially change the ultimate moment, M_u. If the dimensions of the concrete section do not change then the gross section properties of the section do not change and hence the M_{cr} does not change. Calculations demonstrating this are presented in Appendix A.

Therefore, the section ductility of a deemed-to-comply design in AS 2870 does not change when equivalent capacity SENSE 600® TrenchMesh™ is substituted for 500L trench mesh.

4.3 Footing System Stiffness

The stiffness of the performance solutions in Section 4 of this Guide were checked using a combination of AS 2870, *Section 4 – Design by engineering principles* and the deemed-to-comply solutions in *Section 3*.

HB28 acknowledges that the deflections of reinforced concrete flexural members, including an allowance for creep and shrinkage warping, is a complex topic. AS 2870, Clause 4.4 (f), simplifies this by permitting the calculation of the deflection using an effective modulus of elasticity of 15,000 MPa compared to the value in AS 3600 of 24,000 MPa for 20 MPa concrete. This Clause requires the value I_{eff} to be as defined in AS 3600.

For consistency with AS 2870 and HB28, the effective moment of inertia values (I_{eff}) for stiffness and deflection are calculated using Branson's Formula which was included in AS 3600: 2009 -

$$I_{eff} = I_{cr} + (I_g - I_{cr}) \times (\frac{M_{cr}}{M_{ser}})^3 \leq I_g$$

Where

I_{cr} = Cracked transformed moment of inertia

I_g = Gross moment of inertia (uncracked)

M_{ser} = Maximum service moment

M_{cr} = Cracking moment of section

AS 2870, Clause 1.4.2, requires that the design ultimate moment M^* be calculated using the load factors in AS/NZS 1170.1 – *Structural design actions*. *Part 1*. For dead loads this factor is 1.2 and for live loads it is 1.5. Furthermore AS 2870, Clause 4.4 (f), requires

$$M^* \leq \varnothing M_u$$

Where

$\varnothing$ = 0.8 from AS 3600 : 2009 (Consistent with the edition of the Standard when the deemed-to-comply designs were produced)

M_u = Calculated ultimate moment capacity of the section

Therefore

$1.2M_{ser} < M^* \leq 0.8M_u$

$M_{ser} \leq 0.8/1.2\ M_u$

That is

$M_{ser} \leq 0.67M_u$

For each of the designs in AS 2870 Section 3 and Section 4 included in this Design Guide, the values of I_g, I_{cr}, and M_{cr}, can be determined accurately by calculation. An upper-bound value of M_{ser} can be determined using the relationship $M_{ser} \leq 0.67M_u$. M_{ser} can be substituted into Branson's Formula to determine the effective moment of inertia (I_{eff}) for each pair of equivalent deemed-to-comply designs. The comparisons tabulated in Appendix B, indicate that for the stiffened raft, waffle raft and strip footing designs the difference in stiffness between the equivalent solutions using a SENSE 600® TrenchMesh™ and a 500L trench mesh is generally less than five per cent and in many cases the upper-bound service load value is less than the cracking moment and thus there is no difference in stiffness between the two solutions. Where there was up to five percent difference in stiffness it was considered not significant enough to require a more detailed analysis, particularly since the M_{ser} value used was an upper-bound value and a lower value would have reduced the difference even further.

Where the difference in stiffness was in excess of five percent, software (CORD) was used to check ten designs. The checks as detailed in Appendix C showed that the moment of inertia for the required stiffness in all cases was below the calculated effective moment of inertia (I_{eff}).

5. Alternative SENSE 600® Standard designs

This section of the SENSE 600® Design Guide is analogous to Section 3 of AS 2870. All the Clauses and their specific requirements apply and should be satisfied except that the SENSE 600® TrenchMesh™ options in the following Tables may be used as an alternative to the equivalent 500L trench mesh.

5.1 Stiffened Raft Slabs

A stiffened raft shall be specified in accordance with AS 2870, Clause 3.2. The concrete section sizes, beam spacing and reinforcement requirements shall be as shown in Figure 4.1 and Table 4.1 which includes the SENSE 600® TrenchMesh™ alternatives.

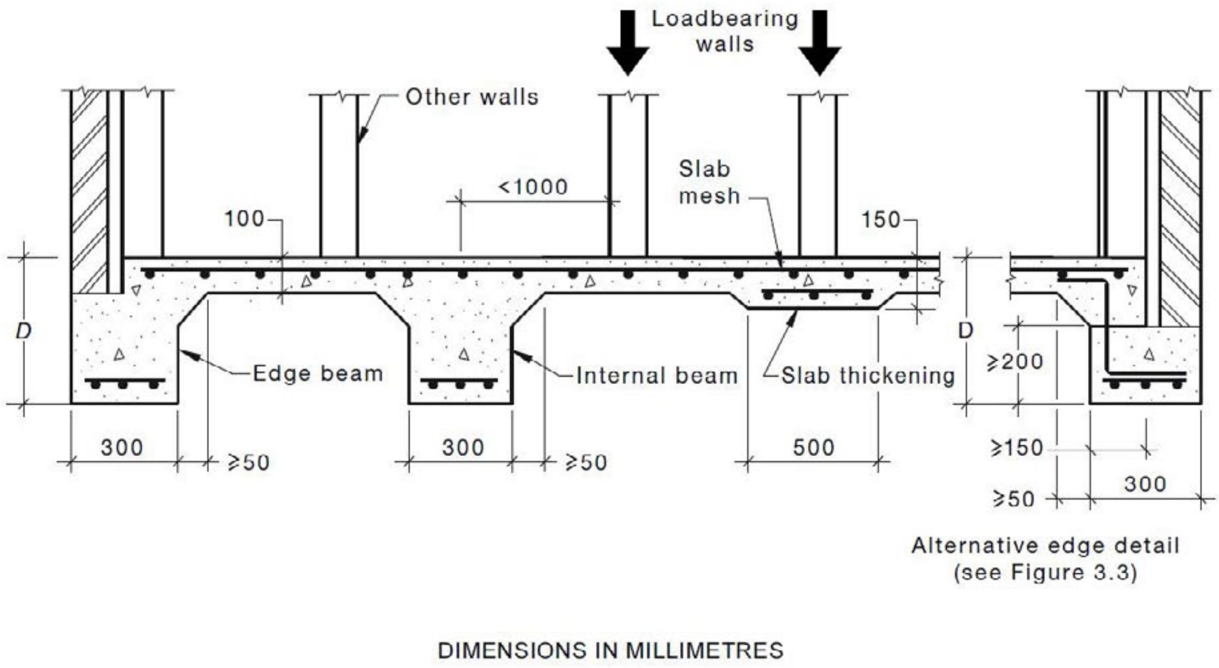


Figure 5.1 – Stiffened raft slab designs: refer Table 5.1

Table 5.1: Stiffened Raft Slab Designs with SENSE 600® TrenchMesh™: refer to Figure 5.1

Site class	Type of Construction	Depth [D] (mm)	Reinforcement				Max Beam Spacing (m)
			Edge Beam Alternatives Bottom		Top Bar Alternatives		
			500 MPa	SENSE 600®	500 MPa	SENSE 600®	
Class S	Masonry veneer	300	3-L11TM	3-S10TM	-	-	-
	Articulated full masonry	500	3-L11TM	3-S10TM	2N12	2S11	-
	Full masonry	700	2 x 3-L11TM	2x3-S10TM	2N16	2S15	5
Class M	Clad frame	300	3-L11TM	3-S10TM	-	-	6
	Articulated masonry veneer	400	3-L11TM	3-S10TM	-	-	6
	Masonry veneer	400	3-L11TM	3-S10TM	-	-	5
	Articulated full masonry	625	3-L11TM	3-S10TM	2N12	2S11	4
	Full masonry	950	2 x 3-L11TM	2x3-S10TM	2N16	2S15	4
Class M-D	Clad frame	400	3-L11TM	3-S10TM	-	-	5
	Articulated masonry veneer	400	3-L11TM	3-S10TM	1N12	1S11	4
	Masonry veneer	500	3-L12TM	3-S11TM	2N12	2S11	4
	Articulated full masonry	650	3-L12TM	3-S11TM	2N16	2S15	4
	Full masonry	1050	2 x 3-L11TM	2x3-S10TM	3N16	3S15	4
Class H1	Clad frame	400	3-L11TM	3-S10TM	-	-	5
	Articulated masonry veneer	400	3-L11TM	3-S10TM	1N12	1S11	4
	Masonry veneer	500	3-L12TM	3-S11TM	3N12	3S11	4
	Articulated full masonry	750	2 x 3- L11TM	2x3-S10TM	2N16	2S15	4
	Full masonry	1050	2 x 3- L12TM	2x3-S11TM	3N16	3S15	4
Class H1-D	Clad frame	400	3-L11TM	3-S10TM	1N12	1N11	4
	Articulated masonry veneer	500	3-L11TM	3-S10TM	2N12	2S11	4
	Masonry veneer	650	2 x 3-L11TM	2x3-S10TM	1N16	1S15	4
	Articulated full masonry	800	2 x 3-L11TM	2x3-S10TM	2N16	2S15	4
	Full masonry	1100	2 x 3-L12TM	2x3-S11TM	3N16	3S15	4
Class H2	Clad frame	550	3-L11TM	3-S10TM	2N12	2S11	4
	Articulated masonry veneer	600	3-L12TM	3-S11TM	2N12	2S11	4
	Masonry veneer	750	2 x 3-L11TM	2x3-S10TM	2N16	2S15	4
	Articulated full masonry	1000	2 x 3-L11TM	2x3-S10TM	2N16	2S15	4
	Full masonry	-	-	-	-	-	-
Class H2-D	Clad frame	550	2 x 3-L11TM	2x3-S10TM	2N16	2S15	4
	Articulated masonry veneer	700	2 x 3-L11TM	2x3-S10TM	2N16	2S15	4
	Masonry veneer	750	2 x 3-L11TM	2x3-S10TM	2N16	2S15	4
	Articulated full masonry	1000	2 x 3-L11TM	2x3-S10TM	2N16	2S15	4
	Full masonry	-	-	-	-	-	-

Note: Slab reinforcement for all Site Classes shall be as noted in AS 2870 for Stiffened Raft Designs, specifically
(a) SL72, where slab length <18m
(b) SL82, where slab length ≥8m and <25
(c) SL92, where slab length ≥25m and <30

5.2 Footing slabs

Footing slabs shall be specified in accordance with Figure 5.2 for Site Class S. SENSE 600® TrenchMesh™ 3-S10TM may be used as an alternative to 3-L11TM.

