ELITE PRECAST CONCRETE LIMITED

PRELIMINARY HEIGHT GUIDE FOR RETAINING WALLS USING RETAINER-ROCK® CONCRETE BLOCKS

Document No. EPCL-2023-RRPHG-01 – P03

January 2024

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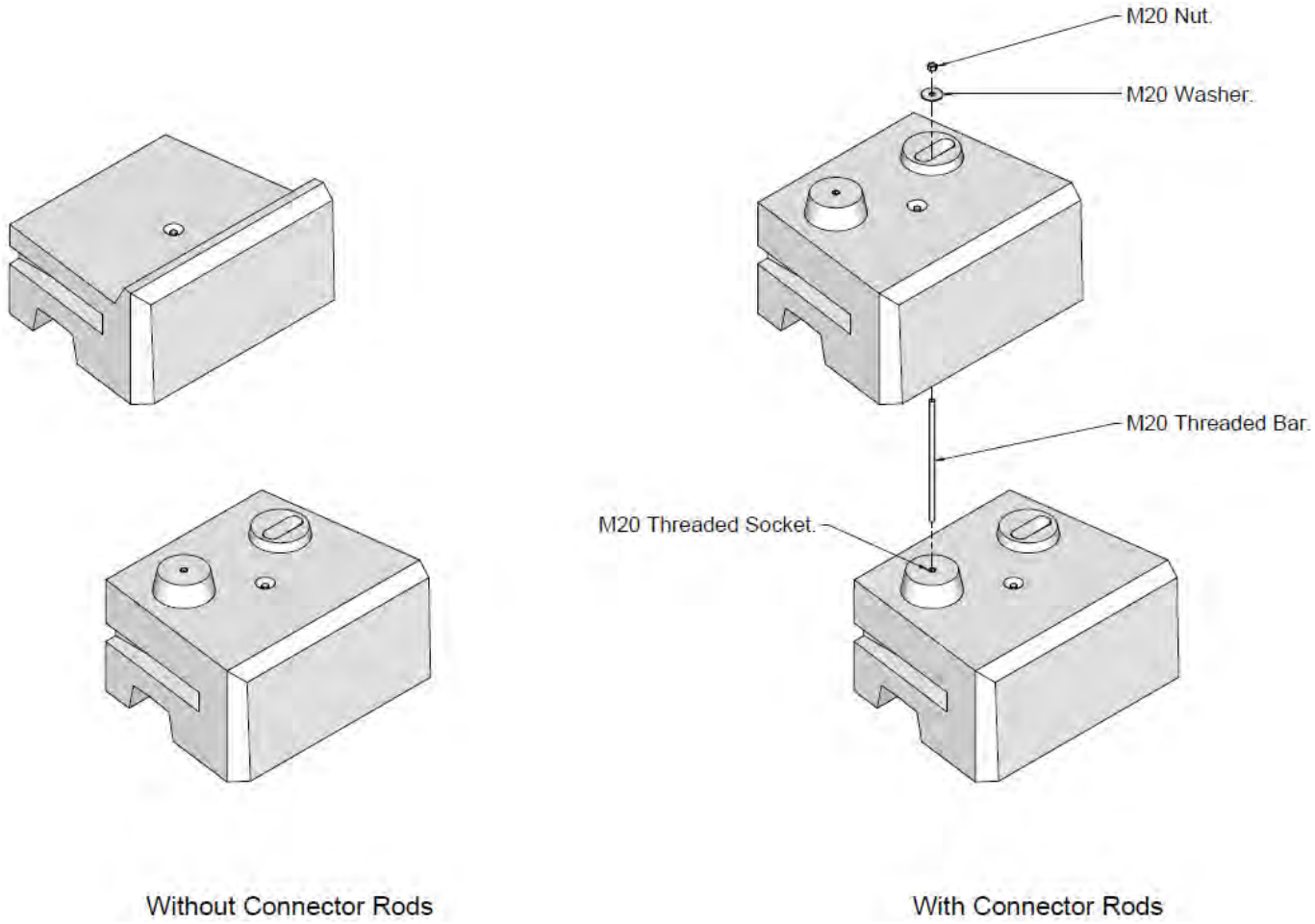
1. Introduction

This document has been prepared to provide guidance on appropriate wall heights when specifying retaining walls using Elite Precast Concrete Limited's Retainer-Rock® concrete blocks (a G-Block concept).

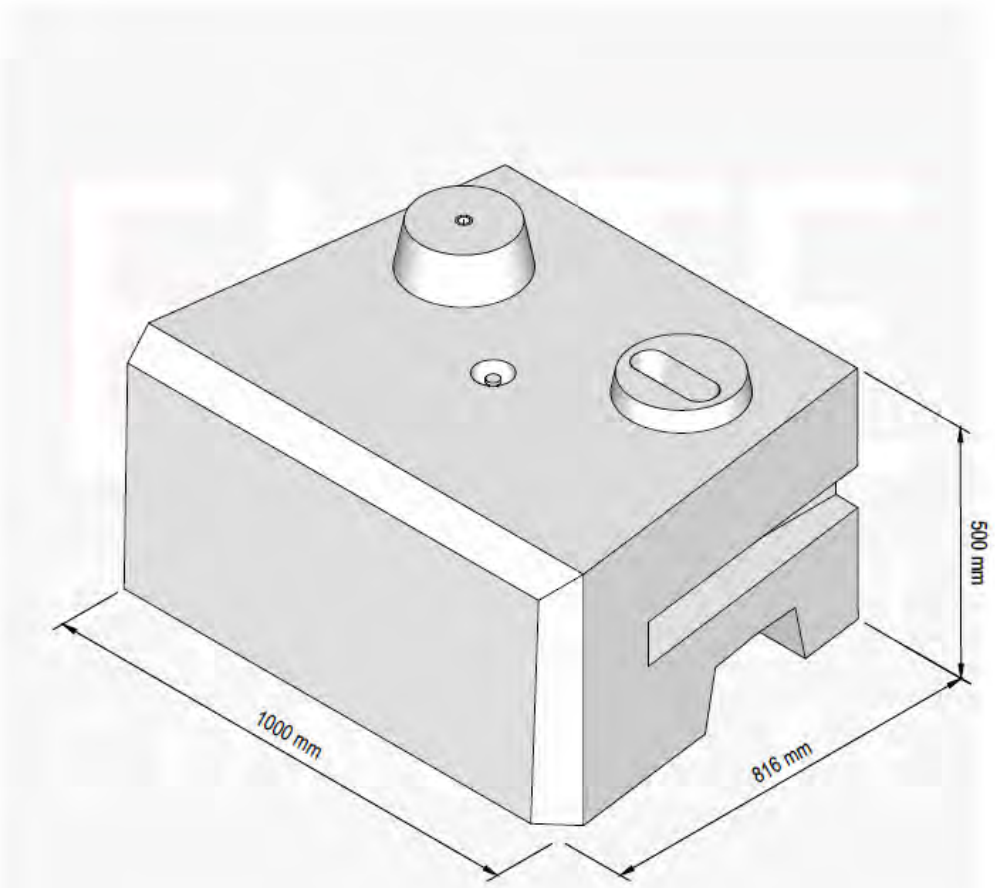
The system comprises precast blocks manufactured from high strength unreinforced concrete. The blocks are dry laid and incorporate interlocking elements to distribute loads between adjacent blocks. The 'standard' block size is supplemented by blocks of different dimensions to facilitate various wall layouts (see drawings EPC-RRK-001 to 006 on the following pages). In addition, the system allows for the use of vertical connector rods between successive rows of blocks and the foundation slab. This feature enables walls of greater height to be achieved using the same standard block size. The standard block and vertical connectors for the system are shown in Figure 1.1.

