Reinforcing Connections for Jumpform Construction:

Focus on Code Compliant Design & Detailing

ASSOCIATION OF CONSULTING STRUCTURAL ENGINEERS NSW

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Reinforcing Connections for Jumpform Construction

1.0 Jumpform Elements & Applications

- Typical Construction Joints
- Reinforcing Connection Types & Rebate Systems

2.0 Design Principles to Australian Standards

- Design Actions & AS3600:2018 Criteria
- Headed & Cog Anchorage Capacity Calculations
- Starter bar development & lapped splice length

3.0 Specifications & Detailing

- Structural Drawing typical detail
- Shop drawings for Formworkers

Construction Joint Applications

Vertical Jumpform Elements: Core Walls, Stair Boxes, Columns, Blades, Wing Walls, Stitch / Infill Walls to precast elements

- Lift/Stair Core only (balance precast & conv)
- Full Floor SuperJump Systems

Horizontal Connected Elements: Floor Decks, Transfer Slabs, Band Beams, Stair Landings, Cantilever Balconies, Planters

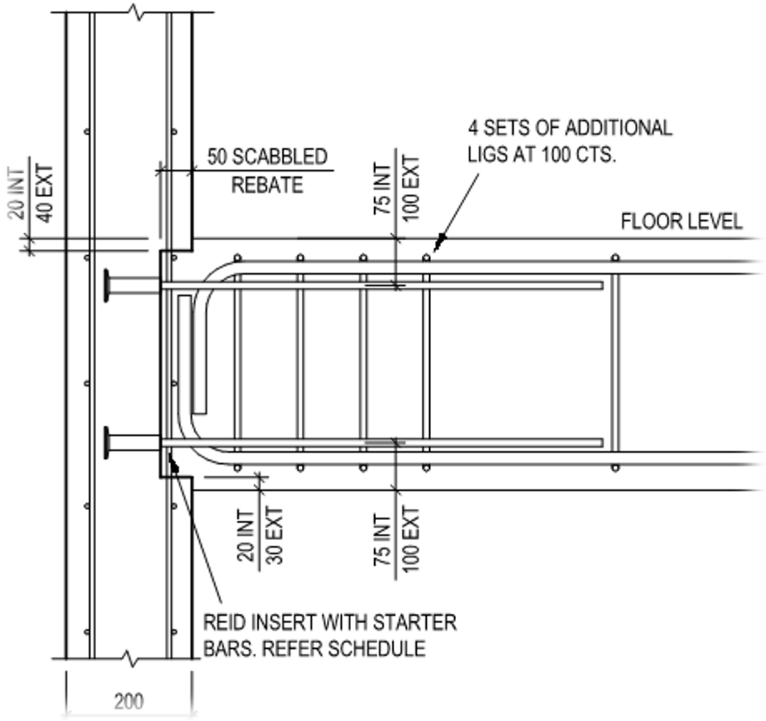
Vertical Connected Elements: Shear Walls, Wing walls, Outrigger walls, Tank walls

Connections at constructions joint of jumpform elements to connecting elements require;

(i) a fixing anchor in the jumpform element, an

(ii) a reinforcement starter bar / lap bar in the joining element.

Reinforcing Connections for Jumpform Construction



Connection specifications detail:

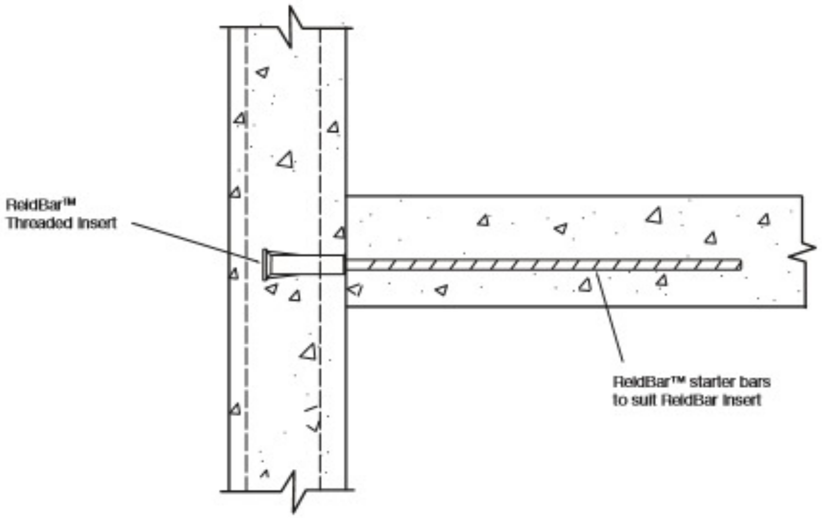
- Bar Size
- Spacing
- No. Rows & Location – Top & Bottom / Central
- Anchorage Type – Headed Anchor (Inserts) or Coupler & Cog Bar
- Rebate Depth & Type
- Starter Bar / Lapped Splice Lengths

Reinforcing Connections for Jumpform Construction

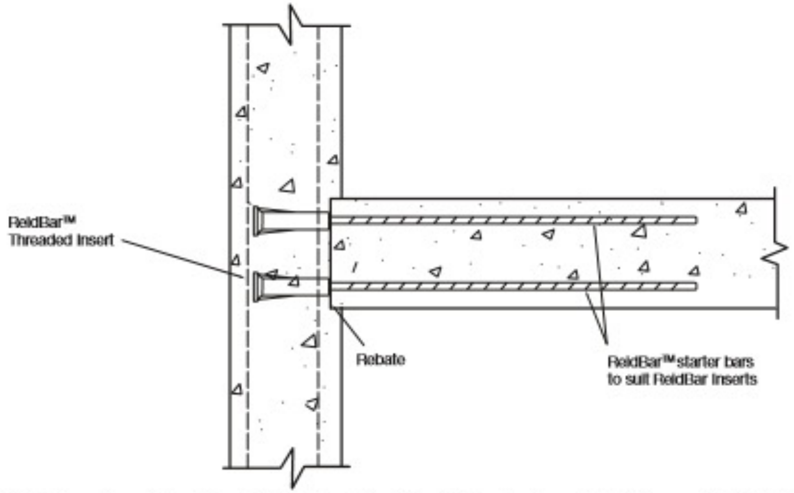
Headed Anchors - Core Wall to Slab

Headed Anchors – Core Wall to Slab

Slab to insitu wall - single row

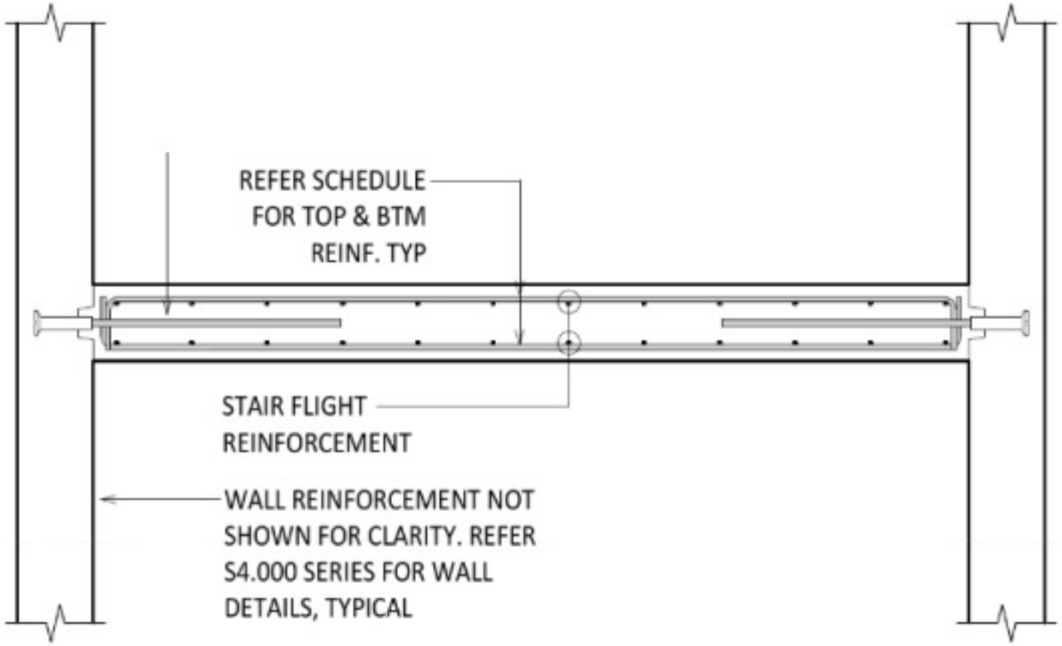


Slab to in-situ wall - double row

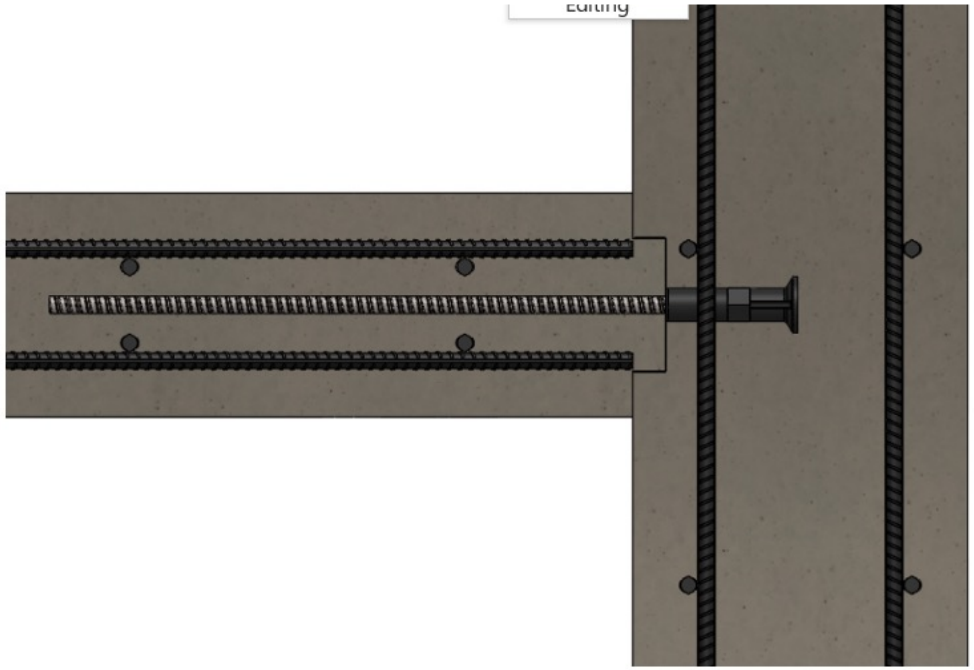


Reid™ offers various rebate solutions to fix and locate inserts to suit all construction methods. Please contact Reid™ for more information.