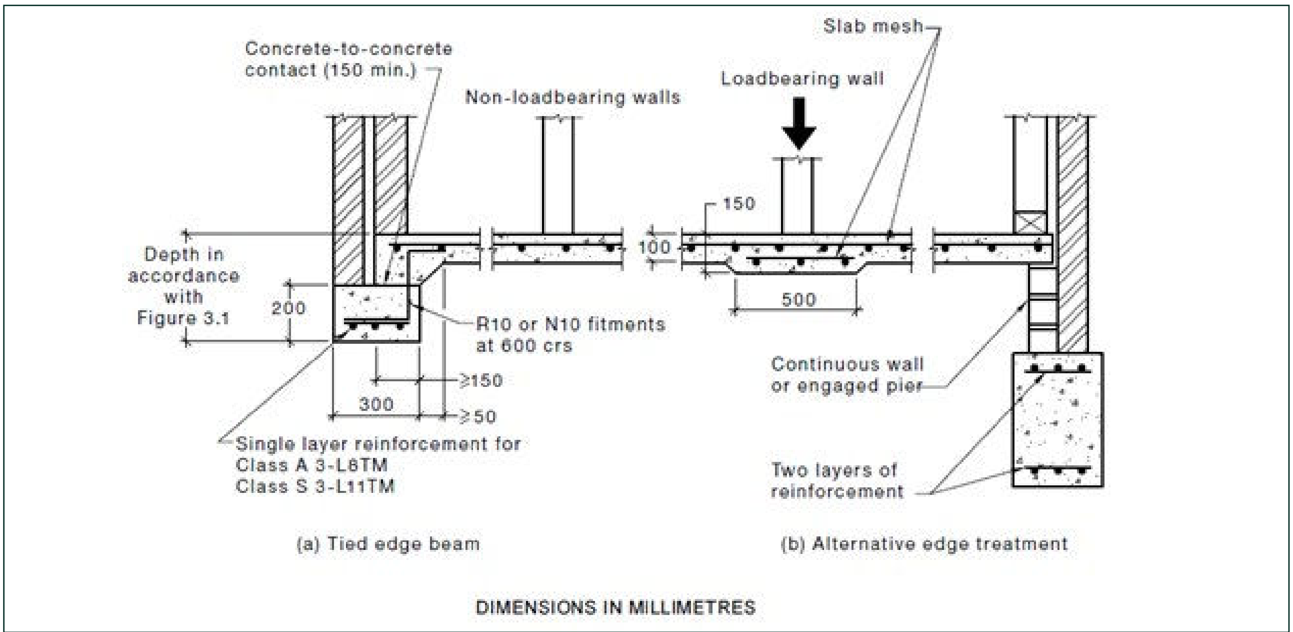


Figure 5.2 – Footing slab for Class S sites for Clad frame, articulated masonry veneer, articulated full masonry or full masonry

5.3 Waffle Rafts

Waffle rafts shall be specified in accordance with AS 2870, Clause 3.4. The concrete section sizes, beam spacing and reinforcement requirements for stiffened rafts shall be as shown in Figure 5.3 and Table 5.3 which includes the SENSE 600® TrenchMesh™ alternatives.

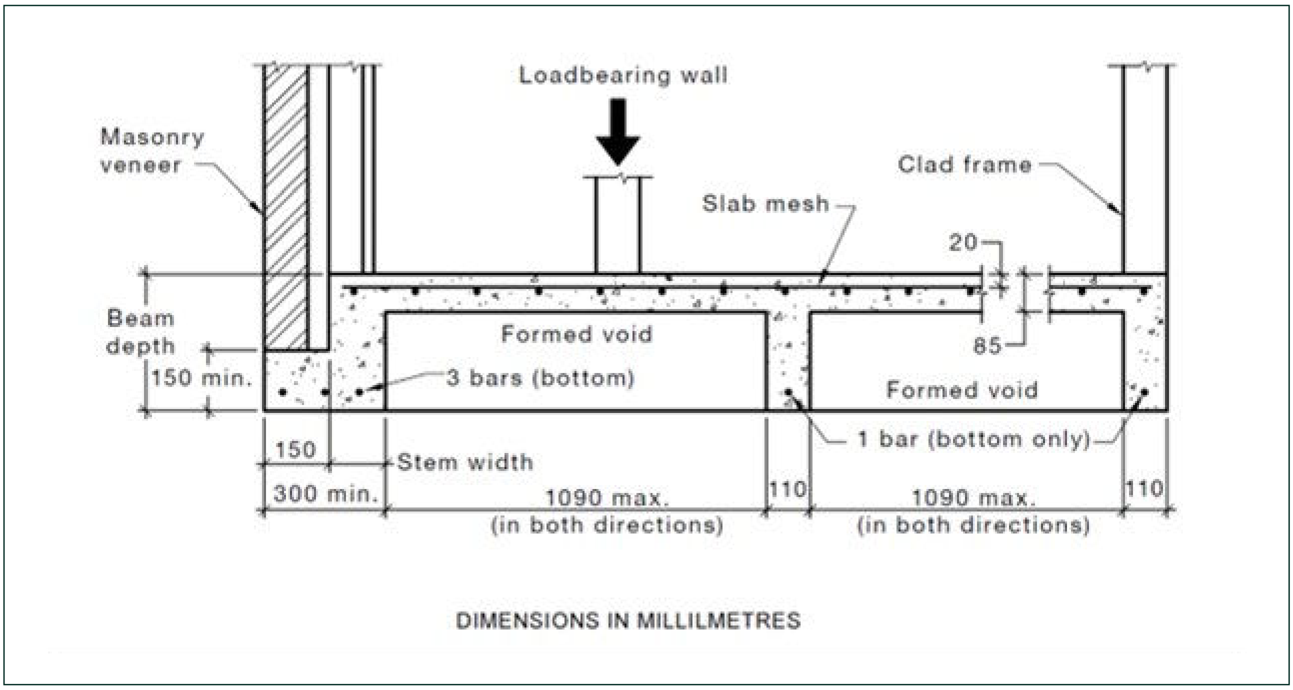


Figure 5.3 – Waffle raft designs: refer Table 4.3

Table 5.3: Waffle Raft Designs with SENSE 600® TrenchMesh™: refer to Figure 5.3

Site class	Type of Construction	Depth [D] (mm)	Bottom Reinforcement				Slab Mesh	
			Edge Beam Alternatives Bottom		Internal Beam Alternatives Top and Bottom		Slab Length (m)	
			500 MPa	SENSE 600®	500 MPa	SENSE 600®	<20	≥20 - <30
Class M	Clad frame	310	3-L11TM	3-S10TM	1N12	1S11	SL72	SL82
	Articulated masonry veneer	310	3-L11TM	3-S10TM	1N12	1S11	SL72	SL82
	Masonry veneer	310	3-L11TM	3-S10TM	1N12	1S11	SL72	SL82
	Articulated full masonry	610	2 x 3-L11TM	2x3-S10TM	1N16	1S15	SL72	SL82
	Full masonry	-	-	-	-	-	-	-
Class M-D	Clad frame	310	3-L11TM	3-S10TM	1N12	1S11	SL72	SL92
	Articulated masonry veneer	310	3-L11TM	3-S10TM	1N12	1S11	SL72	SL92
	Masonry veneer	385	2x3-L11TM	2x3-S10TM	1N16	1S15	SL72	SL92
	Articulated full masonry	610	2x3-L11TM	2x3-S10TM	1N16	1S15	SL72	SL92
	Full masonry	-	-	-	-	-	-	-
Class H1	Clad frame	310	3-L11TM	3-S10TM	1N12	1S11	SL82	SL92
	Articulated masonry veneer	385	3-L11TM	3-S10TM	1N12	1S11	SL82	SL92
	Masonry veneer	460	2 x 3-L11TM	2x3-S10TM	1N16	1S15	SL82	SL92
	Articulated full masonry	610	2 x 3-L11TM	2x3-S10TM	1N16	1S15	SL82	SL92
	Full masonry	-	-	-	-	-	-	-
Class H1-D	Clad frame	310	3-L11TM	3-S10TM	1N12	1S11	SL82	SL92
	Articulated masonry veneer	385	3-L11TM	3-S10TM	1N12	1S11	SL82	SL92
	Masonry veneer	460	2 x 3-L11TM	2x3-S10TM	1N16	1S15	SL82	SL92
	Articulated full masonry	-	-	-	-	-	-	-
	Full masonry	-	-	-	-	-	-	-
Class H2	Clad frame	310	3-L11TM	3-S10TM	2N12	1S11	SL82	SL92
	Articulated masonry veneer	385	2 x 3-L11TM	2x3-S10TM	2N16	1S15	SL82	SL92
	Masonry veneer	-	-	-	-	-	-	-
	Articulated full masonry	-	-	-	-	-	-	-
	Full masonry	-	-	-	-	-	-	-
Class H2-D	Clad frame	385	2 x 3-L11TM	2x3-S10TM	1N16	1S15	SL82	SL92
	Articulated masonry veneer	460	2 x 3-L11TM	2x3-S10TM	1N16	1S15	SL82	SL92
	Masonry veneer	-	-	-	-	-	-	-
	Articulated full masonry	-	-	-	-	-	-	-
	Full masonry	-	-	-	-	-	-	-

5.4 Stiffened slab with deep edge beam

A stiffened slab with a deep edge beam shall be specified in accordance with AS 2870 Clause 3.5. SENSE 600® 3-S10TM TrenchMesh™ may be substituted for the 3-L11TM as shown in Figure 5.4.