Figure 1.1 Standard blocks and vertical connectors



The purpose of this preliminary wall height guide is to enable a specifier to select an appropriate wall arrangement for typical earth retaining wall applications.

Main Full Block



Approx. Weight : 780kg

REV	DATE	REASON FOR ISSUE	DRN	APP	REV	DATE	REASON FOR ISSUE	DRN	APP
					O	05.01.24	For Information.	CTC	RMD

TITLE

RETAINER ROCK

ELITE PRECAST CONCRETE LTD
HALESFIELD 9, TELFORD
SHROPSHIRE TF7 4QW
www.eliteprecast.co.uk

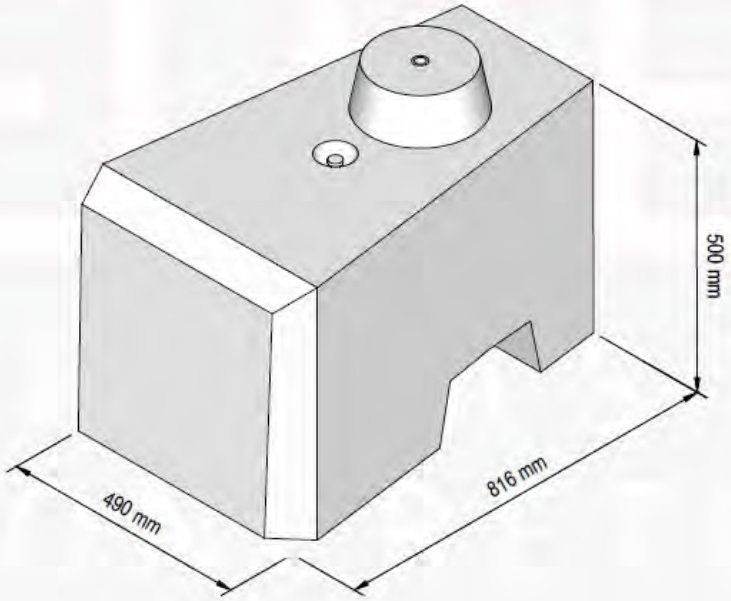
ELITE PRECAST CONCRETE

DRN	CHKD	DATE	SIZE	SCALE	DRG	REV
CTC	PJC	05-01-24	A4	1:10	EPC-RRK-001	O

EPC-RRK-001 - Retainer Rock® - Full Block

January 5, 2024

Main Half Block 1



Approx. Weight : 362kg

					O	05.01.24	For Information.	CTC	RMD
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EPC-RRK-002 - Retainer Rock® - Half Block

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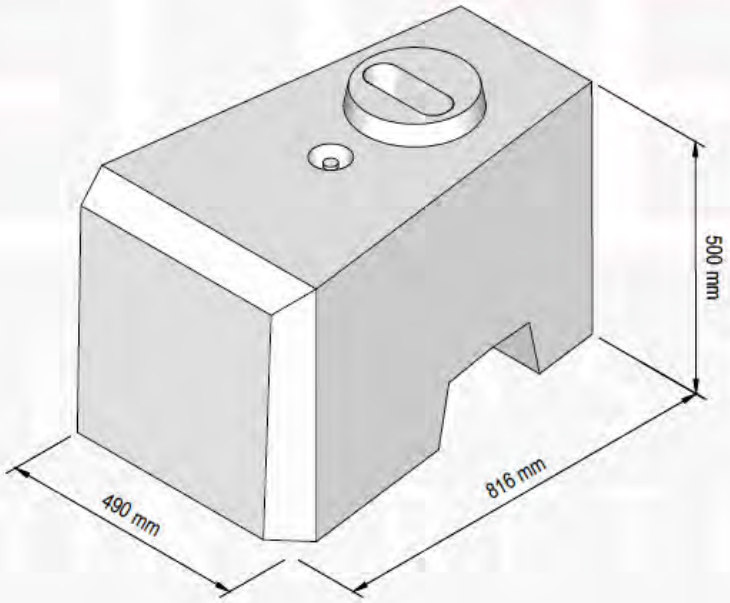
Main Half Block 2



Approx. Weight : 347kg

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CTC	PJC	05-01-24	A4	1:10	EPC-RRK-003	O

EPC-RRK-003 - Retainer Rock® - Half Block 2

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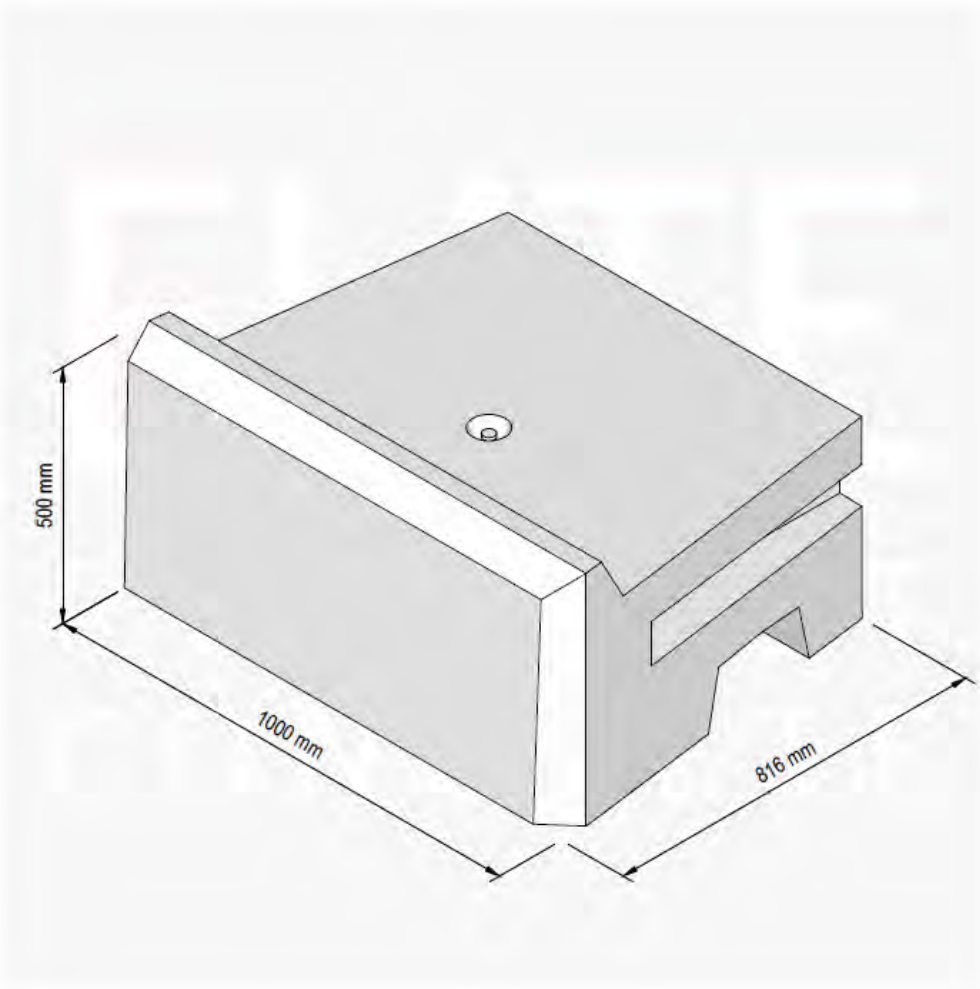
Main Top Block



Approx. Weight : 637kg

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CTC	PJC	05-01-24	A4	1:10	EPC-RRK-004	O