Headed Anchors -Core Wall to Stair Landing Reinforcing Connections in Jumpform Elements

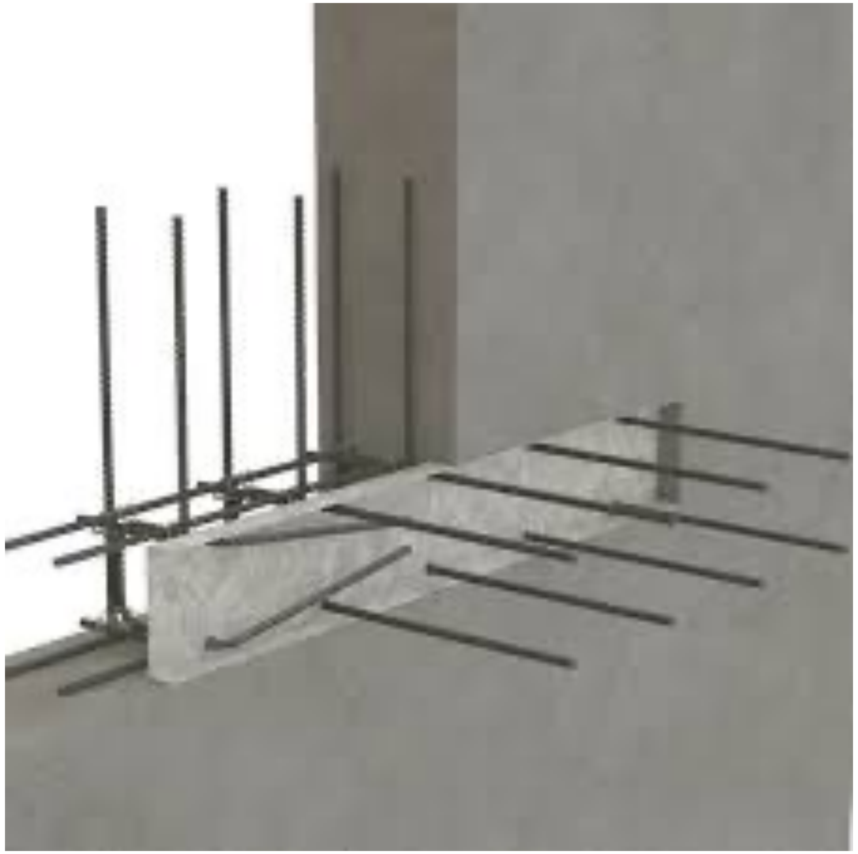


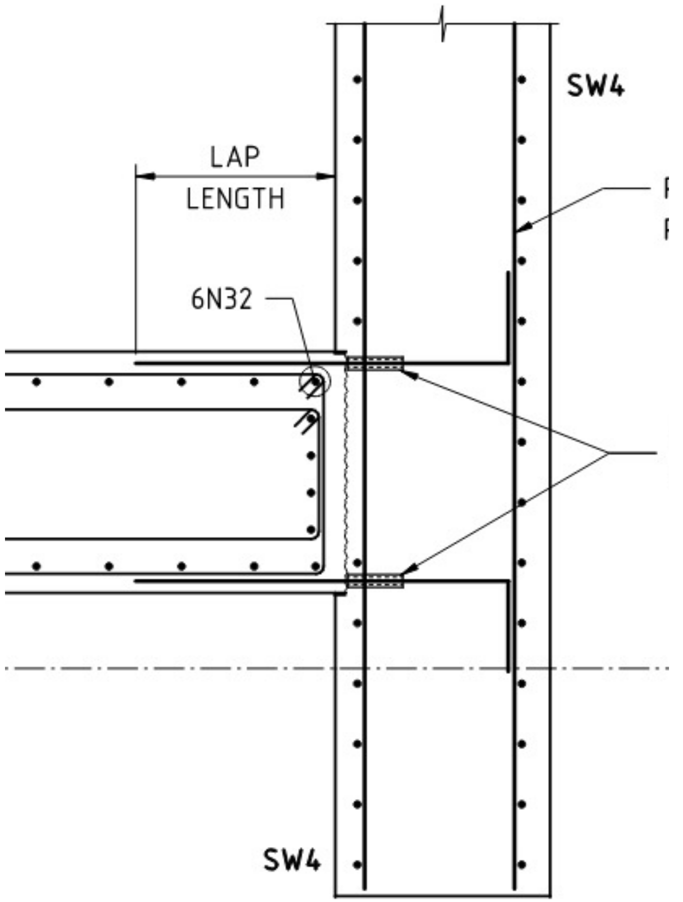
LANDING TO INSITU WALL
CONNECTION



Coupler & Cog Anchors – Core Walls to Beams / Transfer Slabs

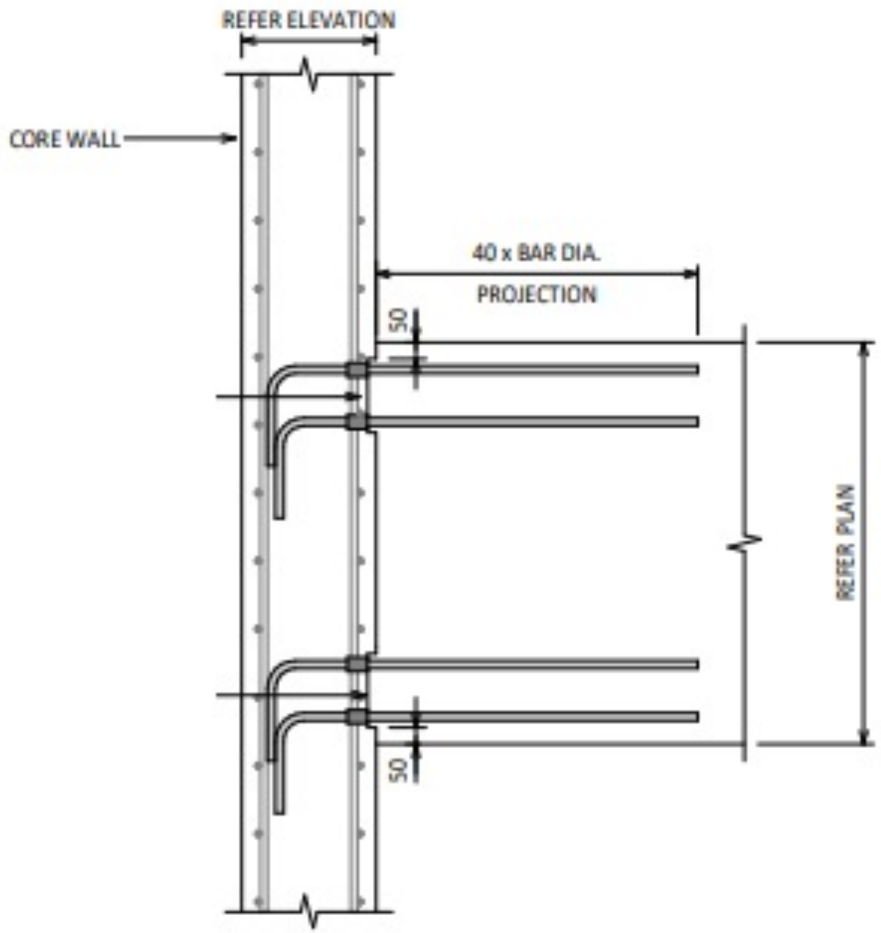
Reinforcing Connections for Jumpform Construction