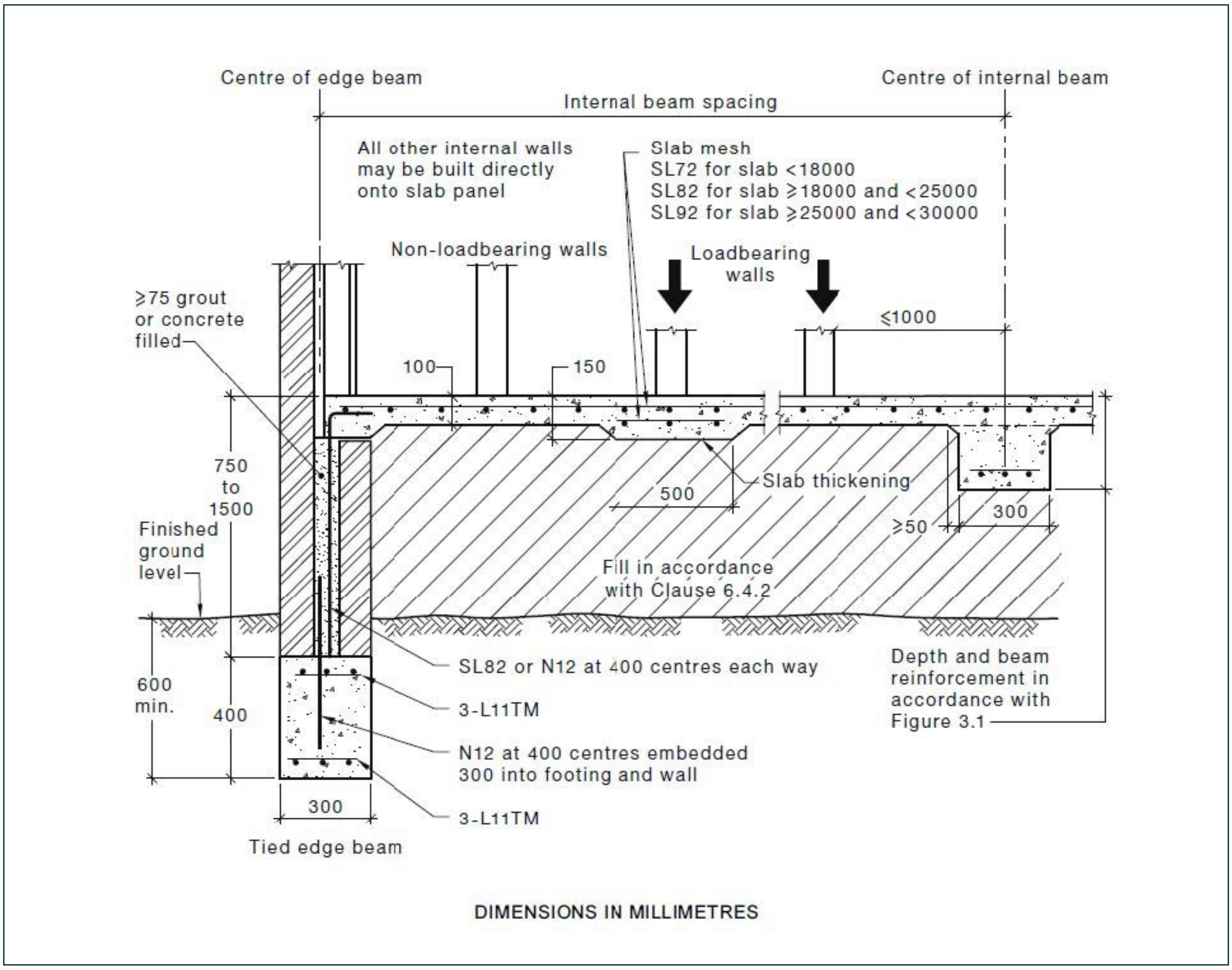


Figure 5.4 – Stiffened slab with deep edge beam for Masonry veneer and articulated masonry veneer with SENSE 600® TrenchMesh™ option - Class M site

5.5 Strip Footings

Strip footings shall be specified in accordance with AS 2870, Clause 3.6. The concrete section sizes, beam spacing and reinforcement requirements for strip footings shall be as shown in Figure 5.5 and Table 5.5 which includes the SENSE 600® TrenchMesh™ alternatives.

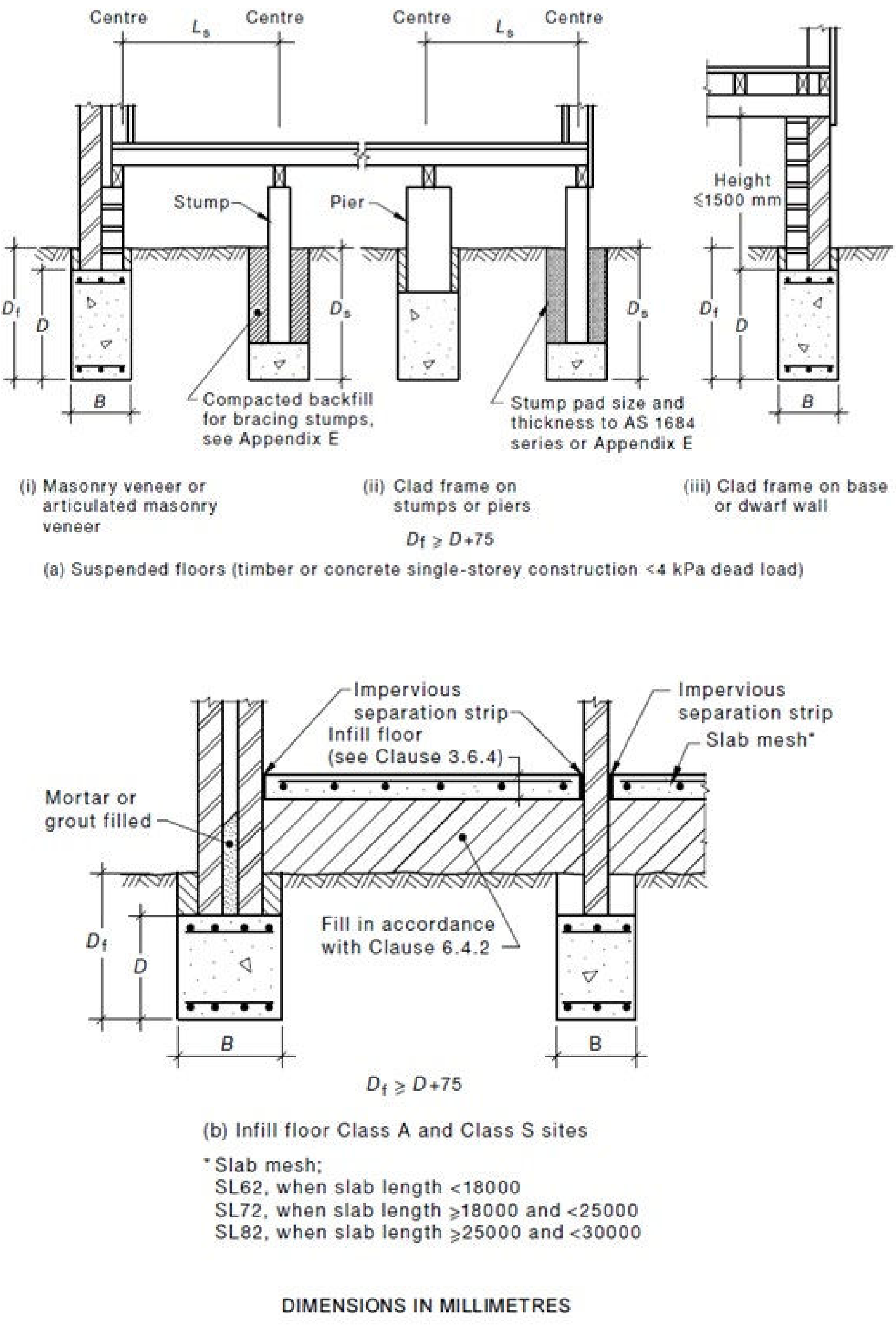


Figure 5.5 – Strip footing systems: refer Table 5.4

Table 5.5: Strip footing with SENSE 600® TrenchMesh™ Option: refer to Figure 5.4							
Site class	Type of Construction	Depth [*D*] (mm)	Width [*B*] (mm)	Reinforcement Alternatives		D_f (mm)	L_s (mm)
				500 MPa	SENSE 600®		
Class S	Articulated masonry veneer	400	400	4-L11TM	4-S10TM	400	-
	Full masonry	500	400	4-L11TM	4-S10TM	400	-
Class M	Clad frame	400	300	3-L11TM	3-S10TM	500	-
	Articulated masonry veneer	450	300	3-L11TM	3-S10TM	500	-
	Masonry veneer	500	300	3-L12TM	3-S11TM	500	-
	Articulated full masonry	600	400	4-L12TM	4-S11TM	500	-
	Full masonry	900	400	4-L12TM	4-S11TM	500	-
Class M-D	Clad frame	500	300	3-L11TM	3-S10TM	800	-
	Articulated masonry veneer	550	300	3-L12TM	3-S10TM	800	-
	Masonry veneer	700	300	3N16	3-S15TM	800	-
	Articulated full masonry	1100	400	4N16	4-S15TM	800	-
Class H1	Clad frame	500	300	3-L11TM	3-S10TM	1000	≥2400
	Articulated masonry veneer	600	300	3-L12TM	3-S11TM	1000	≥2400
	Masonry veneer	850	300	3N16	3-S15TM	1000	≥2400
	Articulated full masonry	1100	400	4N16	4-S15TM	1000	≥2400

3-S15TM may be substituted for three individual S15 bars
4-S15TM may be substituted for four individual S15 bars

6. Appendix A – Strength and ductility calculations

HB28 refers to the sagging mode which induces positive moments in footing systems and a hogging mode which induces negative moments. This same convention is adopted for consistency. Similarly, the HB28 nomenclature for the area of steel to reinforce the footing under sagging A_{st} and area of steel to reinforce the footing under hogging A_{sc} is also adopted for consistency.