EPC-RRK-004 - Retainer Rock® - Full Top Block

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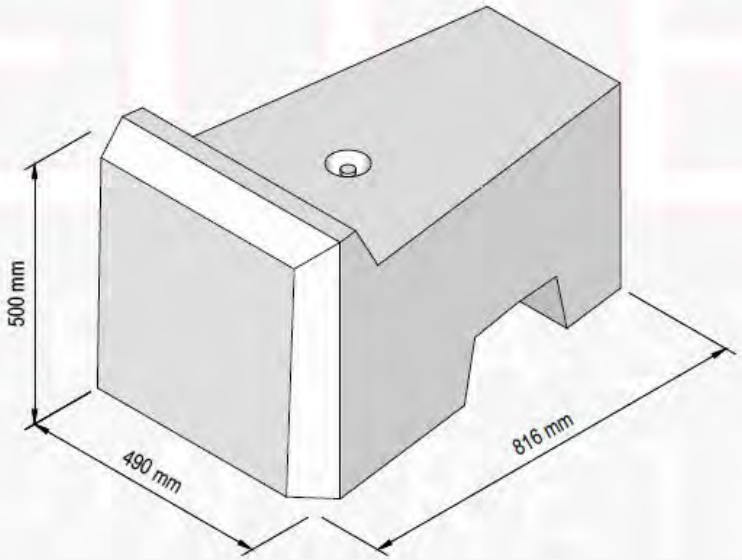
Half Top Block



Approx. Weight : 294kg

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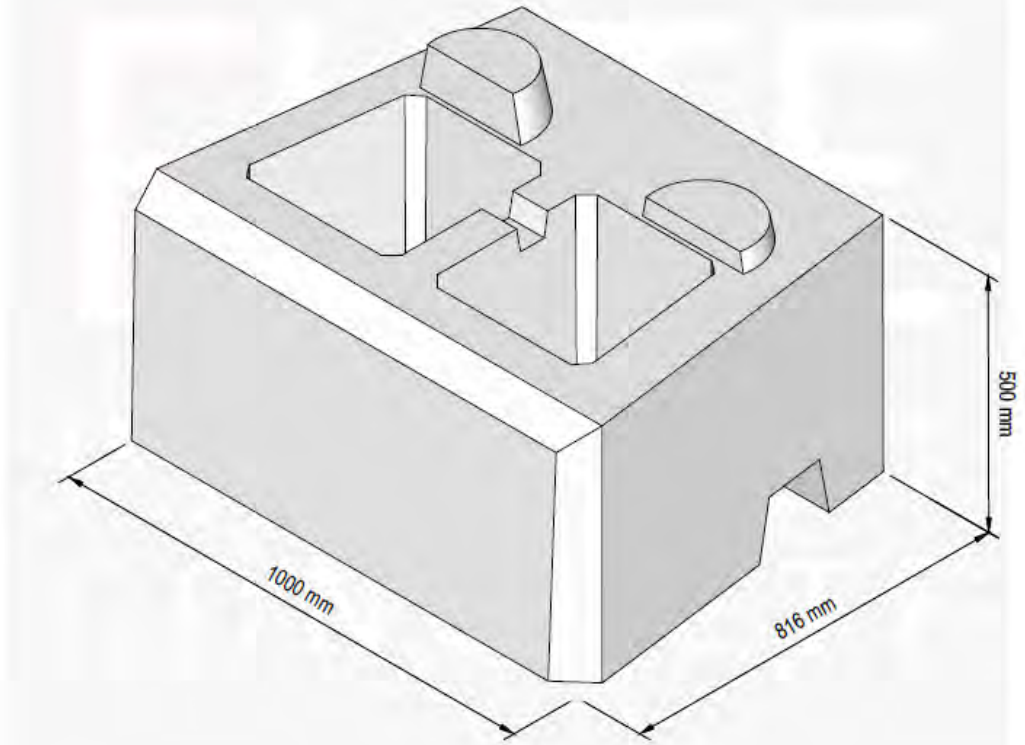
CTC	PJC	05-01-24	A4	1:10	EPC-RRK-005	O

EPC-RRK-005 - Retainer Rock® - Half Top Block

January 5, 2024

Hollow Block



Approx. Weight : 567kg

REV	DATE	REASON FOR ISSUE	DRN	APP	REV	DATE	REASON FOR ISSUE	DRN	APP
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DRN	CHKD	DATE	SIZE	SCALE	DRG	REV
CTC	PJC	05-01-24	A4	1:10	EPC-RRK-006	O

EPC-RRK-006 - Retainer Rock® - Hollow Block

January 5, 2024

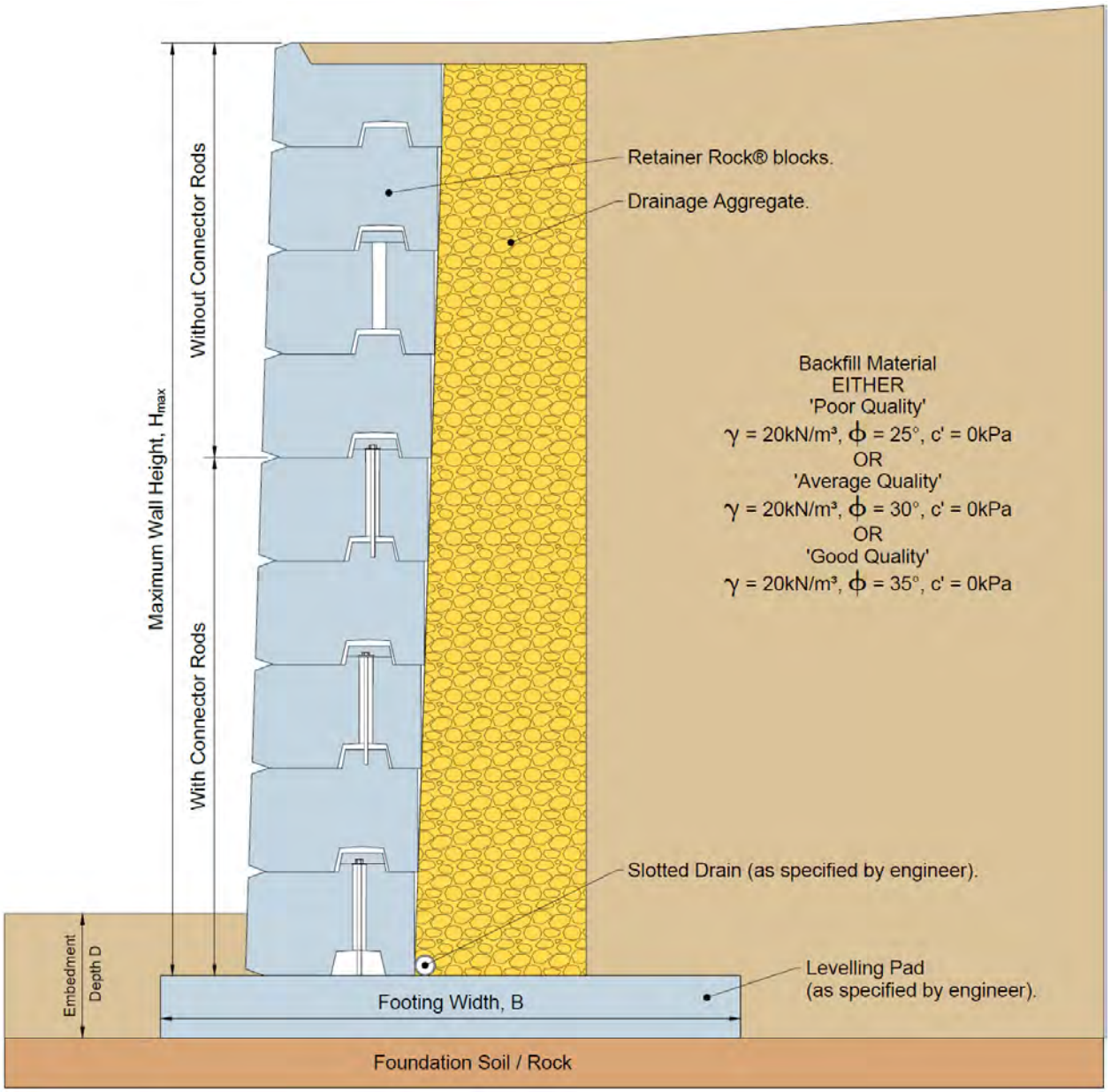
2. Design notes and assumptions

The design of retaining structures in the UK should conform with the requirements of the structural Eurocodes and associated UK National Annexes. These Eurocodes have largely replaced British Standards, although other documents exist that provide non-contradictory complimentary information for use with the Eurocodes. For this guidance document, the following standards are relevant:

- BS EN1990 (+ UK NA to BS EN1990) – Eurocode 0 – Basis of structural design
- BS EN1991 (+ UK NA to BS EN1991) – Eurocode 1 - Actions on structures
- BS EN1997 (+ UK NA to BS EN1997) – Eurocode 7 – Geotechnical design
- BS 8002:2015 – Code of practice for earth retaining structures (non-contradictory complimentary recommendations for use in conjunction with BS EN1997-1 and its UK NA)

Unlike other Elite Precast Concrete Ltd retaining wall systems, the Retainer-Rock® wall height guide is based upon a single width of block over the full retained height. To accommodate increasing wall heights, the lower sections are tied together and fixed to the foundation slab with threaded bars (see Figure 2.1). The wall guide will indicate at what height the threaded bar is required for different design cases and the maximum wall height.

Figure 2.1 Typical cross section through Retainer-Rock® wall



For this preliminary wall guide, the following typical design cases have been considered:

1. Level retained ground, no slope in front of the wall, no live surcharge load
2. Level retained ground, no slope in front of the wall, 10kPa live surcharge load (equivalent to normal road traffic loading)
3. Sloping retained ground at approximately 1v:2.5h, no slope in front of the wall, no live surcharge load.
4. Level retained ground, no slope in front of the wall, 5kPa pedestrian surcharge load and 0.75kN/m handrail loading

Three different types of backfill behind the wall have been considered. These have friction angles of ϕ' = 25°, 30° and 35° representing 'Poor' quality site won Silt/Clay, 'Average' quality site won Sand/Gravel and 'Good' quality imported granular fill (e.g. Class 6N fill) respectively. If the Designer /Installer intends to use site won fill without adequate information from a site investigation report to assess the backfill quality, a conservative approach should be adopted and 'Poor' quality backfill assumed for the block layout using the relevant Preliminary Height guide'

For each of the four design cases, the following assumptions have been made:

- The wall sections have been designed for the ultimate limit state (ULS) in accordance with BS EN1997-1 to ensure adequate resistance against internal stability failure between successive layers of blocks and the foundation slab. Partial factor sets for Design Approach 1, Combinations 1 and 2 have been considered.
- The designs assume a competent foundation. Bearing capacity resistance, forward sliding and overall stability of the whole structure have not been assessed.
- Passive pressure in front of the blocks has been conservatively ignored. However, it is recommended that a minimum 200mm of fill is placed above the toe of the foundation slab in front of the blocks.
- The active earth pressure acting along the back of the wall is inclined at an angle, δ_a, where $\delta_a = \tan^{-1}(0.66\tan\phi')$
- The interfaces between successive concrete blocks is modelled with no tension, thereby allowing overturning to occur.
- The horizontal interfaces between the concrete blocks take account of the shear strength of the circular connector nibs on the top of each block.
- The connector rods have been modelled with a design tensile resistance of 87.4kN per block. The design strength of these connections is limited by the strength of the M20 cast-in rebar couplers, not the tensile strength of the M20 threaded rod.
- Density of the Retainer-Rock® blocks taken as γ = 22.5kN/m³
- Free draining fill material will be placed behind the retaining wall and drainage measures will prevent groundwater from building up behind the wall. The wall will be modelled with no retained water pressures.
- The free draining fill material immediately behind the wall is assumed to have the same soil parameters as the retained fill. This is a conservative assumption, especially for 'Poor' and 'Average' quality fills.
- The width of the footing, B, is dependent on the bearing capacity of the foundation soil/rock. For preliminary purposes, it is reasonable to assume a value of B = 0.6 × H, where H is the total height of the blocks forming the wall. The width of the footing should not be less than 1.40m.
- The embedment depth, D, is taken to the underside of the footing. For preliminary purposes, embedment depth may be taken as the maximum of 0.50m or H/10.
- For preliminary purposes, the thickness of the footing may be assumed to be a minimum of 0.30m.
- The backslope angle, β, is taken as 21.8° (1v:2.5h) for 'Average' & 'Good' quality backfill. For 'Poor' quality backfill, β, is taken as 20.4° (1v:2.7h) to ensure the slope is stable when assessed to BS EN1997-1, Design Approach 1, Combination 2 partial factors.

3. Preliminary wall height guide charts

The results of the wall analysis are summarised in Table 3.1 and shown graphically on the following pages. These show the maximum wall heights that can be achieved with and without the use of the vertical connector rods for each design case and backfill type.