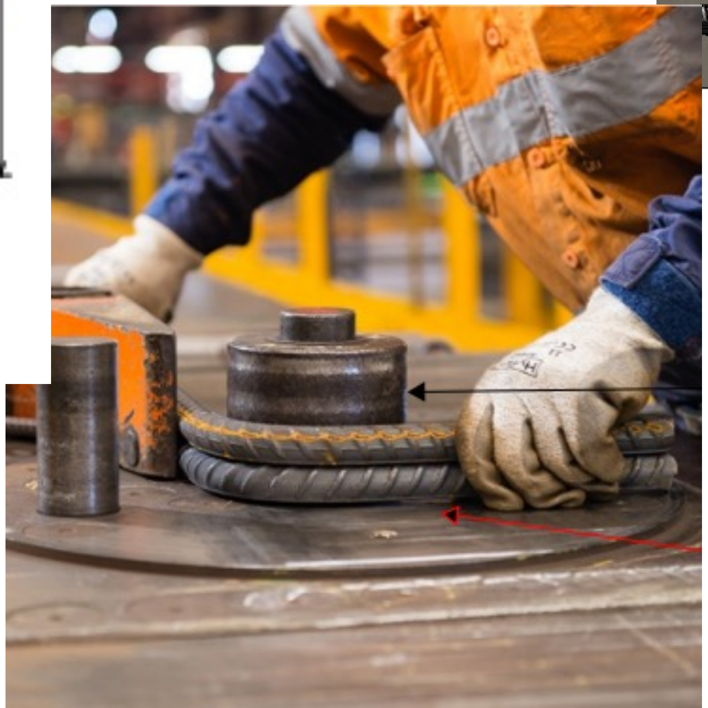


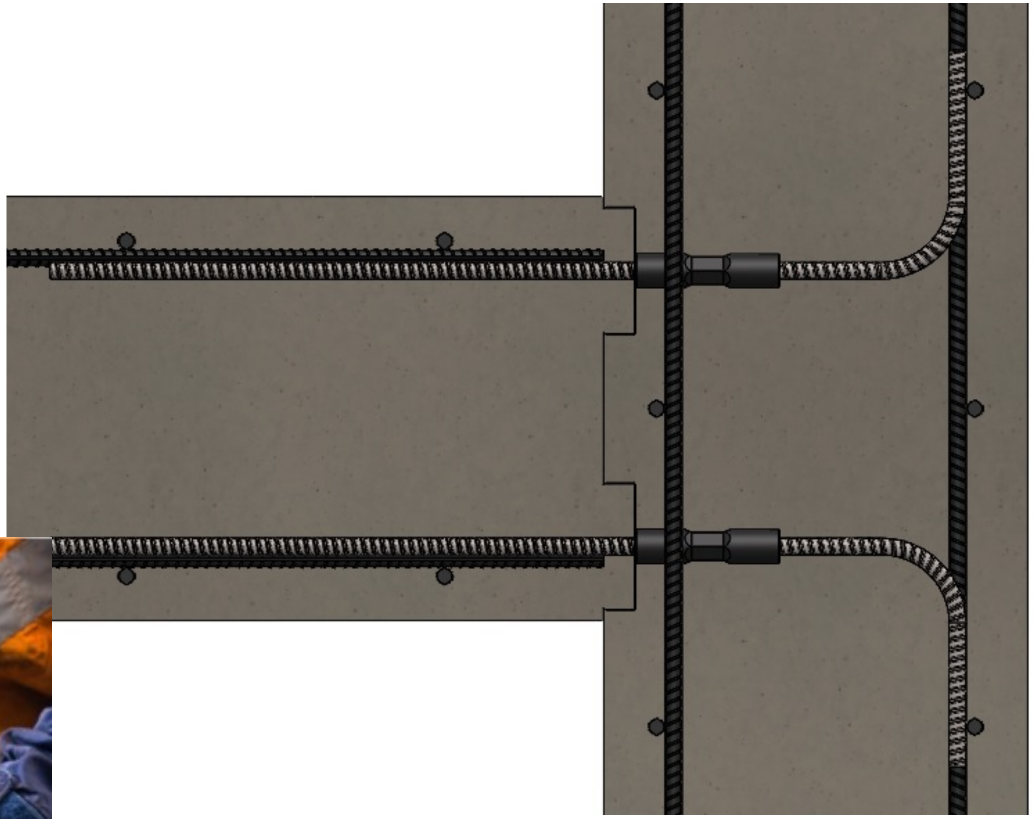


Coupler & Cog Anchors – Core Walls to Beams / Transfer Slabs

Reinforcing Connections in Jumpform Construction

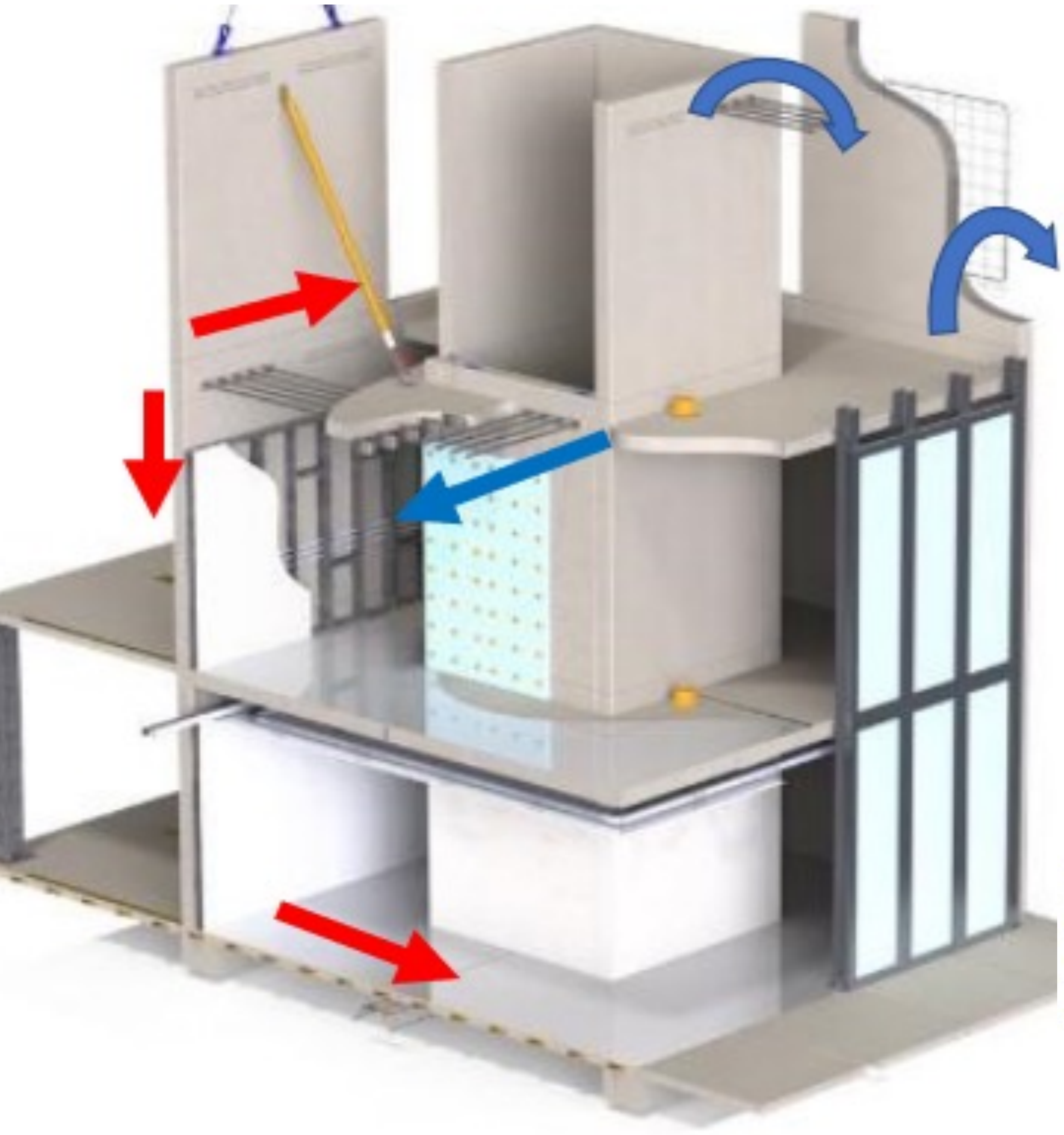






Design Actions & Capacity Checks

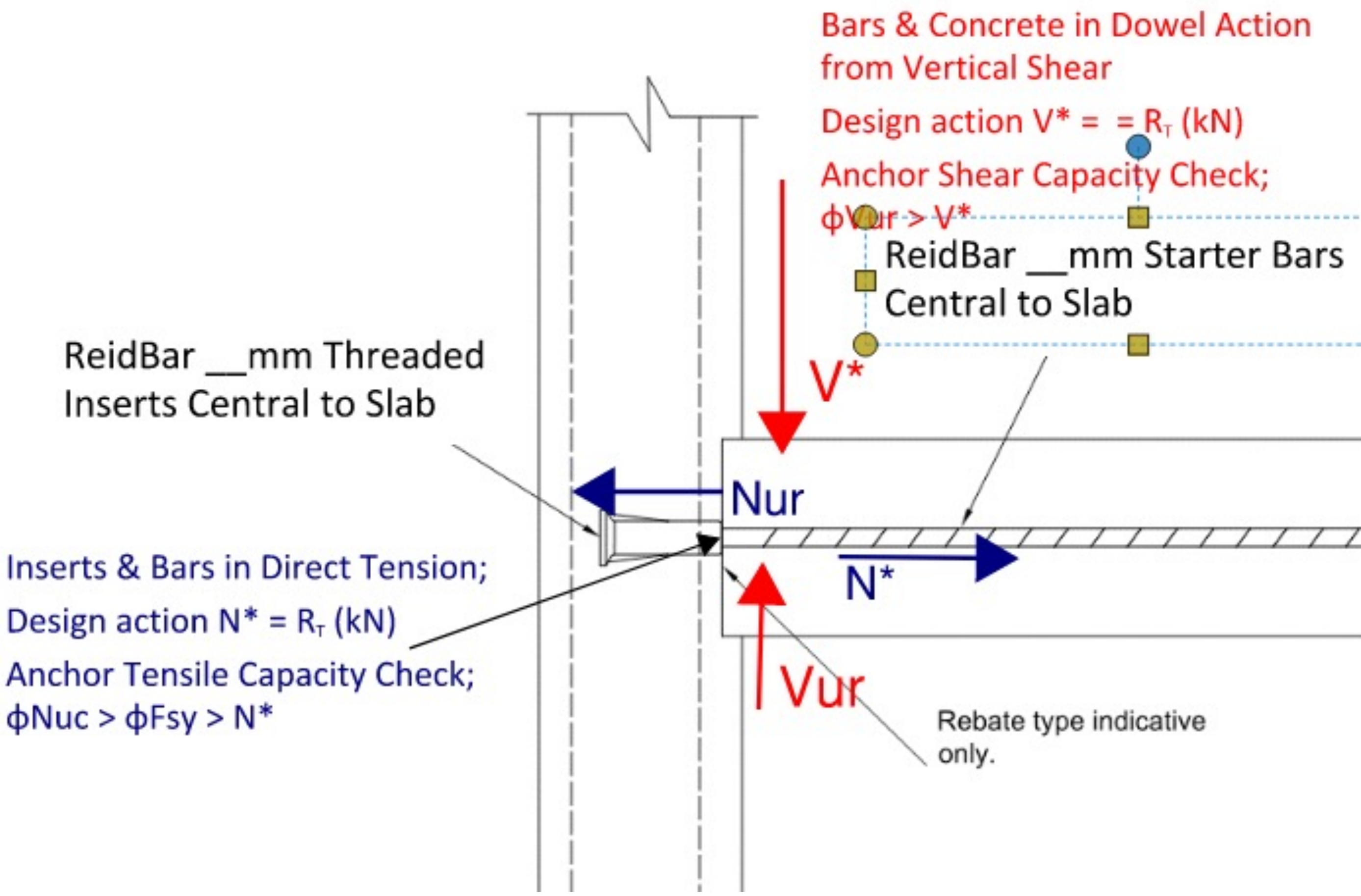
Reinforcing Connections for Jumpform Construction



Forces Acting at Connection:

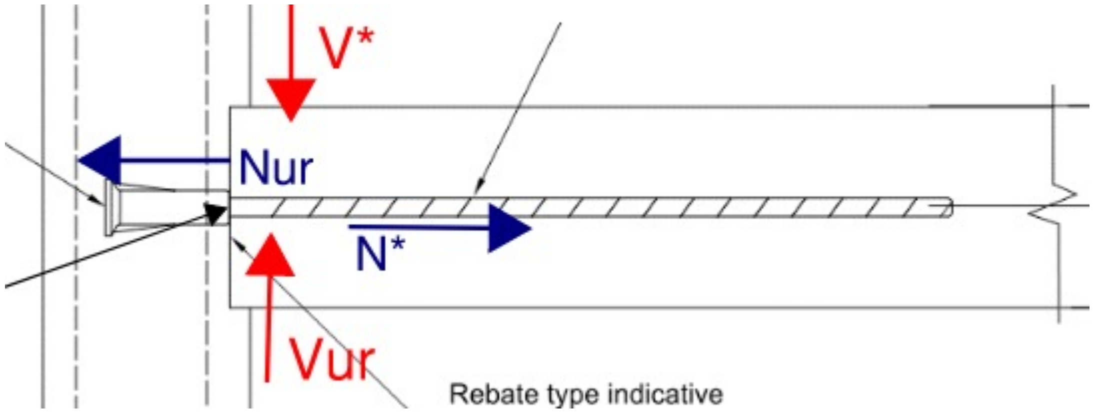
Axial Tension & Bending Moments

Vertical Shear, Horizontal Shear In/out of Plane



Design Actions & Capacity Checks

Tension	Shear
Steel Reduced Tensile Yield Capacity ϕfsy Φ = 0.85 Concrete Reduced Ultimate Tensile Design Capacity ϕNurc, Φ = 0.6, + spacing reductions factors apply Design Reduced Ultimate Tensile Capacity ϕNur = min. of ϕNurc or ϕfsy Direct axial Tensile limit state load = N*	Steel Reduced Ultimate Shear Capacity ϕVus Φ = 0.7 (Note, 500N bar Vus = 0.62fsy) Concrete Reduced Ultimate Shear Capacity ϕVuc, ϕ=0.6 + close edge reduction factors apply Design Reduced Ultimate Shear Capacity ϕVur = min. of ϕVuc or ϕVus Vertical or Horizontal Shear limit state load = V*
Check Tensile Strength Capacity N*/ ϕNur < 1.0	Check Shear Strength Capacity V*/ ϕVur < 1.0



Design Actions & Capacity Checks

Combined Tension & Shear

Interactive Tension and Shear loading of anchors is limited to 120% of combined capacity ϕNur + ϕVur;