A1.1 Sagging Mode (M_u^+)

Consider Figure A.1.1 below for the ultimate positive bending moment strength for stiffened raft slabs, waffle raft slabs and strip footings. The ultimate moment can be determined using the formula:

$$M_u^+ = A_{st} \times f_{sy} \times L \qquad \text{Eq. A.1.1}$$

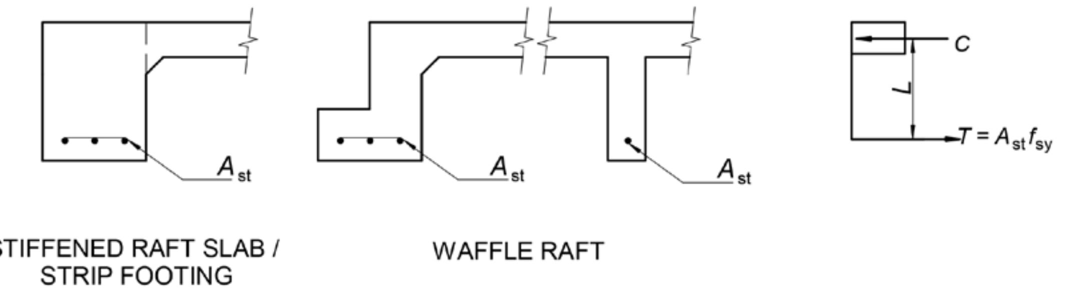


Figure A.1.1 – Ultimate bending moment strength in sagging mode – M_u^+

For the deemed-to-comply designs in AS 2870

$$M_{u(500)}^+ = A_{st(500)} \times 500 \times L \qquad \text{Eq. A.1.2}$$

However, if equivalent load capacity SENSE 600® TrenchMesh™ is used in place of 500L trench mesh or bar then

$$M_{u(\text{SENSE 600®})}^+ = A_{st(\text{SENSE 600®})} \times 600 \times L \qquad \text{Eq. A.1.3}$$

However, from Table 2a

$$A_{st(\text{SENSE 600®})} \times 600 \geq A_{st(500)} \times 500 \qquad \text{Eq. A.1.4}$$

Substituting Eq. A.1.4 into Eq. A.1.3 gives

$$M_{u(\text{SENSE 600®})}^+ = A_{st(500)} \times 500 \times L \qquad \text{Eq. A.1.5}$$

And substituting Eq. A.1.2 into Eq. A.1.5 gives

$$M_{u(\text{SENSE 600®})}^+ \geq M_{u(500)} \qquad \text{Eq. A.1.6}$$

Therefore

$$M_{u(\text{Performance Solution})}^+ \geq M_{u(\text{deemed-to-comply})} \qquad \text{Eq. A.1.7}$$

Thus, the ultimate positive moment capacity (M_u) of a footing is essentially the same, and in some cases higher, if the 500L trench mesh is replaced by equivalent capacity SENSE 600® TrenchMesh™. It is noted that the lever arm (L) is slightly longer for the SENSE 600® TrenchMesh™ as the bar is smaller in diameter and hence the ultimate sagging moment is slightly higher, however this improvement is, at best 0.7 mm, which is significantly less than the accuracy with which the steel can be fixed and therefore has been ignored.

A.1.2 Hogging Mode (M_u)

The ultimate negative bending moment strength for stiffened raft slabs, waffle raft slabs and strip footings were treated separately as the reinforcing steel layout differs for each, unlike the reinforcing steel for sagging moments.

In a strip footing the calculation for the negative moment is identical to the sagging moment, given the section is symmetrical about the horizontal axis. Therefore, the substitution of SENSE 600® TrenchMesh™ for 500 MPa trench mesh or bar has the same performance in terms of its ultimate bending moment strength.

The slab reinforcement, in the Performance Solutions for the waffle raft slabs, is changed therefore the ultimate negative moment strength is not changed. Therefore, the Performance Solution is equal to, if not better than the deemed-to-comply solution.

For the stiffened raft Performance Solutions where there are additional top bars, refer to Figure A. 1. 2 the ultimate moment can be determined by the following formula.

$M_u^- = A_{sc(mesh)} \times f_{sy(mesh)} \times L_1 + A_{sc(bar)} \times f_{sy(bar)} \times L_2$ Eq. A.1.8

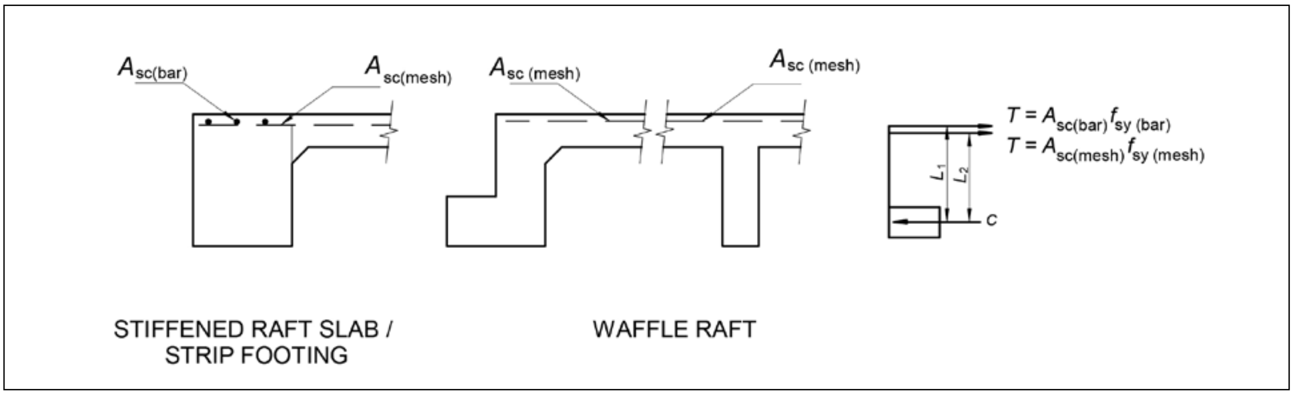


Figure A.1.2 – Ultimate bending moment strength in hogging mode (M_u^-)

For the deemed-to-comply designs in AS 2870

$M^-_{u(500)} = A_{sc(mesh)} \times 500 \times L_1 + A_{sc(500)} \times 500 \times L_2$ Eq. A.1.9

If equivalent load capacity SENSE 600® TrenchMesh™ or bar is used in place of 500 MPa trench mesh or bar, then

$M^-_{u(SENSE\ 600®)} = A_{sc\ (mesh)} \times 500 \times L_1 + A_{sc(SENSE\ 600®)} \times 600 \times L_2$ Eq. A.1.10

However, from Table 2a

$A_{sc(SENSE\ 600®)} \times 600 \geq A_{sc(500)} \times 500$ Eq. A.1.11

Substituting Eq. A.1.11 into Eq. A.1.10 gives

$M^-_{u(SENSE\ 600®)} \geq A_{sc\ (mesh)} \times 500 \times L_1 + A_{sc(500)} \times 500 \times L_2$ Eq. A.1.12

And substituting Eq. A.1.9 into Eq. A.1.12 gives

$M^-_{u(SENSE\ 600®)} \geq M^-_{u(500)}$ Eq. A.1.13

Thus, the ultimate negative moment capacity (M_u) of a stiffened raft footing is essentially the same or in some cases higher if the 500N bar is replaced by equivalent capacity SENSE 600® bar. The lever arm (L) is slightly longer for the SENSE 600® as the bar is smaller in diameter and hence the ultimate negative moment is slightly higher but has been ignored because of its insignificance as discussed previously.

A.2 Footing Ductility

A ductile steel means that the load in a cracked zone has a greater capacity of being transferred to a stiffer uncracked zone. Therefore, the performance of a beam is generally improved if a more ductile steel is used in place of a low ductility steel. SENSE 600® TrenchMesh™ is a Ductility Class N steel and has superior ductility to 500L trench mesh and therefore will provide improved performance.