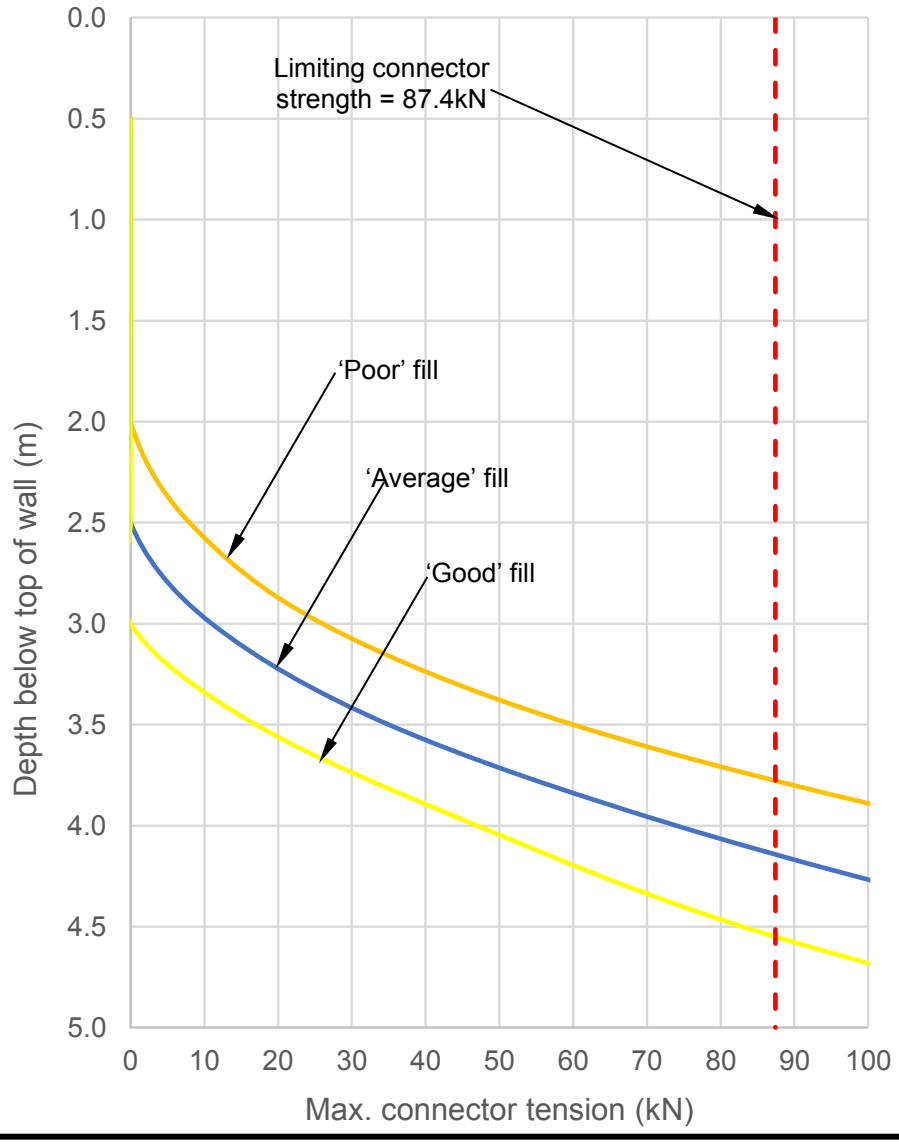
Table 3.1 – Maximum wall heights

Design Case	Inclusions	'Poor' quality fill		'Average' quality fill		'Good' quality fill	
		Without connectors (m)	With connectors (m)	Without connectors (m)	With connectors (m)	Without connectors (m)	With connectors (m)
1	Surcharge × Backslope × Handrail ×	2.0	3.5	2.5	4.0	3.0	4.5
2	Surcharge ✓ Backslope × Handrail ×	1.5	3.0	1.5	3.5	2.0	3.5
3	Surcharge × Backslope ✓ Handrail ×	1.5	3.0	2.0	3.5	2.5	3.5
4	Surcharge ✓ Backslope × Handrail ✓	1.5	3.0	2.0	3.5	2.0	4.0

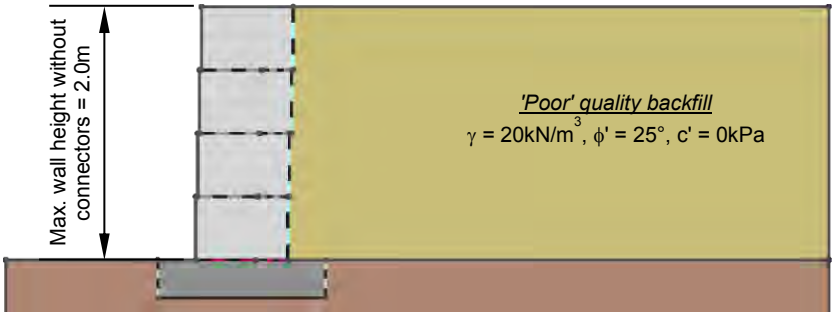
Design case 1 – No live load surcharge / No backslope

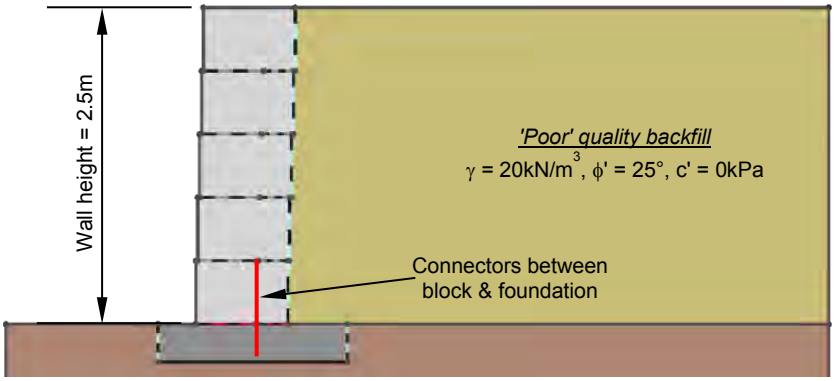
No. of blocks	Wall height (m)	'Poor' quality fill		'Average' quality fill		'Good' quality fill	
		Connected blocks	Tension (kN)	Connected blocks	Tension (kN)	Connected blocks	Tension (kN)
1	0.5	0	0	0	0	0	0
2	1.0	0	0	0	0	0	0
3	1.5	0	0	0	0	0	0
4	2.0	0	0	0	0	0	0
5	2.5	1	8	0	0	0	0
6	3.0	2	26	1	11	0	0
7	3.5	3	60	2	35	1	17
8	4.0	4	**113**	3	74	2	47
9	4.5	5	**180**	4	**125**	3	83
10	5.0	6	**270**	5	**185**	4	**133**

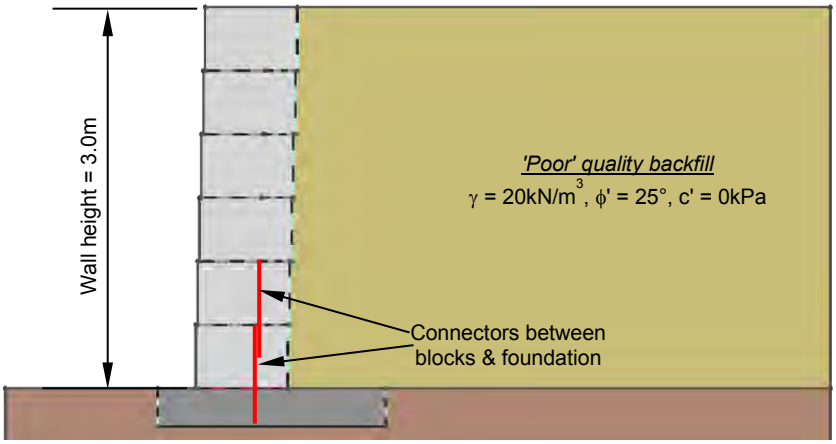
Design case 1 – Connector tension with depth below top of wall