ϕN* / ϕNur + ϕV* / ϕVur < 1.2

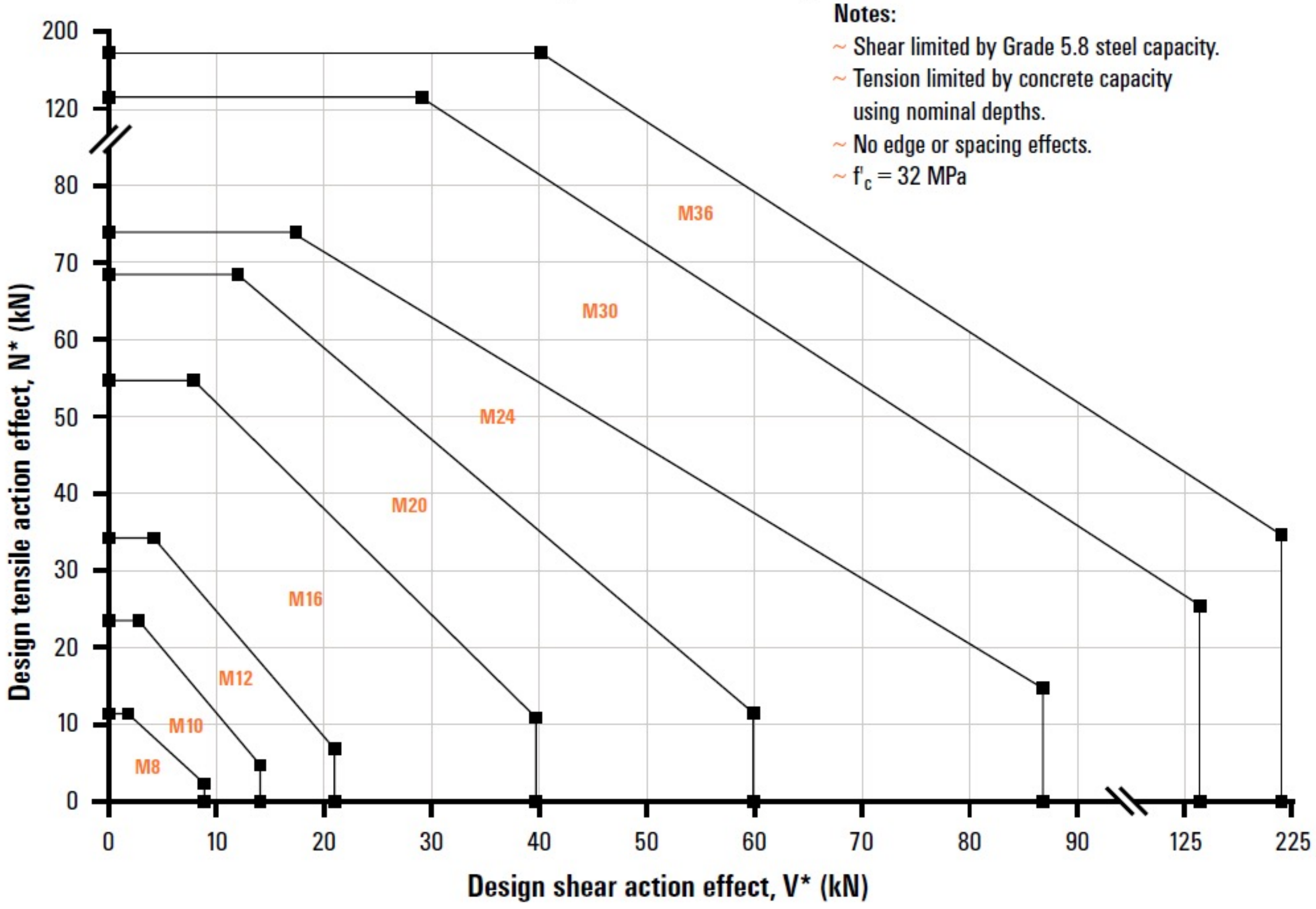
Design Case Example:

Anchor is designed to 80% of steel shear capacity to carry vertical shear from dead load of suspended slab.

The design tension capacity is now limited to 40% of ϕNur (min. of ϕNurc or ϕfsy), and may result in premature tensile failure of the fixing by pullout or steel yield in the event of overload with combined actions

Investigate ductile design solution with shared utilization in tension & shear

Table 1a Indicative combined loading – interaction diagram



AS3600:2018

19.3 FIXINGS

19.3.1 General

Fixings, including holding-down bolts, inserts and ferrules, shall conform with the following:

(a) A fixing shall be designed to transmit all forces, acting or likely to act on it.

(b) Lifting inserts or fixings which are intended for lifting or for the attachment of temporary supports shall comply with the requirements of AS 3850.1.

(c) Fixings shall be designed to yield before ultimate failure in the event of overload.

(d) The anchorage of any fixings shall be designed in accordance with Section 13. The design strength of this anchorage shall be taken as ϕ times the ultimate strength, where $\phi = 0.6$. In the case of shallow anchorages, cone-type failure in the concrete surrounding the fixing shall be investigated taking into account edge distance, spacing, the effect of reinforcement, if any, and concrete strength at time of loading.

(e) In the absence of calculations, the strength of a fixing shall be determined by load testing of a prototype to failure in accordance with Paragraph B4, Appendix B. The design strength of the fixing shall be taken as ϕ times the ultimate strength where the ultimate strength is taken as the average failure load divided by the appropriate factor given in Table B4.3, Appendix B and $\phi = 0.6$.

Cl 13.1.4 Development of Headed Anchorage

$L_{db} = L_{sy.hb}$

Cl 13.1.2.6

Full Development of a Hook or Cog Anchorage

Lst = 0.5Lsy.t

Concrete Capacity Design (CCD) Principles

Concrete tensile capacity of headed anchors will be influenced by;

- Embedment depth (anchor length + rebate depth)
- Concrete design strength
- Anchor spacing centres
- Anchor distance to concrete edge
- Head bearing area and shape

CCD Method References for Headed Anchors

ACI318: Building Code Requirements for Structural Concrete

EN1992-1-1 Eurocode 2: Design of Concrete Structures

AS3600:2018 Concrete Structures, Section 19 references AS3850.1 Appendix B

AS 3850:2015 Prefabricated Concrete Elements, Appendix B

AS5216:2018 Design of Post-Installed & Cast-In Fasteners

NZS3101:2107 Concrete Structures Amendment A3, Section 17

The designer must consult technical design data and/or advice provided by the anchor manufacturer/supplier to ensure correct design and detailing of the structural connection to achieve the required tensile and shear strength, and investigate load transfer and mode of failure for ductile behaviour.

Headed Anchorage
Concrete Capacity Design Principles & Methods

Calculated Concrete Tensile Capacity – Pullout Cone Mode of Failure for Headed Anchorages

$Nuc = k.\ f'_c{}^{0.5}\ h_{ef}^{1.5}$ (Isolated direct tension of a single anchor*)

Where:

- Nuc = Characteristic Ultimate Concrete Tensile Capacity (kN)
- k = 12.5 for Uncracked Concrete, k = 10 for cracked concrete
- **f'c = characteristic concrete compressive strength (MPa)**
- **h_{ef} = effective embedment depth of anchor (mm)**

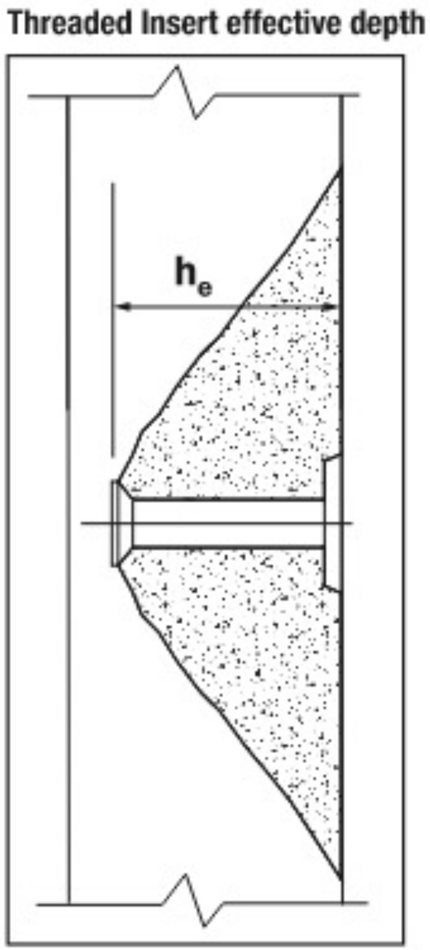
*Group effects apply: effect of spacing on anchors in a single row or multiple rows to be calculated as;

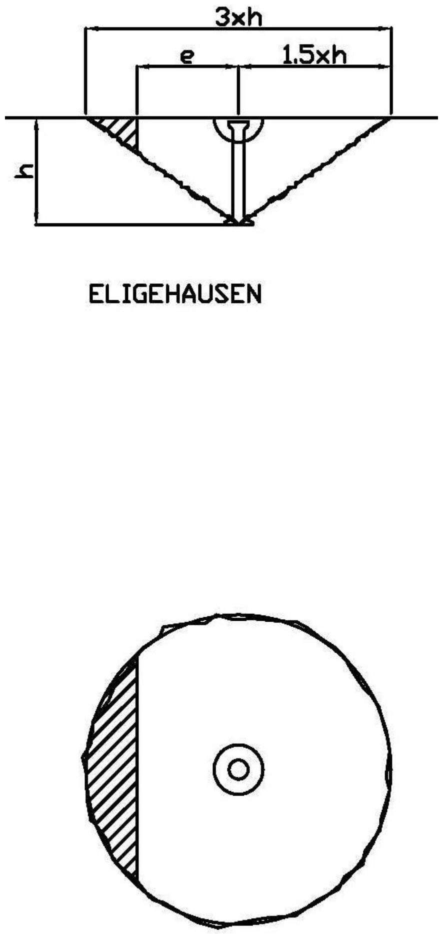
$Xnai = a / 3 \times h_{ef}$

Where:

- a = Anchor spacing distance (mm)
- h_{ef} = effective embedment depth of anchor (mm)

* Shape modification factors may apply, validated by proof testing to establish proprietary data for anchor geometry

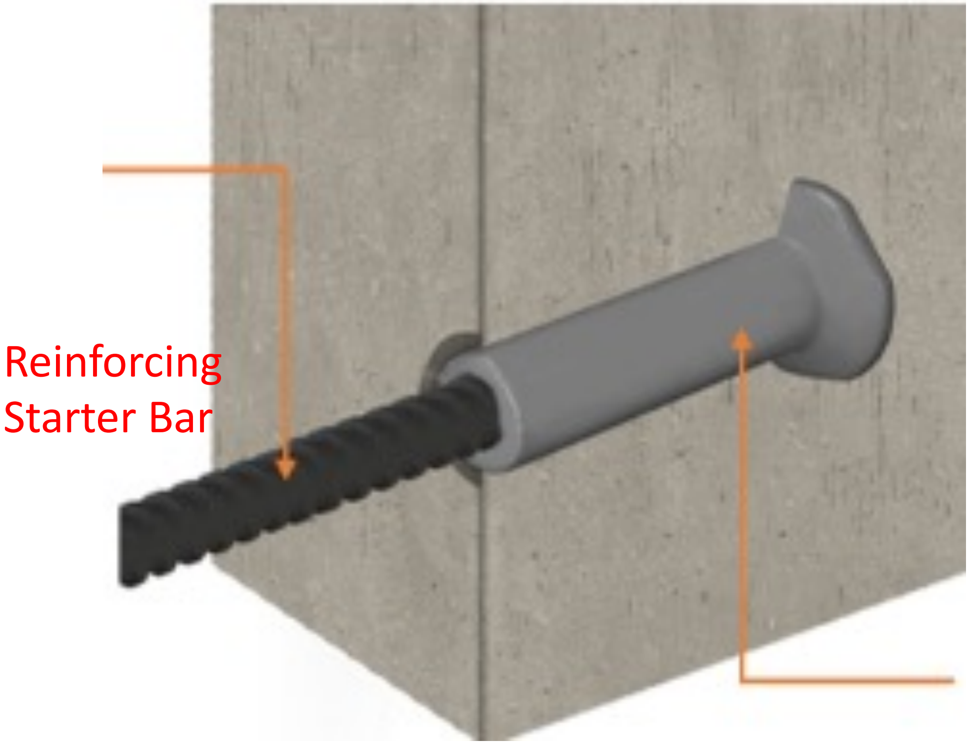




Compliant Reinforcing Bar Connections

Reinforcing Connections for Jumpform Construction

- Reinforcing connection anchors are long anchors for optimised effective embedment depths.
- The failure load of the concrete surrounding the anchor is greater than the yield capacity of the bar.
- The concrete tensile capacity is checked for the rebated embedment depth of the anchors, and their spacing centres.
- Reinforcing connection anchor systems can be value engineered for design capacity to full tensile yield capacity of 500N Grade reinforcing bar with ductile mode of failure at the full , and the connection design complies with AS3600 Section 19.3.1 (c).