Member ductility is important when the cracking moment (M_{cr}) of the section is exceeded, as the reinforcement is designed to carry the load. The deemed-to-comply designs in AS 2870 have ultimate moment (M_u) capacities that meet the ductility requirement, that is:

$$M_u > 1.2\, M_{cr} \qquad \text{Eq. A.2.1}$$

HB28 provides the following formulae to determine the section properties of a footing. Refer to Figure A.2 for the notations. For an uncracked T or L footing beam section the depth to the neutral axis is given by:

$$kd = \left[\frac{(b-b_w)t}{2} + \left(\frac{b_w D^2}{2}\right)\right] / \left[\,(b - b_w)t + b_{wD}\,\right] \qquad \text{Eq. A.2.2}$$

Hence the gross moment of inertia (I_g) of the footing beam is given by:

$$I_g=\left[(b-b_w)t\,\left(kd - \frac{t}{2}\right)^2 + \frac{(b-b_w)t^3}{12}\right] + \left[b_w D\,\left(kd - \frac{D}{2}\right)^2 + \left(b_w\frac{D^3}{12}\right)\right] \qquad \text{Eq. A.2.3}$$

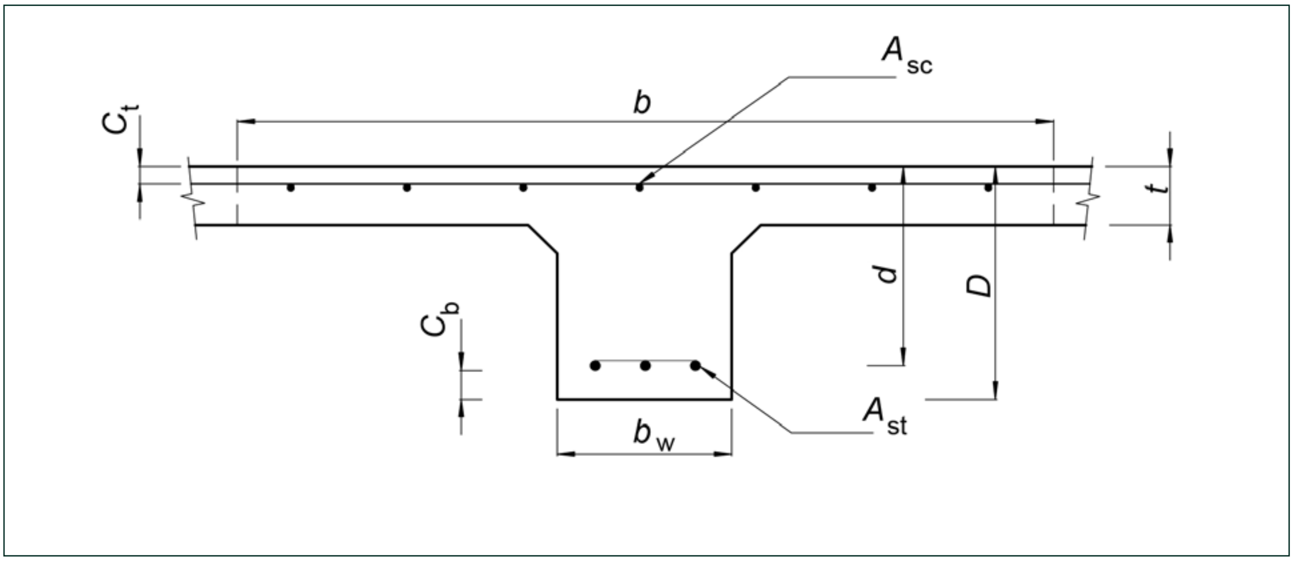


Figure A2 – Notation for T beam

The section modulus for calculating the cracking moments is obtained from the uncracked moment of inertia (I) as follows:

$Z_c = I_g/kd$ (hogging) Eq. A.2.4

$Z_t = I_g/(D\text{-}kd)$ (sagging) Eq. A.2.5

HB28 indicates the cracking moments in deemed-to-comply designs were calculated using a concrete stress of 2.7 MPa for cracking at the bottom of the section due to sagging and 1.8 MPa at the top to allow for the restrained shrinkage in top slab panels. The calculated cracking moments are:

$M_{cr(hogging)} = I_g/kd \times 1.8$ Eq. A.2.6

$M_{cr(sagging)} = I_g/(D\text{-}kd) \times 2.7$ Eq. A.2.7

The cracking moment is a function of the overall concrete dimensions which are not changed in the Performance Solutions. Given the uncracked section properties are not dependent on the yield strength of the steel (f_{sy}) nor the area of bottom steel (A_{st}) or the top steel (A_{sc}), the substitution of SENSE 600® TrenchMesh™ and SENSE 600® bar for 500L trench mesh and 500N bar respectively, does not alter the uncracked section properties of the footing system. That is,

$M_{cr(600N)} = M_{cr(deemed\text{-}to\text{-}comply)}$ Eq. A.2.8

It is clear from Section 3.1 the substitution of equivalent capacity SENSE 600® TrenchMesh™ for 500L trench mesh and SENSE 600® bar for 500N bar results in footing systems that have the same performance in terms of the ultimate bending moment strength, both sagging and hogging. If the dimensions of the concrete section do not change then the gross section properties of the section do not change and hence the M_{cr} does not change. That is

$M_{u(600N)} = M_{u(deemed\text{-}to\text{-}comply)}$ Eq. A.2.9

If

$M_{u(deemed\text{-}to\text{-}comply)} > 1.2 \times M_{cr(deemed\text{-}to\text{-}comply)}$ Eq. A.2.9

Then

$M_{u(600N)} > 1.2 \times M_{cr(600N)}$ Eq 3.2.10

Therefore, the section ductility of the footings with SENSE 600® TrenchMesh™ or SENSE 600® bar is equivalent in performance to a deemed-to-comply design in AS 2870.

7. Appendix B – Stiffness Calculations

This Appendix tabulates the results of stiffness calculations for each of the SENSE 600® TrenchMesh™ and bar footing systems compared with its corresponding deemed-to-comply 500L footing systems from AS 2870. The calculations follow the method described in Section 3.3 AS2870, Footing System Stiffness.

Table B1 – Stiffness Summary

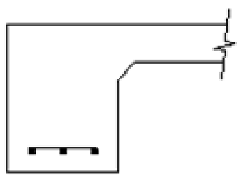
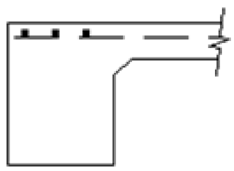
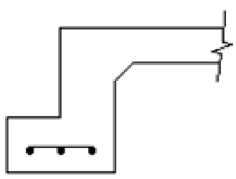
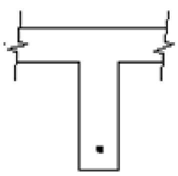
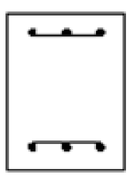
Table No.	Description	Diagram	Comment
B1	Stiffened raft slabs – sagging mode		Stiffness for the edge beams only was considered, as the smaller effective width (compare to the internal beams) gives the lowest comparative stiffness when SENSE 600® TrenchMesh™ is used in place of 500L trench mesh.
B2	Stiffened raft slabs – hogging mode		A slab reinforced with SL72 mesh was considered the critical case in combination with additional top bars as this this gives the lowest comparative stiffness when SENSE 600® TrenchMesh™ is used in place of 500N bars.
B3	Waffle raft slab – edge beamsagging mode		Only the sagging mode in waffle raft slabs was considered, as the reinforcing steel in the slab which impacts the hogging mode is not changed in the Performance Solution compared with the deemed-to-comply designs.
B4	Waffle raft slab – internal beam sagging mode		
B5	Strip footing – sagging and hogging mode		The stiffness of the footing in the sagging mode is the same as the hogging mode as the footing is symmetrical about the horizontal plane.

Table B2 – Stiffened Raft Slabs Comparison of Effective Moments of Inertia (I_{eff}) Sagging Mode