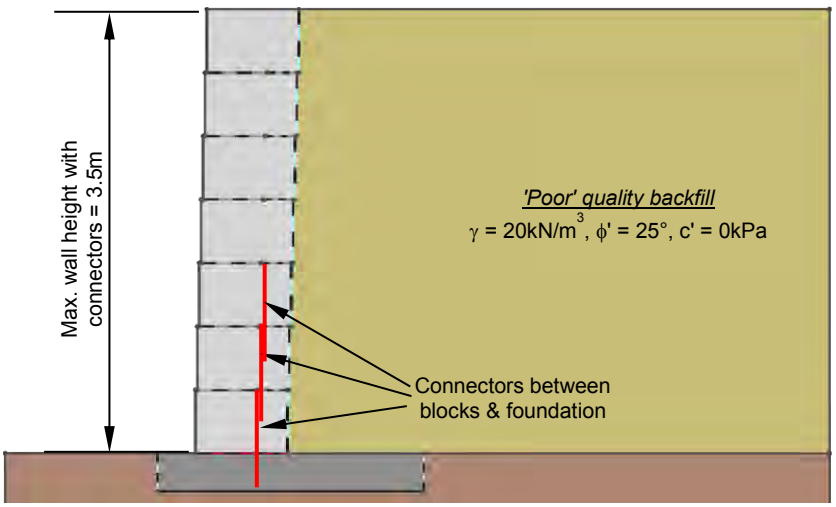


Design case 1 – No live load surcharge / No backslope – 'Poor' quality fill

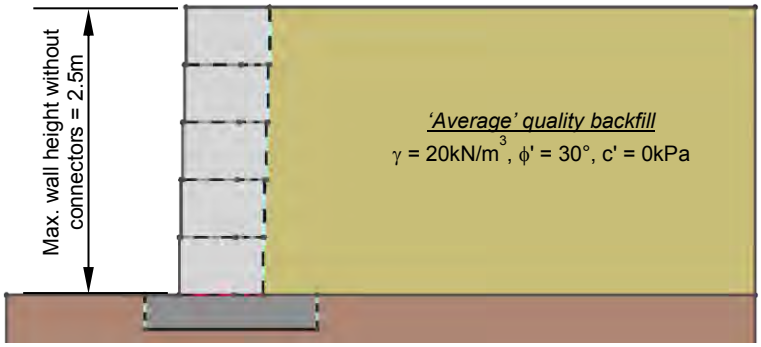


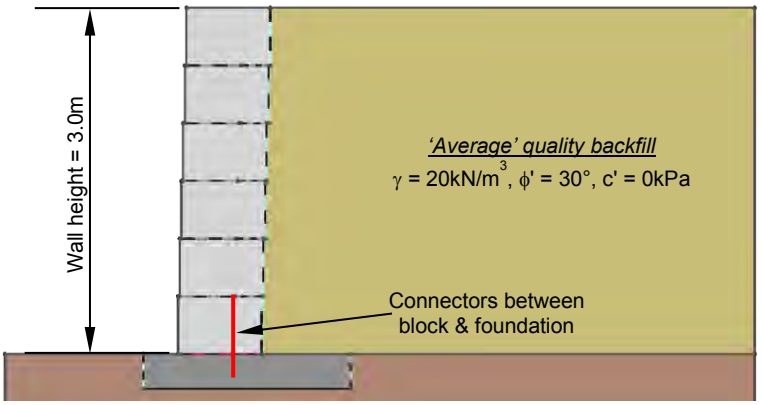


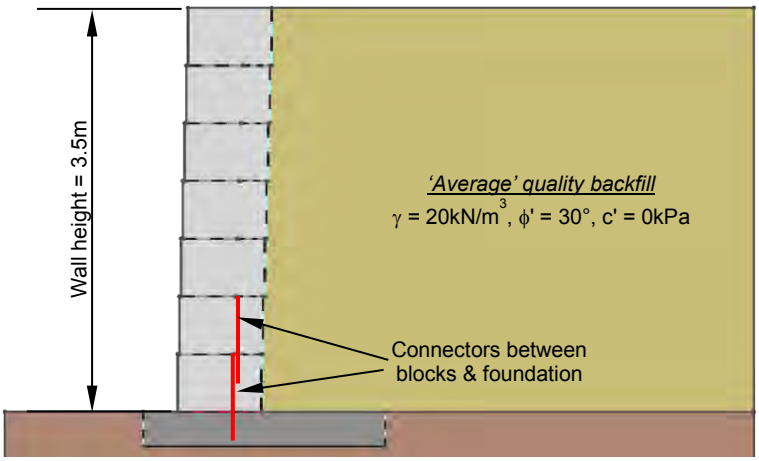


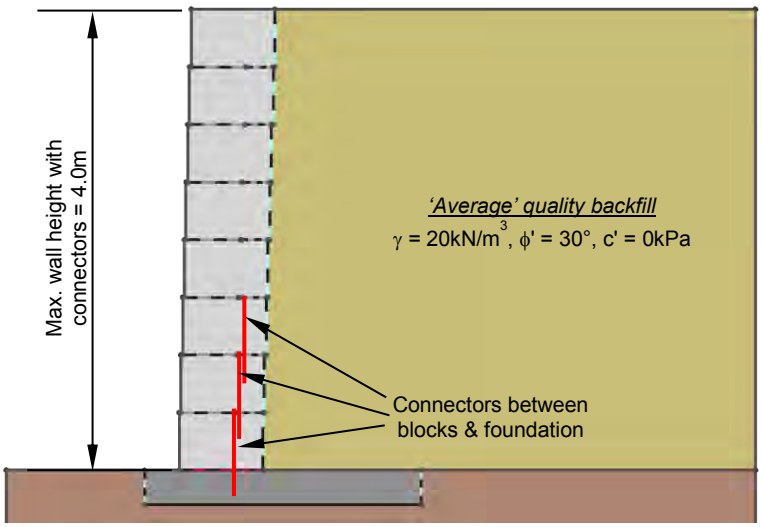


Design case 1 – No live load surcharge / No backslope – 'Average' quality fill

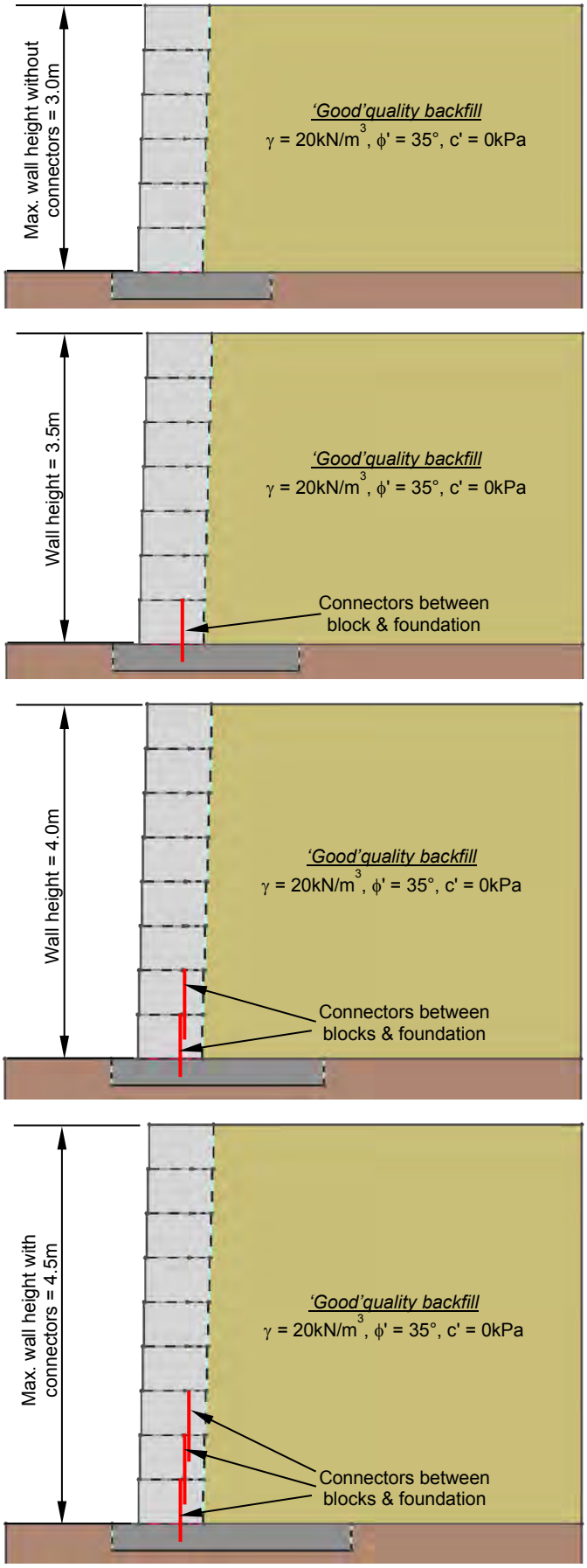








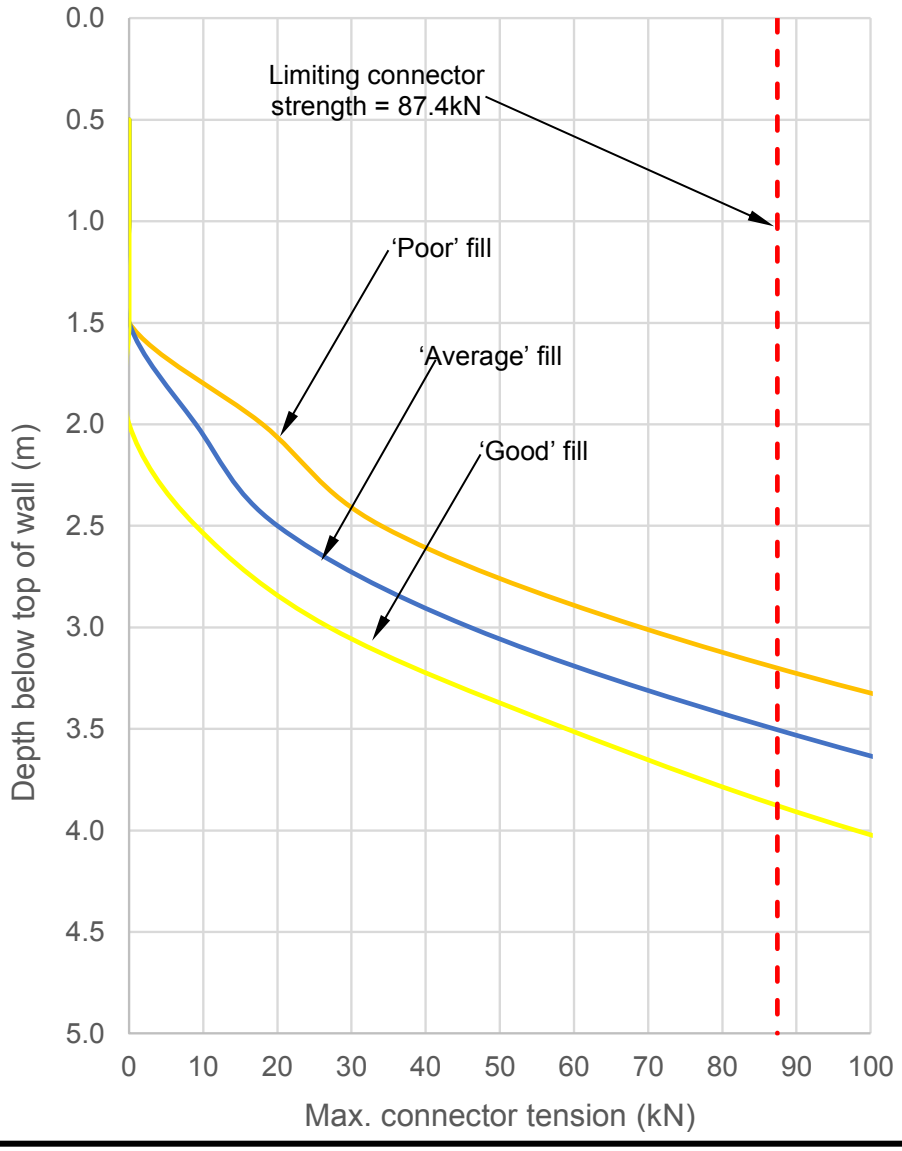
Design case 1 – No live load surcharge / No backslope – 'Good' quality fill



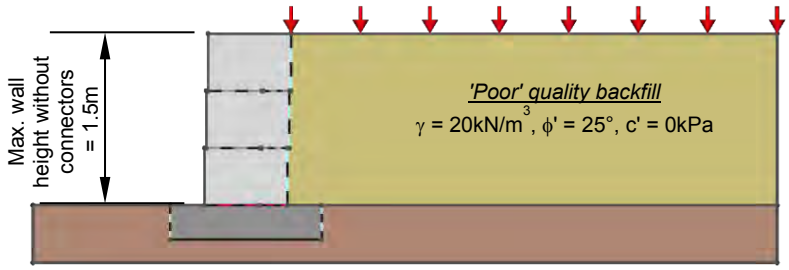
Design case 2 – 10kPa live load surcharge / No backslope