e.g. ductile ReidBar Threaded Insert configurations:
RB12 @250
RBA16 @300
RBA20 @400

*calculation and in concrete testing verified

Cog Anchorage Detailing

Full Yield Stress development Embedment depth;
$L_{st} = 0.5L_{sy.t}$

For thin elements where embedment Ldb < $0.5L_{sy.t}$ anchor development is less than Yield Strength as per Cl 13.1.2.4;

Formula is reconfigured to calculate reduced stress design capacity at reduced embedment

Note: Min. 12db & ductile anchorage of fixings must be satisfied for reinforcing connections

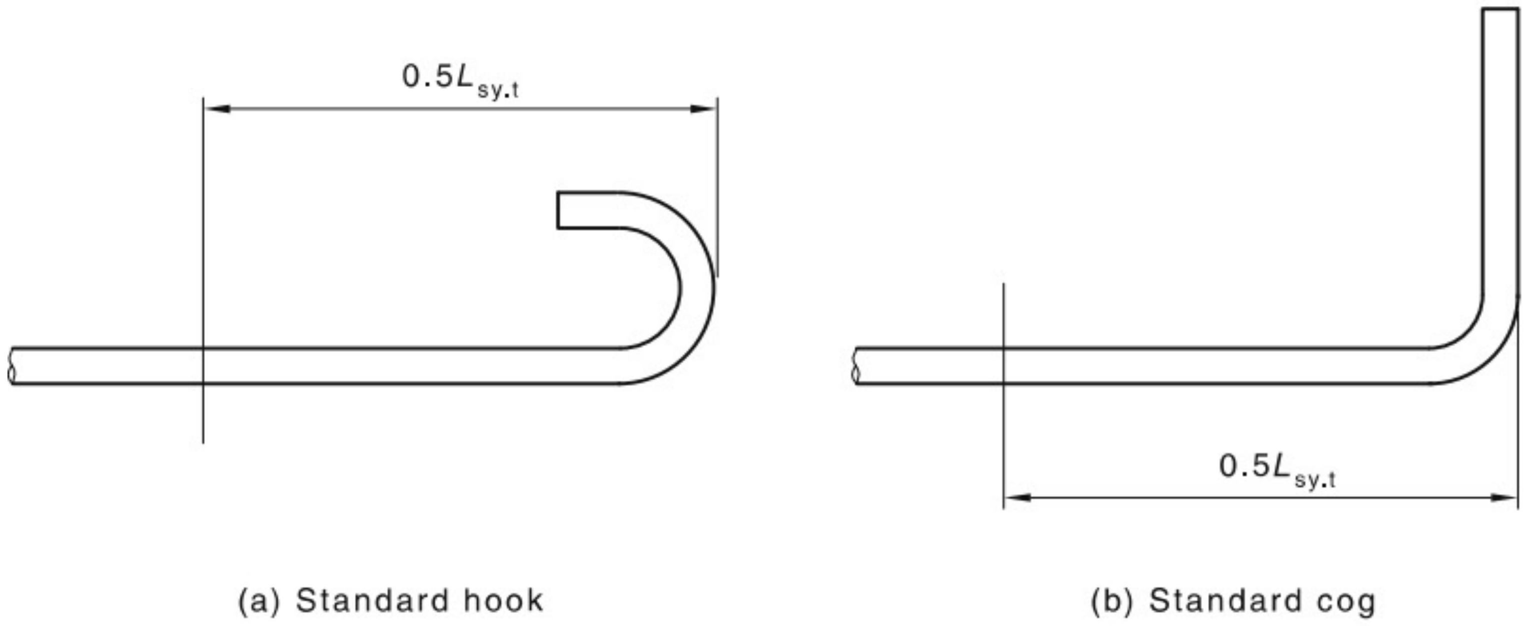


FIGURE 13.1.2.6 DEVELOPMENT LENGTH OF A DEFORMED BAR WITH A STANDARD HOOK OR COG

13.1.2.4 *Development length to develop less than the yield strength*

Where the full yield strength of the bar is not required, the development length (L_{st}) to develop a tensile stress (σ_{st}), less than the yield strength (f_{sy}), shall be calculated from—

$$L_{st} = L_{sy.t}\frac{\sigma_{st}}{f_{sy}} \qquad \ldots 13.1.2.4$$

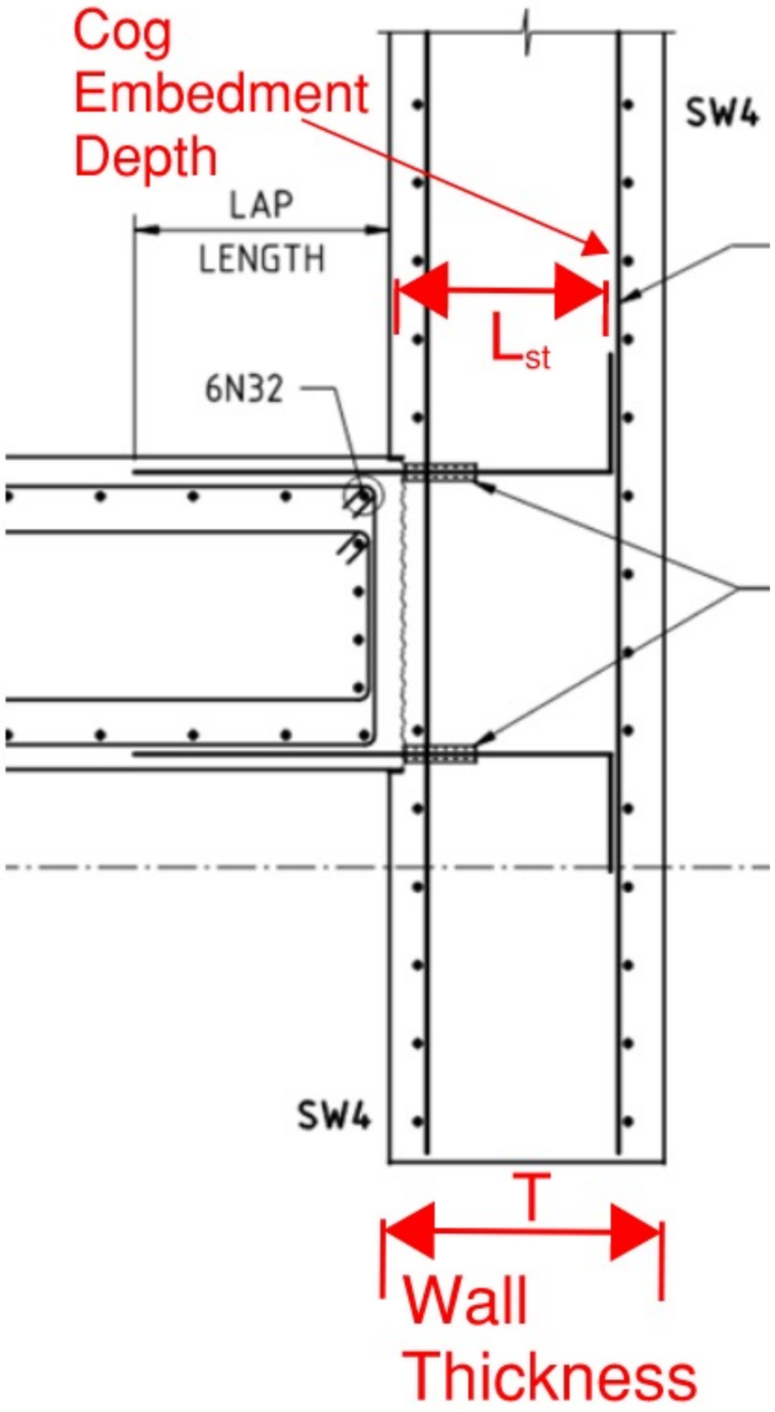
but shall be not less than—

(a) $12d_b$; or

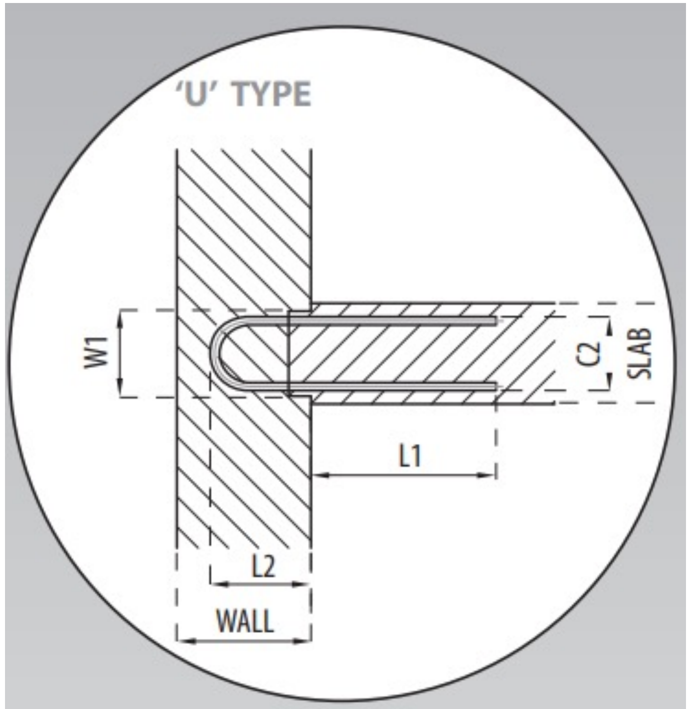
Cog Anchorage – Reduced Stress Development at Reduced Embedment Depths