Site Class	Type of Construction	Depth [D] (mm)	Bottom Reinforcement		I_g (mm^6)	M_{tc} (kNm)	M_{ut} (kNm)	M_s (kNm)	500L trench mesh		SENSE 600® TrenchMesh™		$I_{eff(600)}$/ $I_{eff(500)}$ (%)
			500L trench mesh	SENSE 600® TrenchMesh™					I_{cr} (mm^6)	$I_{eff\ (500)}$ (mm^6)	I_{cr} (mm^6)	$I_{eff(600)}$ (mm^6)	
Class S	Masonry veneer	300	3-L11TM	3-S10TM	1.41E+09	17.5	24.4	16.3	1.83E+08	3.00E+09	1.83E+08	3.00E+09	98
	Articulated full masonry	500	3-L11TM	3-S10TM	6.45E+09	48.6	59.9	39.9	1.00E+09	1.68E+10	9.48E+08	1.69E+10	100
	Full masonry	700	2x3-L11TM	2x3-S10TM	1.72E+10	95.2	172.1	114.7	2.78E+09	1.62E+10	2.58E+09	1.60E+10	98
Class M	Clad frame	300	3-L11TM	3-S10TM	1.41E+09	17.5	32.9	21.9	1.83E+08	1.32E+09	1.83E+08	1.31E+09	98
	Articulated masonry veneer	400	3-L11TM	3-S10TM	3.32E+09	31.0	46.4	30.9	3.87E+08	5.04E+09	3.87E+08	5.04E+09	100
	Masonry veneer	400	3-L11TM	3-S10TM	3.32E+09	31.0	46.4	30.9	3.87E+08	5.04E+09	3.87E+08	5.04E+09	100
	Articulated full masonry	625	3-L11TM	3-S10TM	1.24E+10	76.0	76.8	51.2	1.72E+09	5.96E+10	1.63E+09	6.00E+10	100
	Full masonry	950	2x3-L11TM	2x3-S10TM	4.08E+10	172.8	239.6	159.7	5.69E+09	8.29E+10	5.27E+09	8.32E+10	100
Class M-D	Clad frame	400	3-L11TM	3-S10TM	3.32E+09	31.0	46.4	30.9	3.87E+08	5.04E+09	3.87E+08	5.04E+09	100
	Articulated masonry veneer	400	3-L11TM	3-S10TM	3.32E+09	31.0	46.4	30.9	4.82E+08	5.04E+09	4.66E+08	5.04E+09	100
	Masonry veneer	500	3-L12TM	3-S11TM	6.45E+09	48.6	73.9	49.3	1.00E+09	9.23E+09	9.48E+08	9.23E+09	100
	Articulated full masonry	650	3-L12TM	3-S11TM	1.39E+10	82.2	99.0	66.0	2.33E+09	3.97E+10	2.17E+09	4.00E+10	100
	Full masonry	1050	2x3-L11TM	2x3-S10TM	5.4E+10	209.5	266.6	177.7	8.68E+09	1.43E+11	7.93E+09	1.44E+11	100
Class H1	Clad frame	400	3-L11TM	3-S10TM	3.32E+09	31.0	46.4	30.9	3.87E+08	5.04E+09	3.87E+08	5.04E+09	100
	Articulated masonry veneer	400	3-L11TM	3-S10TM	3.32E+09	31.0	46.4	30.9	4.82E+08	5.04E+09	4.66E+08	5.04E+09	100
	Masonry veneer	500	3-L11TM	3-S10TM	6.45E+09	48.6	73.9	49.3	1.15E+09	9.23E+09	1.07E+09	9.23E+09	100
	Articulated full masonry	750	2x3-L11TM	2x3-S10TM	2.09E+10	109.0	185.6	123.7	3.28E+09	2.33E+10	3.04E+09	2.31E+10	99
	Full masonry	1050	2x3-L12TM	2x3-S11TM	5.4E+10	209.5	266.2	177.5	8.68E+09	1.43E+11	7.93E+09	1.44E+11	100
Class H1-D	Clad frame	400	3-L11TM	3-S10TM	3.32E+09	31.0	46.4	30.9	4.82E+08	5.04E+09	4.66E+08	5.04E+09	100
	Articulated masonry veneer	500	3-L11TM	3-S10TM	6.45E+09	48.6	59.9	39.9	1.00E+09	1.68E+10	9.48E+08	1.69E+10	100
	Masonry veneer	650	2x3-L11TM	2x3-S10TM	1.39E+10	82.2	158.6	105.7	1.82E+09	1.11E+10	1.73E+09	1.09E+10	97
	Articulated full masonry	800	2x3-L11TM	2x3-S10TM	2.51E+10	123.7	199.1	132.7	3.82E+09	3.28E+10	3.54E+09	3.27E+10	99
	Full masonry	1100	2x3-L12TM	2x3-S11TM	6.15E+10	229.1	345.9	230.6	9.66E+09	1.01E+11	8.82E+09	9.93E+10	98
Class H2	Clad frame	550	3-L11TM	3-S10TM	8.54E+09	58.9	66.6	44.4	1.26E+09	2.88E+10	1.20E+09	2.90E+10	100
	Articulated masonry veneer	600	3-L12TM	3-S11TM	1.1E+10	70.1	90.6	60.4	1.56E+09	2.53E+10	1.48E+09	2.54E+10	100
	Masonry veneer	750	2x3-L11TM	2x3-S10TM	2.09E+10	109.0	185.6	123.7	3.28E+09	2.33E+10	3.04E+09	2.31E+10	99
	Articulated full masonry	1000	2x3-L11TM	2x3-S10TM	4.71E+10	190.8	253.1	168.7	6.40E+09	1.10E+11	5.93E+09	1.10E+11	100
	Full masonry	-	-	-			-	-		-		-	
Class H2-D	Clad frame	550	2x3-L11TM	2x3-S10TM	8.54E+09	58.9	131.6	87.7	1.55E+09	4.90E+09	1.44E+09	4.73E+09	95
	Articulated masonry veneer	700	2x3-L11TM	2x3-S10TM	1.72E+10	95.2	172.1	114.7	2.78E+09	1.62E+10	2.58E+09	1.60E+10	98
	Masonry veneer	750	2x3-L11TM	2x3-S10TM	2.09E+10	109.0	185.6	123.7	3.28E+09	2.33E+10	3.04E+09	2.31E+10	99
	Articulated full masonry	1000	2x3-L11TM	2x3-S10TM	4.71E+10	190.8	253.1	168.7	6.40E+09	1.10E+11	5.93E+09	1.10E+11	100

Table B3 – Stiffened Raft Slabs Comparison of Effective Moments of Inertia (I_{eff}) Hogging Mode

Site Class	Type of Construction	Depth [D] (mm)	Top Reinforcement + SL72		I_g (mm⁶)	M_{tc} (kNm)	M_{ut} (kNm)	M_s (kNm)	500N Bar		SENSE 600® Bar		$I_{eff(600)}$/ $I_{eff(500)}$ (%)
			500N Bar	SENSE 600® Bar					I_{cr} (mm^6)	$I_{eff(500)}$ (mm^6)	I_{cr} (mm^6)	$I_{eff(600)}$ (mm^6)	
Class S	Masonry veneer	300	-	-	1.41E+09	29.7	40.9	27.3	1.83E+08	1.76E+09	1.83E+08	1.76E+09	100
	Articulated full masonry	500	2N12	2S11	6.45E+09	80.3	121.9	81.2	1.00E+09	6.27E+09	9.48E+08	6.27E+09	100
	Full masonry	700	2N16	2S15	1.72E+10	142.4	230.7	153.8	2.78E+09	1.42E+10	2.58E+09	1.42E+10	100
Class M	Clad frame	300	-	-	1.41E+09	29.7	40.9	27.3	1.83E+08	1.76E+09	1.83E+08	1.76E+09	100
	Articulated masonry veneer	400	-	-	3.32E+09	53.1	58.8	39.2	3.87E+08	7.67E+09	3.87E+08	7.67E+09	100
	Masonry veneer	400	-	-	3.32E+09	53.1	58.8	39.2	3.87E+08	7.67E+09	3.87E+08	7.67E+09	100
	Articulated full masonry	625	2N12	2S11	1.24E+10	118.1	158.4	105.6	1.72E+09	1.67E+10	1.63E+09	1.67E+10	100
	Full masonry	950	2N16	2S15	4.08E+10	230.9	325.4	216.9	5.69E+09	4.80E+10	5.27E+09	4.81E+10	100
Class M-D	Clad frame	400	-	-	3.32E+09	53.1	58.8	39.2	3.87E+08	7.67E+09	3.87E+08	7.67E+09	100
	Articulated masonry veneer	400	1N12	1S11	3.32E+09	53.1	76.1	50.7	4.82E+08	3.74E+09	4.66E+08	3.74E+09	100
	Masonry veneer	500	2N12	2S11	6.45E+09	80.3	121.9	81.2	1.00E+09	6.27E+09	9.48E+08	6.27E+09	100
	Articulated full masonry	650	2N16	2S15	1.39E+10	126.1	211.7	141.1	2.33E+09	1.06E+10	2.17E+09	1.05E+10	100
	Full masonry	1050	3N16	3S15	5.40E+10	269.4	454.4	302.9	8.68E+09	4.06E+10	7.93E+09	4.03E+10	99
Class H1	Clad frame	400	-	-	3.32E+09	53.1	58.8	39.2	3.87E+08	7.67E+09	3.87E+08	7.67E+09	100
	Articulated masonry veneer	400	1N12	1S11	3.32E+09	53.1	76.1	50.7	4.82E+08	3.74E+09	4.66E+08	3.74E+09	100
	Masonry veneer	500	3N12	3S11	6.45E+09	80.3	143.5	95.6	1.15E+09	4.29E+09	1.07E+09	4.26E+09	99
	Articulated full masonry	750	2N16	2N15	2.09E+10	159.1	249.6	166.4	3.28E+09	1.87E+10	3.04E+09	1.87E+10	100
	Full masonry	1050	3N16	3N15	5.40E+10	269.4	454.4	302.9	8.68E+09	4.06E+10	7.93E+09	4.03E+10	99
Class H1-D	Clad frame	400	1N12	1S11	3.32E+09	53.1	76.1	50.7	4.82E+08	3.74E+09	4.66E+08	3.74E+09	100
	Articulated masonry veneer	500	2N12	2S11	6.45E+09	80.3	121.9	81.2	1.00E+09	6.27E+09	9.48E+08	6.27E+09	100
	Masonry veneer	650	1N16	1S15	1.39E+10	126.1	158.6	105.8	1.82E+09	2.22E+10	1.73E+09	2.23E+10	100
	Articulated full masonry	800	2N16	2S15	2.51E+10	176.4	268.6	179.0	3.82E+09	2.42E+10	3.54E+09	2.42E+10	100
	Full masonry	1100	3N16	3S15	6.15E+10	289.4	478.3	318.9	9.66E+09	4.84E+10	8.82E+09	4.82E+10	100
Class H2	Clad frame	550	2N12	2S11	8.54E+09	95.0	136.5	91.0	1.26E+09	9.55E+09	1.20E+09	9.56E+09	100
	Articulated masonry veneer	600	2N12	2S11	1.10E+10	110.3	151.1	100.7	1.56E+09	1.40E+10	1.48E+09	1.40E+10	100
	Masonry veneer	750	2N16	2S15	2.09E+10	159.1	249.6	166.4	3.28E+09	1.87E+10	3.04E+09	1.87E+10	100
	Articulated full masonry	1000	2N16	2S15	4.71E+10	249.9	344.4	229.6	6.40E+09	5.89E+10	5.93E+09	5.91E+10	100
	Full masonry	-	-	-	-	-	-	-	-	-	-	-	
Class H2-D	Clad frame	550	2N16	2S15	8.54E+09	95.0	173.8	115.9	1.55E+09	5.40E+09	1.44E+09	5.35E+09	99
	Articulated masonry veneer	700	2N16	2S15	1.72E+10	142.4	230.7	153.8	2.78E+09	1.42E+10	2.58E+09	1.42E+10	100
	Masonry veneer	750	2N16	2S15	2.09E+10	159.1	249.6	166.4	3.28E+09	1.87E+10	3.04E+09	1.87E+10	100
	Articulated full masonry	1000	2N16	2S15	4.71E+10	249.9	344.4	229.6	6.40E+09	5.89E+10	5.93E+09	5.91E+10	100