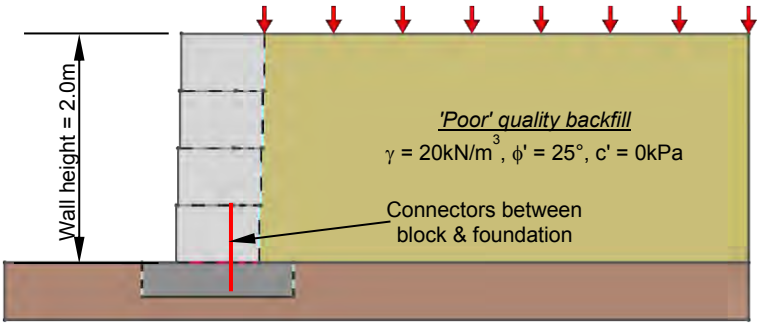
No. of blocks	Wall height (m)	'Poor' quality fill		'Average' quality fill		'Good' quality fill	
		Connected blocks	Tension (kN)	Connected blocks	Tension (kN)	Connected blocks	Tension (kN)
1	0.5	0	0	0	0	0	0
2	1.0	0	0	0	0	0	0
3	1.5	0	0	0	0	0	0
4	2.0	1	18	1	9	0	0
5	2.5	2	34	2	20	1	9
6	3.0	3	69	3	46	2	27
7	3.5	4	**120**	4	87	3	59
8	4.0	5	**190**	5	**140**	4	**98**
9	4.5	6	**275**	6	**205**	5	**150**
10	5.0	7	**390**	7	**290**	6	**215**

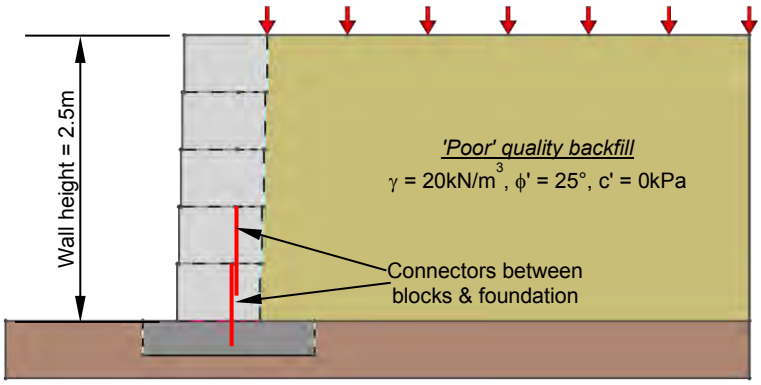
Design case 2 – Connector tension with depth below top of wall