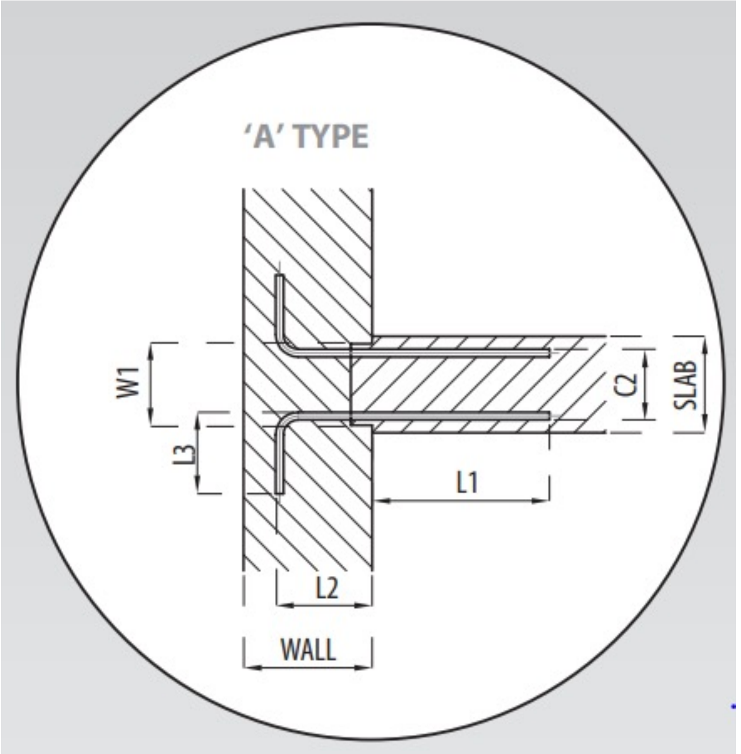
Bar Size	Wall Thickness T (mm)	Cog Anchor Embedment Depth L_{st} (mm)	Cog Reduced Tensile Stress $\phi\sigma_{st}$ (MPa)	Reduced Characteristic Ultimate Capacity	
				Tension $\phi F_{sy.st}$ (kN)	Shear ϕV_{ur} (kN)
N12	200 (min)	144 (12db min)	235	26.5	26.5
	350	280 (max) $L_{st} = 0.5L_{sy.t} = 23d_b$	425	48.0	26.5
N16	250 (min)	196 (12db min)	230	46.0	47.1
	450+	370 (max) $L_{st} = 0.5L_{sy.t} = 23d_b$	425	85.5	47.1
N20	300 (min)	240 (min)	231	72.4	73.6
	500+	460 (max) $L_{st} = 0.5L_{sy.t} = 23d_b$	425	133.5	73.6
N24	350 (min)	288 (12db min)	204	100.2	115.1
	700+	625 (max) $L_{st} = 0.5L_{sy.t} = 25d_b$	425	208.7	115.1
N32	450 (min)	400 (min)	205	164.9	188.4
	900	830 (max) $L_{st} = 0.5L_{sy.t} = 26d_b$	425	341.7	188.4

Reduced tensile yield design capacity of 500N bar ϕf_{sy} = 425MPa



Cog & Hook Anchorages – Pullout Box Design Capacity





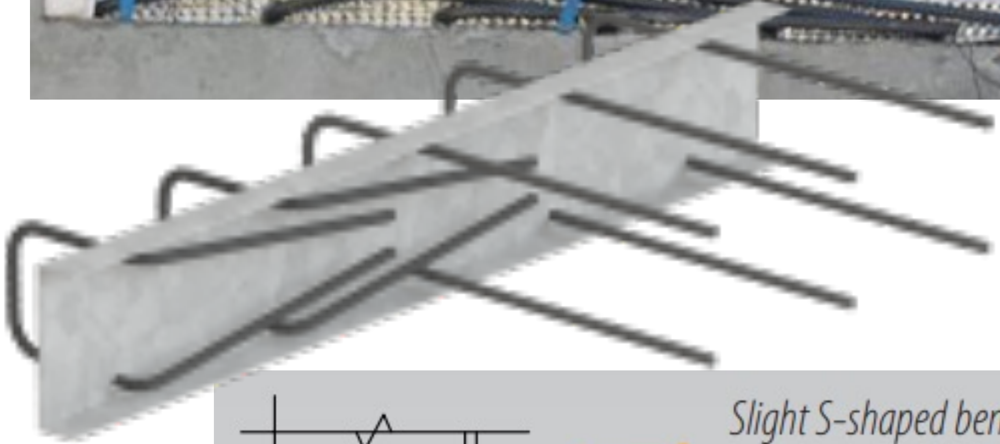
U-Type Box (Hook Anchorage)
Top bar only in tension with single hook anchorage capacity limited by embedment depth L2

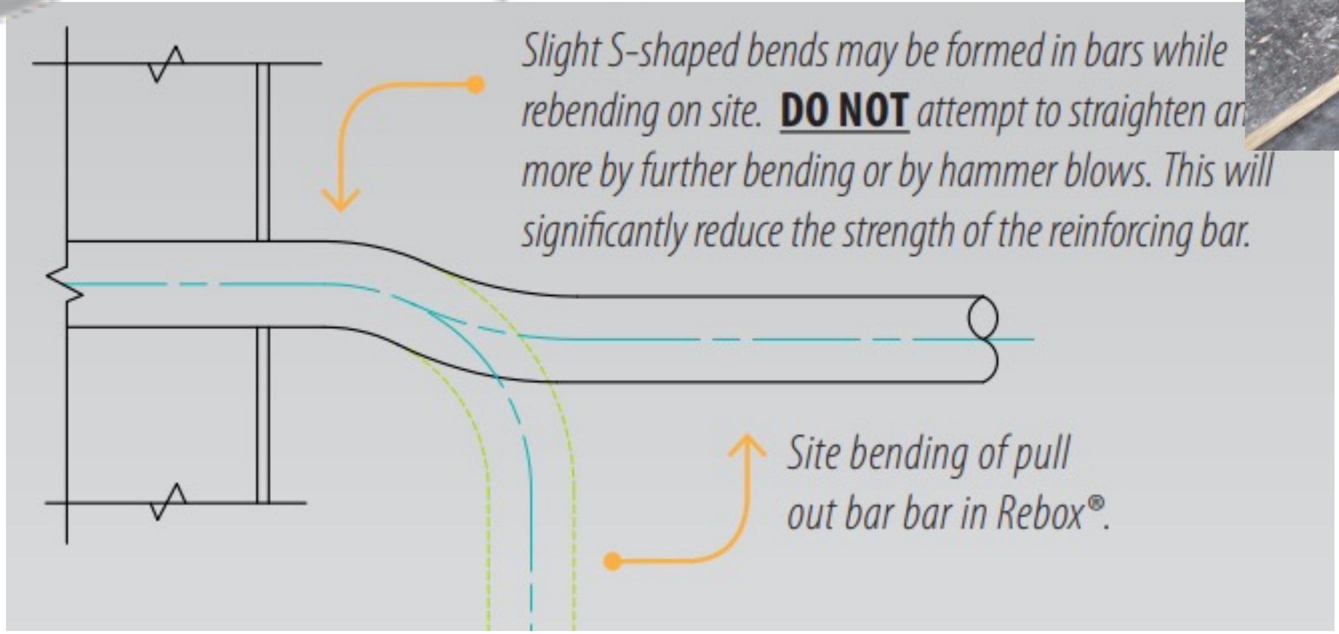
L-Type Box (Double Cog Anchorage)
Double Cog anchorage limited by embedment depth L2
Min. 12db = 144mm achieving minimum reduced stress capacity

To satisfy ductile mode of failure for anchorages ;
L2 = 0.5Lsy.t = 0.5 x 40db = 0.5 x 40 x 12 = 240mm
Requires 300mm thick wall

Cog & Hook Anchorages – Pullout Boxes

Reinforcing Connections in Jumpform Construction





Starter Bar Development & Lap Length

Reinforcing Connections for Jumpform Construction

Development Length

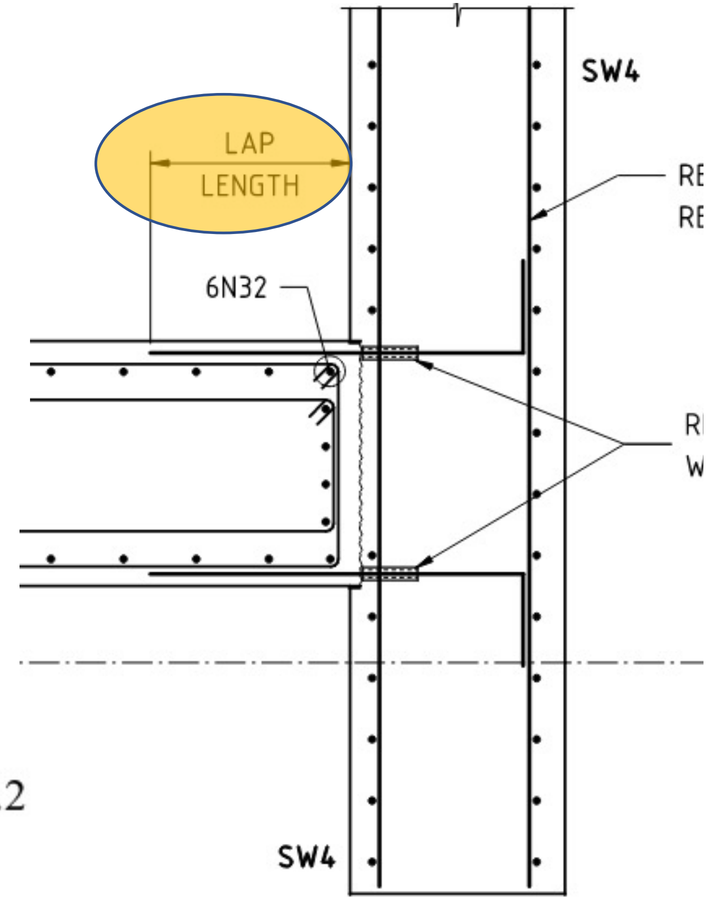
$$L_{sy.tb} = \frac{0.5 k_1 k_3 f_{sy} d_b}{k_2 \sqrt{f'_c}} \geq 0.058 f_{sy} k_1 d_b \qquad \ldots 13.1.2.2$$

where

k_1 = 1.3 for a horizontal bar with more than 300 mm of concrete cast below the bar; or

= 1.0 otherwise

Lsy.tb Typically 40db+ for anchorages in walls with > 300mm concrete under the bar