Table B4 – Waffle Raft Slab Comparison of Effective Moments of Inertia (I_{eff}) Edge Beam Sagging Modes

Site Class	Type of Construction	Depth [D] (mm)	Bottom Reinforcement		I_g (mm^6)	M_{tc} (kNm)	M_{ut} (kNm)	M_s (kNm)	500L Trench Mesh		SENSE 600® TrenchMesh™		$I_{eff(600)}$/ $I_{eff(500)}$ (%)
			500L	SENSE 600®					I_{cr} (mm^6)	$I_{eff(500)}$ (mm^6)	I_{cr} (mm^6)	$I_{eff(600)}$ (mm^6)	
Class M	Clad frame	310	3-L11TM	3-S10TM	1.08E+09	15.6	33.6	22.4	1.79E+08	4.85E+08	1.53E+08	4.66E+08	96
	Articulated masonry veneer	310	3-L11TM	3-S10TM	1.08E+09	15.6	33.6	22.4	1.79E+08	4.85E+08	1.52E+08	4.69E+08	97
	Masonry veneer	310	3-L11TM	3-S10TM	1.08E+09	15.6	33.6	22.4	1.79E+08	4.85E+08	1.51E+08	4.72E+08	97
	Articulated full masonry	610	2X3-L11TM	2X3-S10TM	7.65E+09	59.4	146.6	97.7	1.72E+09	3.05E+09	1.45E+09	2.86E+09	94
	Full masonry	-	-	-	-	-	-	-	-	-	-	-	-
Class M-D	Clad frame	310	3-L11TM	3-S10TM	1.08E+09	15.6	33.6	22.4	1.79E+08	4.85E+08	1.47E+08	4.82E+08	99
	Articulated masonry veneer	310	3-L11TM	3-S10TM	1.08E+09	15.6	33.6	22.4	1.79E+08	4.85E+08	1.46E+08	4.85E+08	100
	Masonry veneer	385	2X3-L11TM	2X3-S10TM	2.03E+09	24.1	85.9	57.2	5.64E+08	6.74E+08	4.63E+08	5.88E+08	87
	Articulated full masonry	610	2X3-L11TM	2X3-S10TM	7.65E+09	59.4	146.6	97.7	1.72E+09	3.05E+09	1.42E+09	2.88E+09	94
	Full masonry	-	-	-	-	-	-	-	-	-	-	-	-
Class H1	Clad frame	310	3-L11TM	3-S10TM	1.08E+09	15.6	33.6	22.4	1.79E+08	4.85E+08	1.41E+08	4.99E+08	100
	Articulated masonry veneer	385	3-L11TM	3-S10TM	2.03E+09	24.1	43.7	29.1	3.10E+08	1.28E+09	2.46E+08	1.36E+09	100
	Masonry veneer	460	2X3-L11TM	2X3-S10TM	3.40E+09	34.2	106.1	70.7	8.77E+08	1.16E+09	7.05E+08	1.04E+09	89
	Articulated full masonry	610	2X3-L11TM	2X3-S10TM	7.65E+09	59.4	146.6	97.7	1.72E+09	3.05E+09	1.40E+09	2.90E+09	95
	Full masonry	-	-	-	-	-	-	-	-	-	-	-	-
Class H1-D	Clad frame	310	3-L11TM	3-S10TM	1.08E+09	15.6	33.6	22.4	1.79E+08	4.85E+08	1.35E+08	5.19E+08	100
	Articulated masonry veneer	385	3-L11TM	3-S10TM	2.03E+09	24.1	43.7	29.1	3.10E+08	1.28E+09	2.38E+08	1.41E+09	100
	Masonry veneer	460	2X3-L11TM	2X3-S10TM	3.40E+09	34.2	106.1	70.7	8.77E+08	1.16E+09	6.86E+08	1.04E+09	89
	Articulated full masonry	-	-	-	-	-	-	-	-	-	-	-	-
	Full masonry	-	-	-	-	-	-	-	-	-	-	-	-
Class H2	Clad frame	310	3-L11TM	3-S10TM	1.08E+09	15.6	33.6	22.4	1.79E+08	4.85E+08	1.29E+08	5.42E+08	100
	Articulated masonry veneer	385	2X3-L11TM	2X3-S10TM	2.03E+09	24.1	85.9	57.2	5.64E+08	6.74E+08	4.21E+08	5.68E+08	84
	Masonry veneer	-	-	-	-	-	-	-	-	-	-	-	-
	Articulated full masonry	-	-	-	-	-	-	-	-	-	-	-	-
	Full masonry	-	-	-	-	-	-	-	-	-	-	-	-
Class H2-D	Clad frame	385	2X3-L11TM	2X3-S10TM	2.03E+09	24.1	85.9	57.2	5.64E+08	6.74E+08	4.09E+08	5.64E+08	84
	Articulated masonry veneer	460	2X3-L11TM	2X3-S10TM	3.40E+09	34.2	106.1	70.7	8.77E+08	1.16E+09	6.52E+08	1.03E+09	89

Table B5 – Waffle Raft Slab Comparison of Effective Moments of Inertia (I_{eff}) Internal Beam Hogging Modes

Site Class	Type of Construction	Depth [D] (mm)	Bottom Reinforcement		I_g (mm⁶)	M_{tc} (kNm)	M_{ut} (kNm)	M_s (kNm)	500N		SENSE 600®		$I_{eff(600)}$/ $I_{eff(500)}$ (%)
			500N Bar	SENSE 600® Bar					I_{cr} (mm⁶)	$I_{eff(500)}$ (mm⁶)	I_{cr} (mm⁶)	$I_{eff(600)}$ (mm⁶)	
Class M	Clad frame	310	1N12	1S11	6.16E+08	7.1	14.3	9.5	8.46E+07	3.05E+08	7.17E+07	2.96E+08	97
	Articulated masonry veneer	310	1N12	1S11	6.16E+08	7.1	14.3	9.5	8.46E+07	3.05E+08	7.11E+07	2.99E+08	98
	Masonry veneer	310	1N12	1S11	6.16E+08	7.1	14.3	9.5	8.46E+07	3.05E+08	7.05E+07	3.01E+08	99
	Articulated full masonry	610	1N16	1S15	4.58E+09	27.7	55.4	37.0	7.24E+08	2.34E+09	6.06E+08	2.28E+09	97
	Full masonry	-	-	-	-	-	-	-	-	-	-	-	-
Class M-D	Clad frame	310	1N12	1S11	6.16E+08	7.1	14.3	9.5	8.46E+07	3.05E+08	6.88E+07	3.09E+08	100
	Articulated masonry veneer	310	1N12	1S11	6.16E+08	7.1	14.3	9.5	8.46E+07	3.05E+08	6.82E+07	3.11E+08	100
	Masonry veneer	385	1N16	1S15	1.18E+09	11.0	32.8	21.9	2.46E+08	3.64E+08	2.00E+08	3.30E+08	91
	Articulated full masonry	610	1N16	1S15	4.58E+09	27.7	55.4	37.0	7.24E+08	2.34E+09	5.95E+08	2.32E+09	99
	Full masonry	-	-	-	-	-	-	-	-	-	-	-	-
Class H1	Clad frame	310	1N12	1S11	6.16E+08	7.1	14.3	9.5	8.46E+07	3.05E+08	6.60E+07	3.22E+08	100
	Articulated masonry veneer	385	1N12	1S11	1.18E+09	11.0	18.5	12.4	1.44E+08	8.68E+08	1.14E+08	9.35E+08	100
	Masonry veneer	460	1N16	1S15	2.00E+09	15.7	40.4	26.9	3.77E+08	7.00E+08	3.01E+08	6.67E+08	95
	Articulated full masonry	610	1N16	1S15	4.58E+09	27.7	55.4	37.0	7.24E+08	2.34E+09	5.84E+08	2.36E+09	100
	Full masonry	-	-	-	-	-	-	-	-	-	-	-	-
Class H1-D	Clad frame	310	1N12	1S11	6.16E+08	7.1	14.3	9.5	8.46E+07	3.05E+08	6.33E+07	3.37E+08	100
	Articulated masonry veneer	385	1N12	1S11	1.18E+09	11.0	18.5	12.4	1.44E+08	8.68E+08	1.10E+08	9.74E+08	100
	Masonry veneer	460	1N16	1S15	2.00E+09	15.7	40.4	26.9	3.77E+08	7.00E+08	2.92E+08	6.78E+08	97
	Articulated full masonry	-	-	-	-	-	-	-	-	-	-	-	-
	Full masonry	-	-	-	-	-	-	-	-	-	-	-	-
Class H2	Clad frame	310	1N12	1S11	6.16E+08	7.1	14.3	9.5	8.46E+07	3.05E+08	6.06E+07	3.54E+08	100
	Articulated masonry veneer	385	1N16	1S15	1.18E+09	11.0	32.8	21.9	2.46E+08	3.64E+08	1.83E+08	3.34E+08	92
	Masonry veneer	-	-	-	-	-	-	-	-	-	-	-	-
	Articulated full masonry	-	-	-	-	-	-	-	-	-	-	-	-
	Full masonry	-	-	-	-	-	-	-	-	-	-	-	-
Class H2-D	Clad frame	385	1N16	1S15	1.18E+09	11.0	32.8	21.9	2.46E+08	3.64E+08	1.78E+08	3.36E+08	92
	Articulated masonry veneer	460	1N16	1S15	2.00E+09	15.7	40.4	26.9	3.77E+08	7.00E+08	2.79E+08	6.93E+08	99

Table B6 – Strip Footing Comparison of Effective Moments of Inertia (I_{eff}) Sagging and Hogging Modes