Lapped Splice for Bars in Tension

$$L_{sy.t.lap} = k_7 L_{sy.t} \geq 0.058 f_{sy} k_1 d_b \qquad \ldots 13.2.2$$

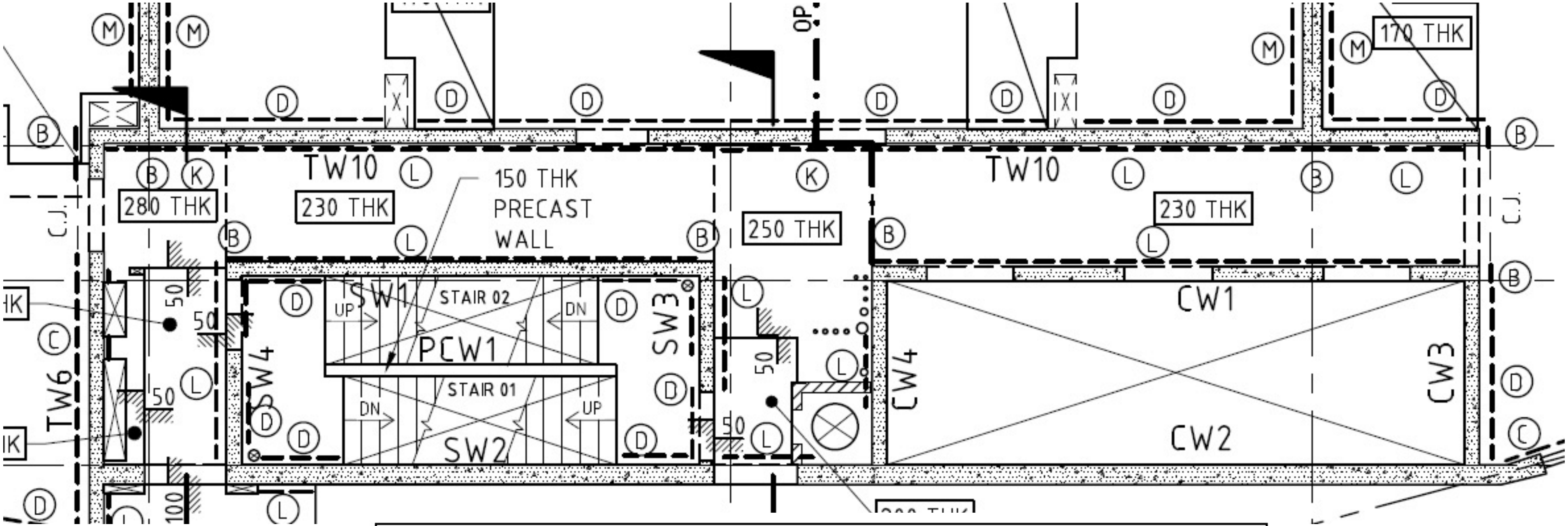
where

$L_{sy.t}$ is calculated in accordance with Clause 13.1.2.1. (In the determination of $L_{sy.t}$ for use in Equation 13.2.2, the lower limit of $0.058 f_{sy} k_1$ in Equation 13.1.2.2 does not apply); and

k_7 shall be taken as 1.25 unless A_s provided is at least twice A_s required and no more than half of the reinforcement at the section is spliced, in which case k_7 may be taken as 1.

Critical strength applications where lap splices are not adequate specify continuous starter bar as top / bottom reo Eg Outrigger walls, Diapragms

Connection Specification

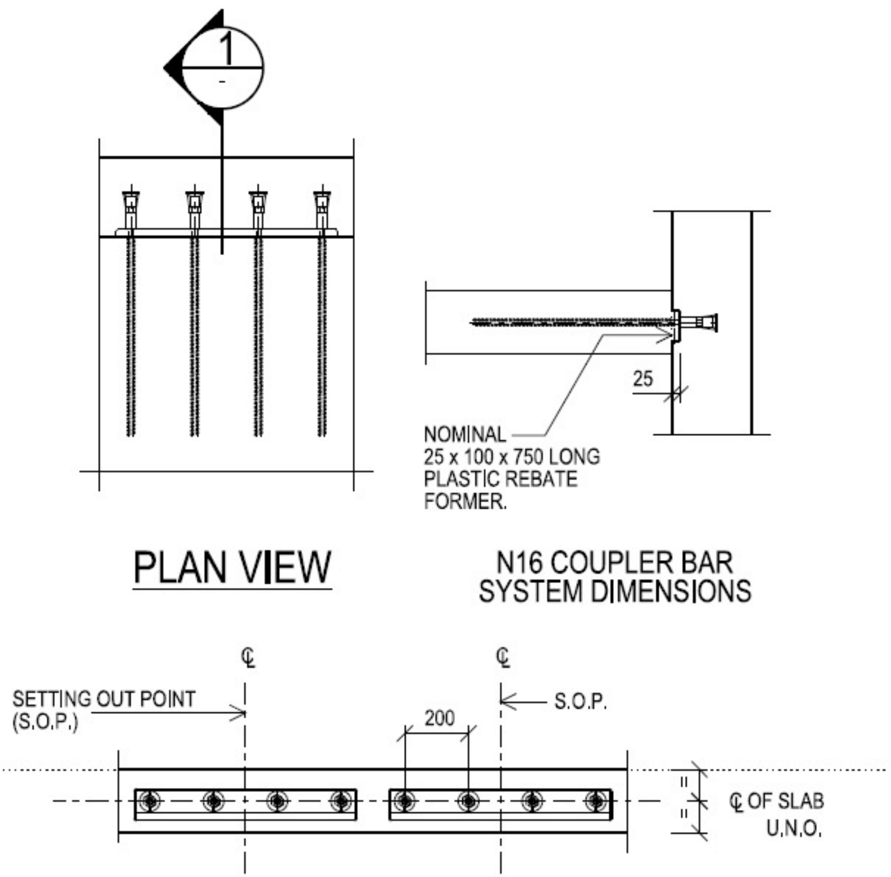


WALL/COLUMN TO SLAB/BEAM CONNECTION SCHEDULE

CONNECTION TYPE	DESCRIPTION
A	N16-150 REINFORCEMENT IN CONDUIT THROUGH WALL TOP AND N16-150 REIDBAR THREADED INSERTS BOTTOM.
B	2N20 TOP & BOTTOM, LAP 1000 MIN. INTO RETURN WALL PLUS COUPLERS.
C	N16-200 TOP & BOTTOM – REIDBAR THREADED INSERTS OR APPROVED EQUAL.
D	N16-200 CENTRAL – REIDBAR THREADED INSERTS OR APPROVED EQUAL.

Connection Specifications

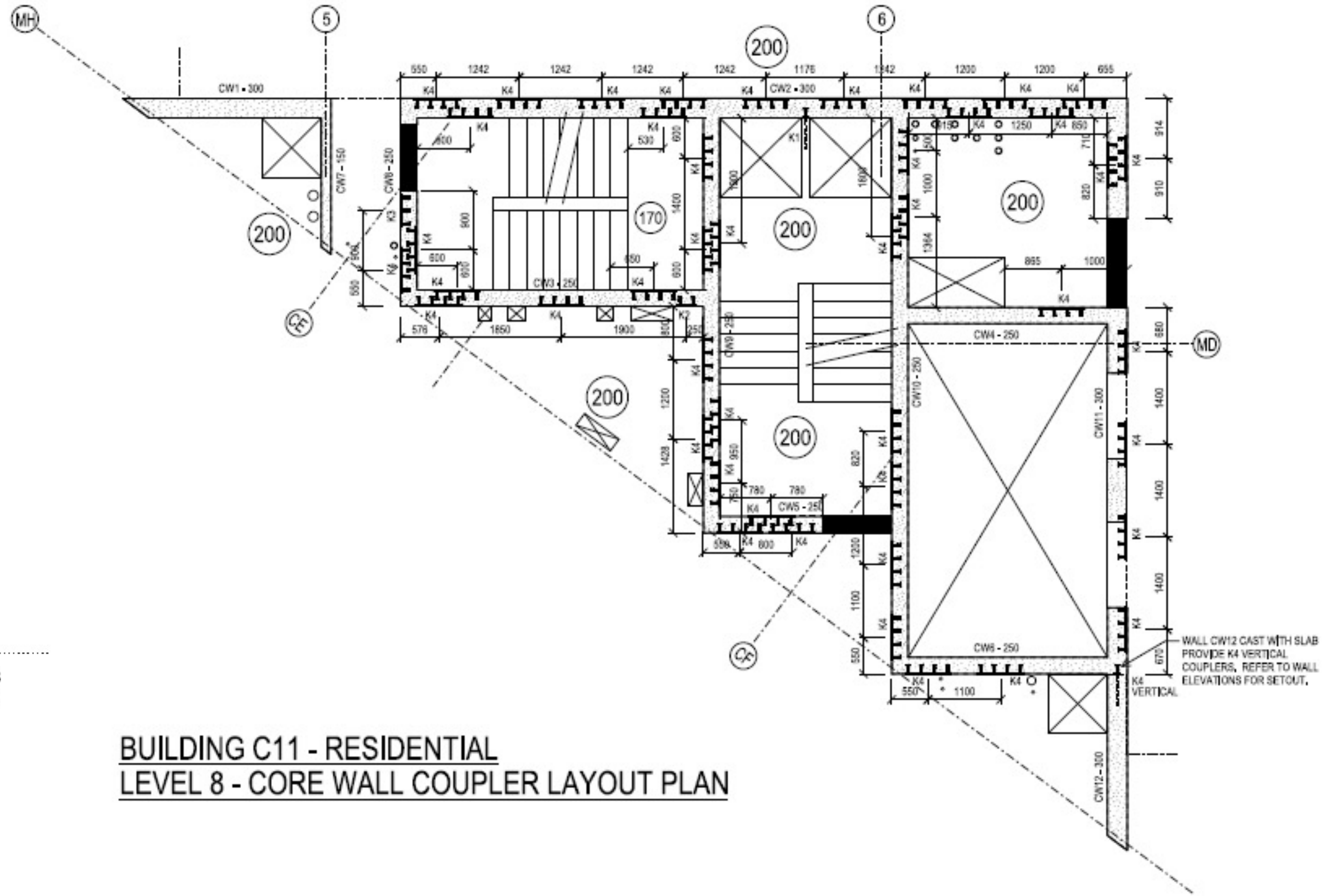
Reinforcing Connections for Jumpform Construction



PLAN VIEW

N16 COUPLER BAR
SYSTEM DIMENSIONS

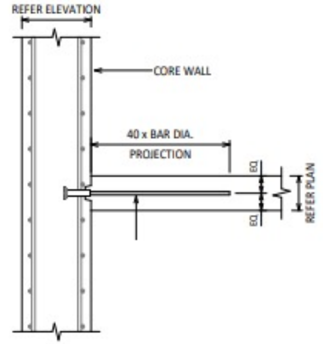
ELEVATION



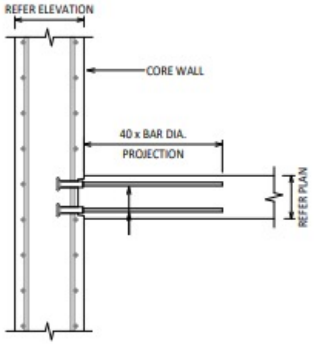
BUILDING C11 - RESIDENTIAL
LEVEL 8 - CORE WALL COUPLER LAYOUT PLAN

Connection Specifications

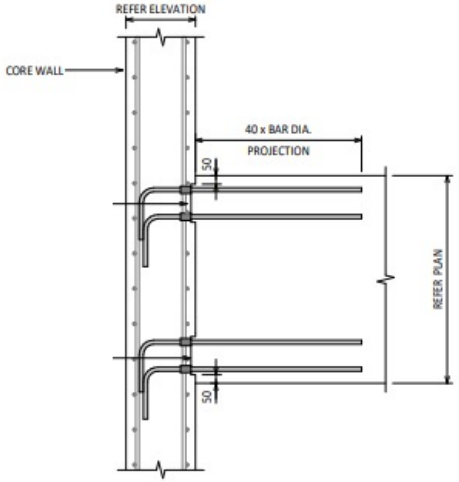
Reinforcing Connections for Jumpform Construction



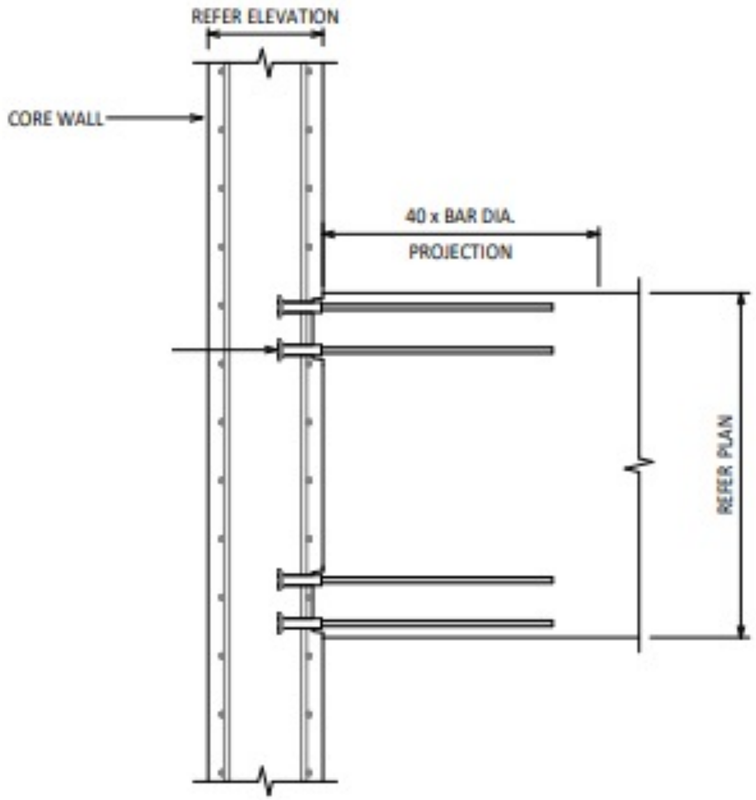
DETAIL A 1 : 20 **SLAB TO CORE WALL CONNECTION - THREADED BARS CENTRAL**



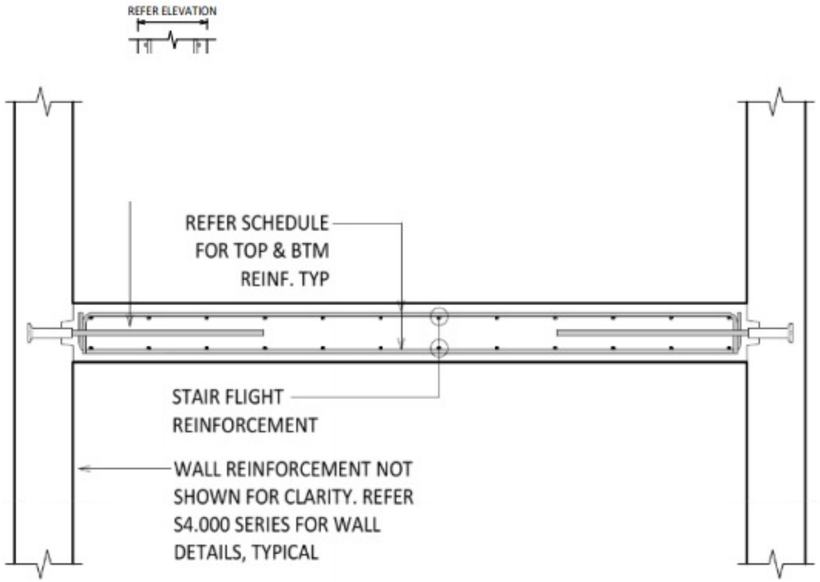
DETAIL B 1 : 20 **SLAB TO CORE WALL CONNECTION - THREADED BARS TOP & BTM**



DETAIL C 1 : 20 **TRANSFER SLAB/BEAM TO CORE WALL CONNECTION - 2 ROWS COGGED BARS TOP & BTM.**

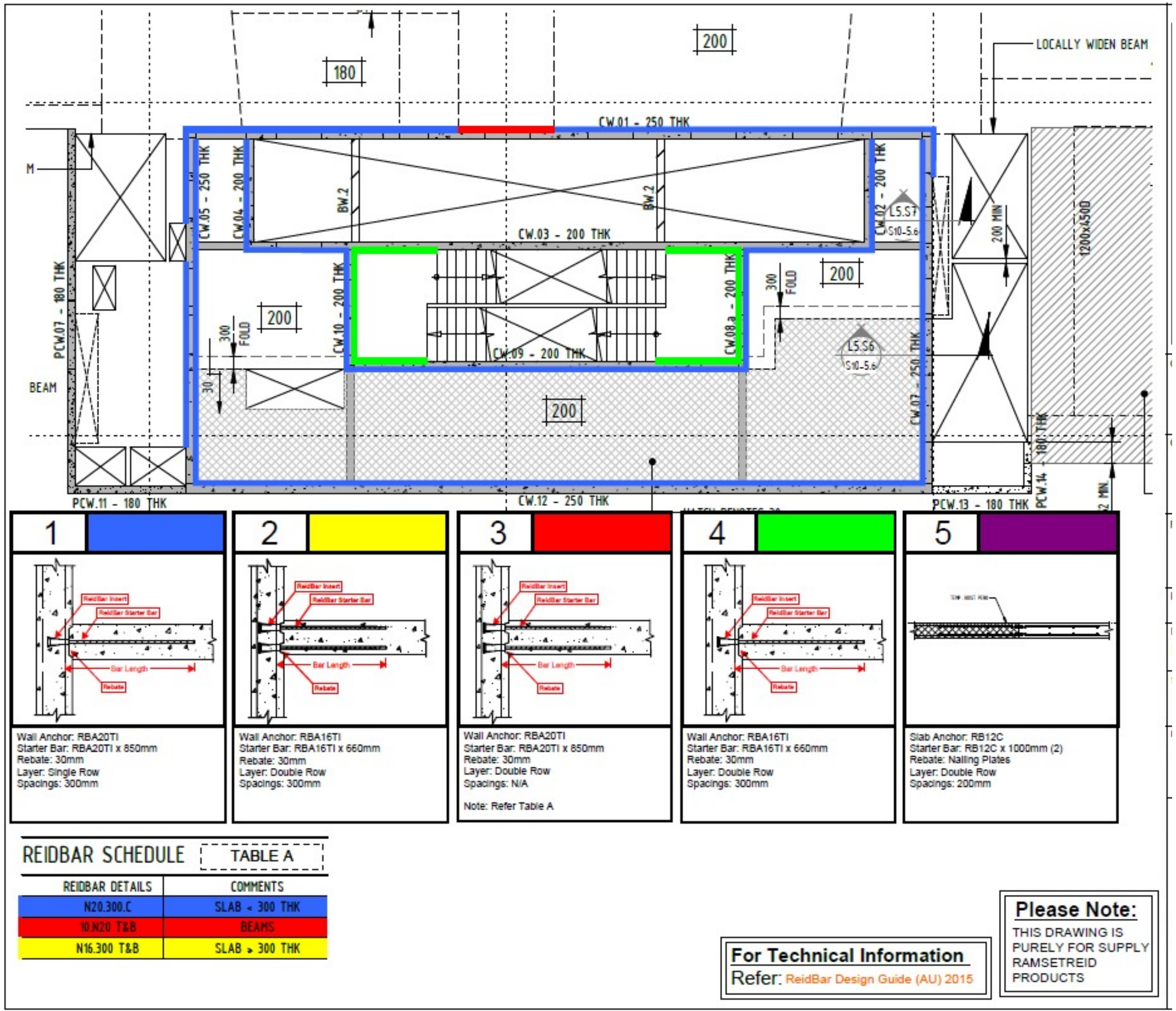


DETAIL D 1 : 20 **TRANSFER SLAB TO CORE WALL CONNECTION - 2 ROWS THREADED BARS TOP & BTM**

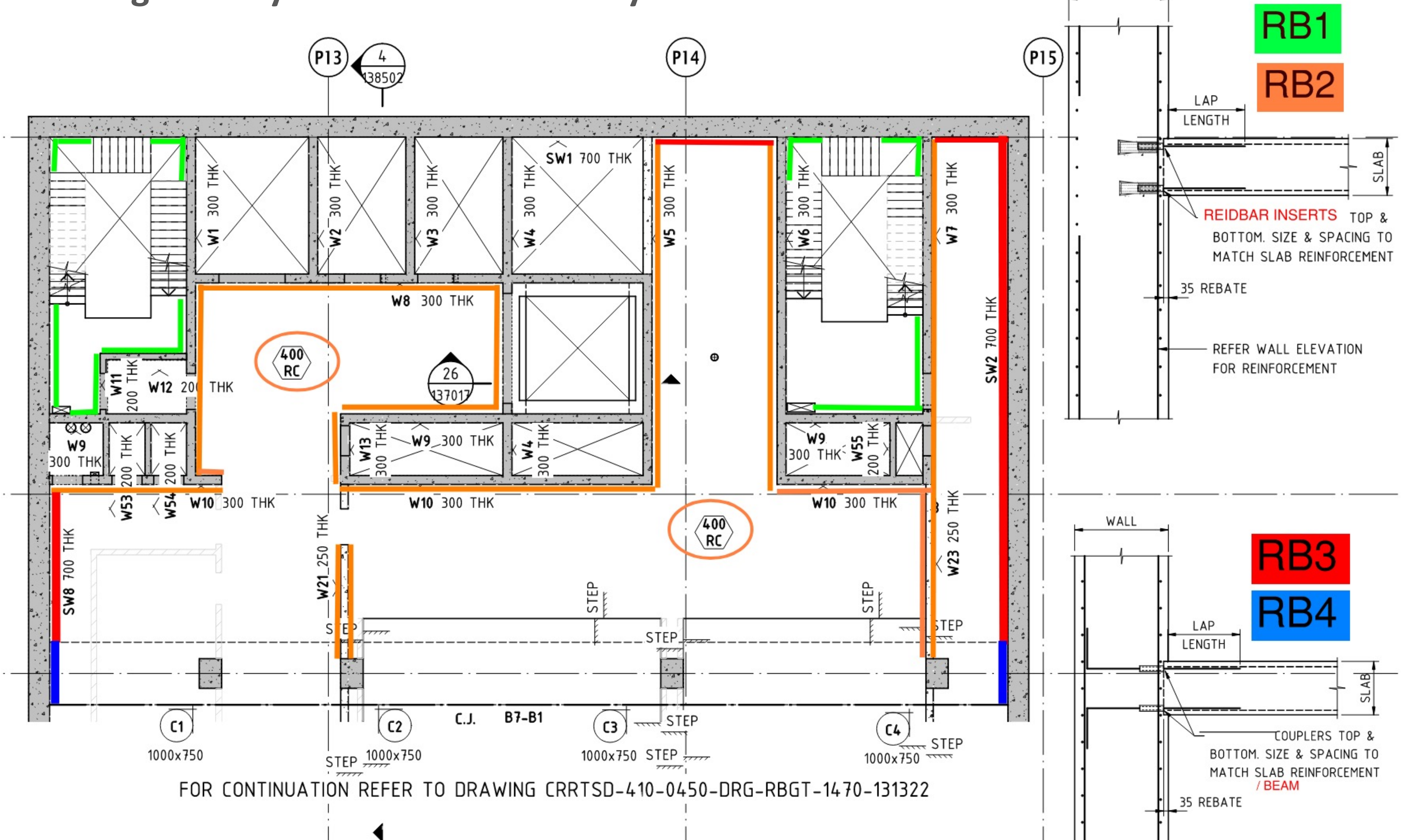


LANDING TO INSITU WALL CONNECTION

Shop Drawings for Layout of Connections by Formworker



Shop Drawings for Layout of Connections by Formworker



Thank You

Questions?

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