Site Class	Type of Construction	Depth [D] (mm)	Width [B] (mm)	Bottom Reinforcement		I_g (mm⁶)	M_{tc} (kNm)	M_{ut} (kNm)	M_s (kNm)	500L Trench Mesh		SENSE 600® TrenchMesh™		$I_{eff(600)}/I_{eff(500)}$ (%)
				500L trench mesh	SENSE 600® TrenchMesh™					I_{cr} (mm^6)	$I_{eff(500)}$ (mm^6)	I_{cr} (mm^6)	$I_{eff(600)}$ (mm^6)	
Class S	Articulated full masonry	400	400	4-L11TM	4-S10TM	2.13E+09	28.6	59.6	39.7	4.04E+08	1.05E+09	3.48E+08	1.01E+09	96
	Full masonry	500	400	4-L11TM	4-S10TM	4.17E+09	44.7	77.6	51.7	7.00E+08	2.94E+09	6.01E+08	2.90E+09	98
Class M	Clad frame	400	300	3-L11TM	3-S10TM	1.60E+09	21.5	44.7	29.8	4.04E+08	8.52E+08	3.48E+08	8.14E+08	96
	Articulated masonry veneer	450	300	3-L11TM	3-S10TM	2.28E+09	27.2	51.4	34.3	5.42E+08	1.41E+09	4.65E+08	1.36E+09	97
	Masonry veneer	500	300	3-L12TM	3-S11TM	3.13E+09	33.5	58.1	38.7	6.99E+08	2.27E+09	5.99E+08	2.23E+09	98
	Articulated full masonry	600	400	4-L12TM	4-S11TM	7.20E+09	64.4	95.5	63.7	1.08E+09	7.42E+09	9.23E+08	7.40E+09	100
	Full masonry	900	400	4-L12TM	4-S11TM	2.43E+10	144.9	149.5	99.7	2.74E+09	6.90E+10	2.33E+09	6.97E+10	101
Class M-D	Clad frame	500	300	3-L11TM	3-S10TM	3.13E+09	33.5	58.2	38.8	7.00E+08	2.27E+09	6.01E+08	2.23E+09	98
	Articulated masonry veneer	550	300	3-L12TM	3-S11TM	4.16E+09	40.6	79.8	53.2	1.05E+09	2.43E+09	9.06E+08	2.35E+09	96
	Masonry veneer	700	300	3-N16	3-S15	8.58E+09	65.7	184.5	123.0	3.04E+09	3.88E+09	2.62E+09	3.53E+09	91
	Articulated full masonry	1100	400	4-N16	4-S15	4.44E+10	216.5	406.8	271.2	8.66E+09	2.68E+10	7.41E+09	2.62E+10	98
Class H1	Clad frame	500	300	3-L11TM	3-S10TM	3.13E+09	33.5	58.2	38.8	7.00E+08	2.27E+09	6.01E+08	2.23E+09	98
	Articulated masonry veneer	600	300	3-L12TM	3-S11TM	5.40E+09	48.3	88.1	58.7	1.30E+09	3.58E+09	1.11E+09	3.49E+09	98
	Masonry veneer	850	300	3-N16	3-S15	1.54E+10	96.9	229.7	153.1	4.79E+09	7.47E+09	4.12E+09	6.96E+09	93
	Articulated full masonry	1100	400	4-N16	4-S15	4.44E+10	216.5	406.4	270.9	8.64E+09	2.69E+10	7.39E+09	2.62E+10	98

8. Appendix C – Supplementary Design Calculations

This Appendix details the calculations conducted to demonstrate from first principles that the Performance Solutions shown in Tables C1 and C2 meet the Performance Requirements of AS 2870, specifically that footing system stiffness results in deflections limited to those in Table 4.1 of AS 2870.

Table C1 – Waffle Raft Slabs

Site Class	Type of Construction	Depth [D] (mm)	300mm and 110mm Edge Beam Reinforcement		110mm Internal Beam Reinforcement	
			500L trench mesh	SENSE 600® TrenchMesh™	500N Bar	SENSE 600® Bar
Class M	Articulated full masonry (S/S)	610	2x3-L11TM	2x3-S10TM	1N16	1S15
Class M-D	Masonry veneer	385	2x3-L11TM	2x3-S10TM	1N16	1S15
	Articulated full masonry	610	2x3-L11TM	2x3-S10TM	1N16	1S15
Class H1	Masonry veneer	460	2x3-L11TM	2x3-S10TM	1N16	1S15
Class H1-D	Masonry veneer	460	2x3-L11TM	2x3-S10TM	1N16	1S15
Class H2	Articulated masonry veneer	385	2x3-L11TM	2x3-S10TM	1N16	1S15
Class H2-D	Clad Frame	385	2x3-L11TM	2x3-S10TM	1N16	1S15
	Articulated masonry veneer	460	2x3-L11TM	2x3-S10TM	1N16	1S15

Table C2 – Strip Footing Systems

Site Class	Type of Construction	Depth [D] (mm)	Width [B] (mm)	Bottom Reinforcement		Top Reinforcement	
				500N	SENSE 600® TrenchMesh™	500N	SENSE 600® TrenchMesh™
Class M-D	Masonry veneer	700	300	3-N16	3-S15	3-N16	3-S15
Class H1	Masonry veneer	850	300	3-N16	3-S15	3-N16	3-S15

Each of the footing systems in Tables C1 and C2 were assessed prior to being analysed using computer software CORD to determine their stiffness compared to the 500L trench mesh or 500N bar deemed-to-comply designs. It is noted that the Class M – Articulated full masonry deemed-to-comply design has the same solution as the Class M-D – Articulated full masonry deemed-to-comply design. Therefore, only the later which has the more severe loading needs to be considered. The same applies to the Class H1 - Masonry veneer deemed-to-comply design and the Class H1-D - Masonry veneer deemed-to-comply design, so again only the latter was checked.

Each of the designs shown in Tables C1 and C2 were checked against the following four footing system layouts which are considered to cover the range of typical residential structures that would utilise the designed footing.

Table C3 provides the edge heave results of the CORD analysis for each of the Site Class/Types of Construction combinations for the waffle rafts with each of the 4 footing layouts reinforced with SENSE 600® bars. The required moment of inertia for the sagging mode is tabulated against the actual inertia of the design footing element. It is noted that the concrete section and the top reinforcing mesh is the same as the deemed-to-comply designs in AS 2870 and therefore the hogging mode causing centre heave does not need to be considered in this performance solution.

Table C3 – Waffle Raft inertia results from CORD runs

Site Class	Type of Construction	Layout (m x m)	Long direction		Short direction	
			$I_{(required)}$	$I_{(actual)}$	$I_{(required)}$	$I_{(required)}$
Class M-D	Masonry veneer	24 x 12	-	1.095	-	1.061
		18 x 12	-	1.095	-	1.073
		12 x 10	-	1.168	-	1.095
		9 x 7	-	1.165	-	1.168
	Articulated full masonry	24 x 12	-	4.261	0.002	4.138
		18 x 12	-	4.261	-	4.179
		12 x 10	-	4.530	-	4.261
		9 x 7	0.001	4.514	0.001	4.525
Class H1-D	Masonry veneer	24 x 12	0.368	1.861	-	1.805
		18 x 12	0.364	1.862	-	1.824
		12 x 10	0.551	1.984	0.346	1.862
		9 x 7	0.764	0.944	0.311	1.982
Class H2	Articulated masonry veneer	24 x 12	0.221	1.095	-	1.061
		18 x 12	0.216	1.095	-	1.073
		12 x 10	0.367	0.756	0.302	0.849
		9 x 7	0.499	0.659	0.245	1.358
Class H2-D	Clad Frame	24 x 12	-	1.095	-	1.061
		18 x 12	-	1.095	-	1.073
		12 x 10	-	1.168	-	1.095
		9 x 7	0.240	0.811	0.159	1.167
	Articulated masonry veneer	24 x 12	0.209	1.861	-	1.805
		18 x 12	0.203	1.862	-	1.824
		12 x 10	0.346	1.984	0.290	1.862
		9 x 7	0.531	0.923	0.258	1.982

Table C4 – Strip Footing inertia results from CORD runs

Site Class	Type of Construction	Layout (m x m)	Long direction		Short direction	
			$I_{(required)}$	$I_{(actual)}$	$I_{(required)}$	$I_{(actual)}$
Class M-D	Masonry veneer	24 x 12 CH	0.503	1.123	0.494	0.760
		24 x 12 EH	0.000	2.240	-	1.835
		18 x 12 CH	0.409	1.373	0.500	0.905
		18 x 12 EH	0.000	2.216	-	1.954
		12 x 10 CH	0.502	2.283	0.784	0.853
		12 x 10 EH	0.000	2.631	-	2.184
		9 x 7 CH	0.835	3.121	0.642	1.196
		9 x 7 EH	0.001	3.737	-	2.896
Class H1	Masonry veneer	24 x 12 CH	0.998	2.162	1.065	1.170
		24 x 12 EH	0.000	3.980	-	3.270
		18 x 12 CH	1.101	2.024	1.082	1.378
		18 x 12 EH	0.000	3.945	-	3.483
		12 x 10 CH	1.148	3.265	1.205	1.298
		12 x 10 EH	0.000	4.692	0.898	3.898
		9 x 7 CH	1.199	5.175	0.840	2.504
		9 x 7 EH	0.425	6.672	0.256	5.174

CH – Centre heave; EH – Edge heave

The CORD analysis confirm that centre heave typically controls the stiffness design. The results in Table C3 indicate that the moment of inertia of the waffle rafts reinforced with SENSE 600® equivalent capacity bars provide the required level of stiffness to resist edge heave. The results in Table C4 indicate that the moment of inertia of the strip footing systems reinforced with SENSE 600® equivalent capacity bars provide the required level of stiffness to resist both the centre heave and the edge heave.

It just makes SENSE