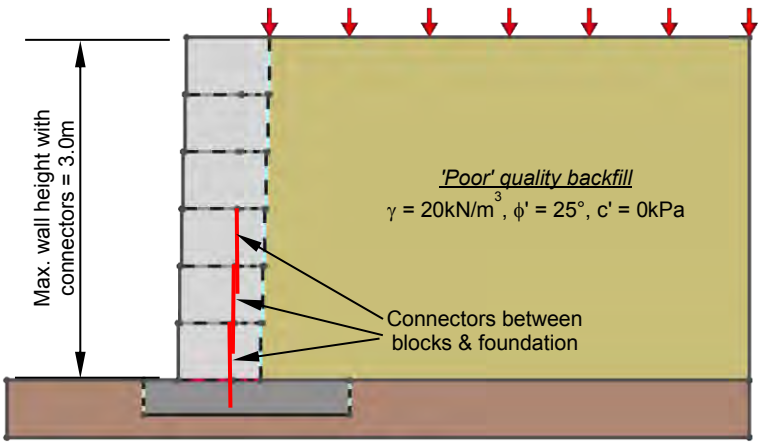


Design case 2 – 10kPa live load surcharge / No backslope – 'Poor' quality fill

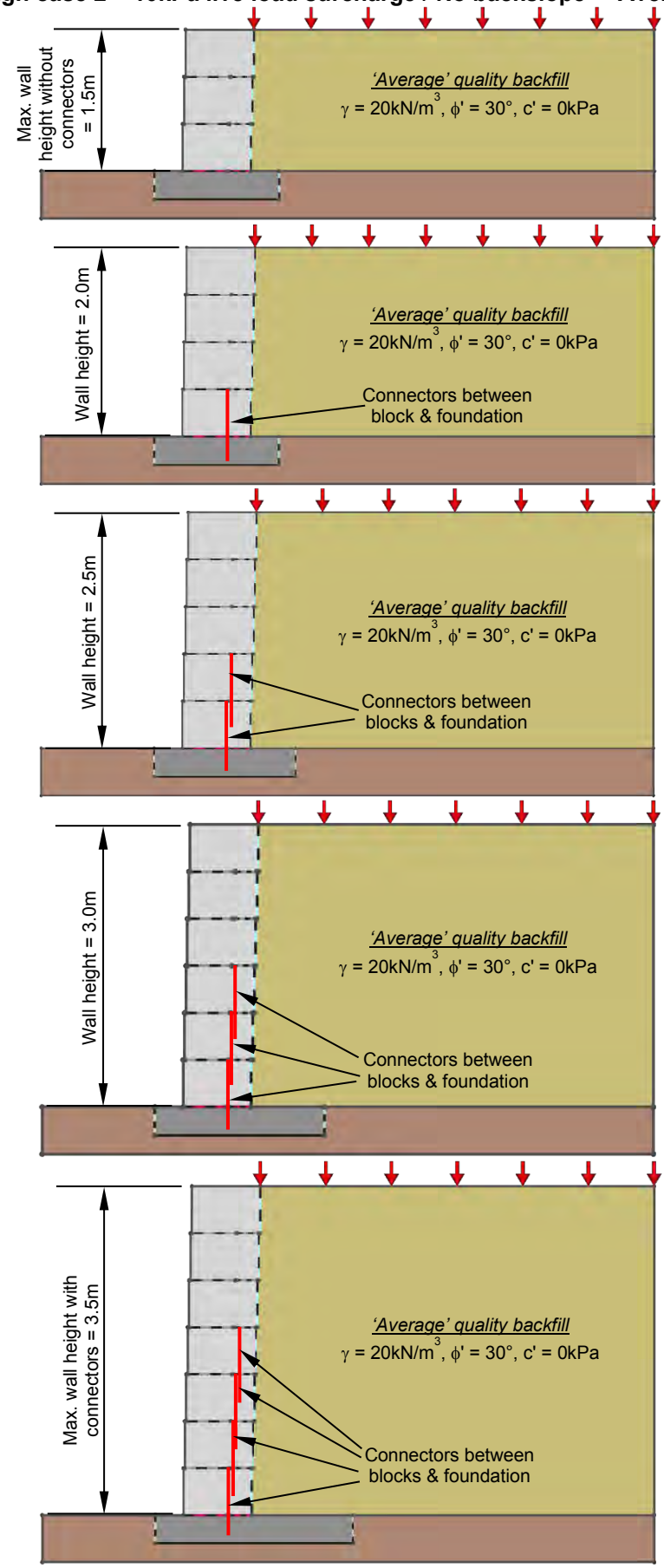




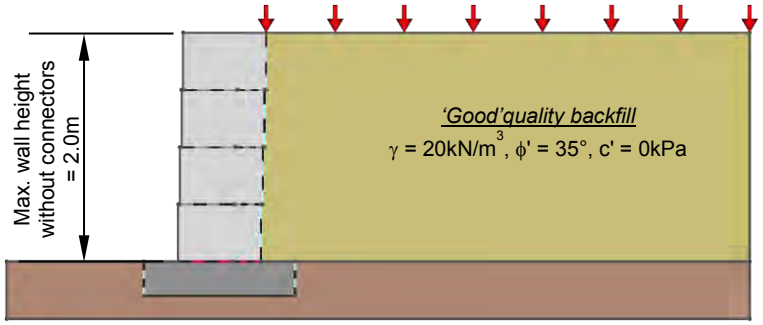


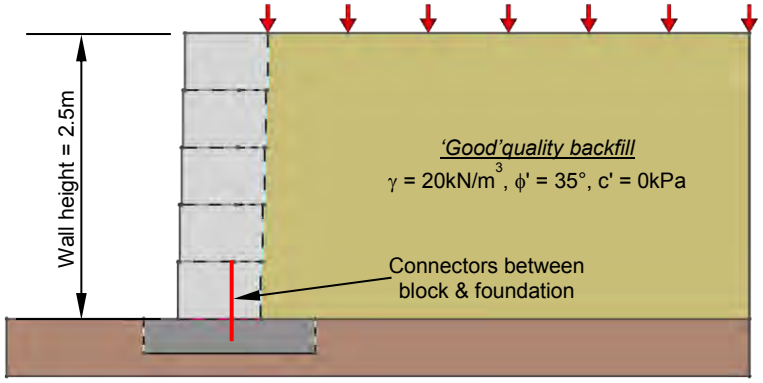


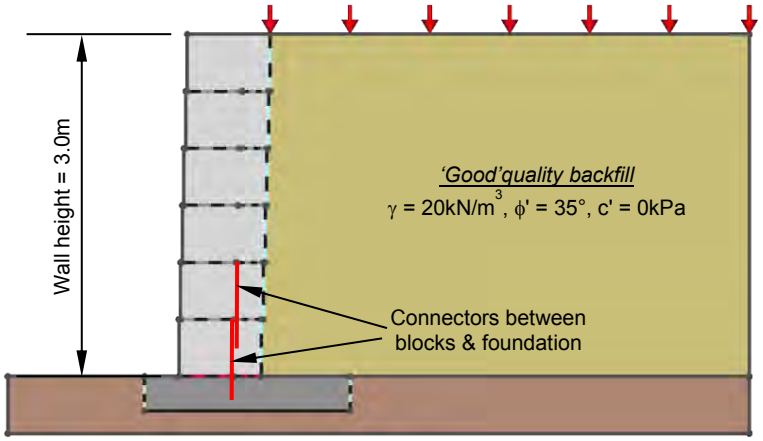
Design case 2 – 10kPa live load surcharge / No backslope – 'Average' quality fill

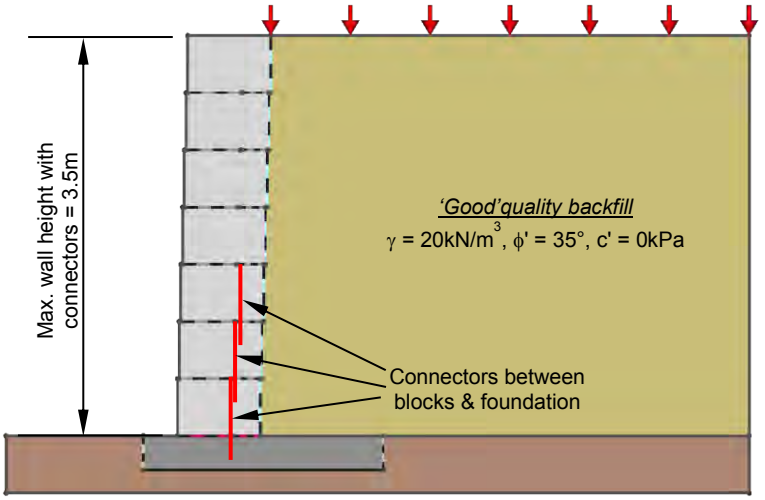


Design case 2 – 10kPa live load surcharge / No backslope – 'Good' quality fill





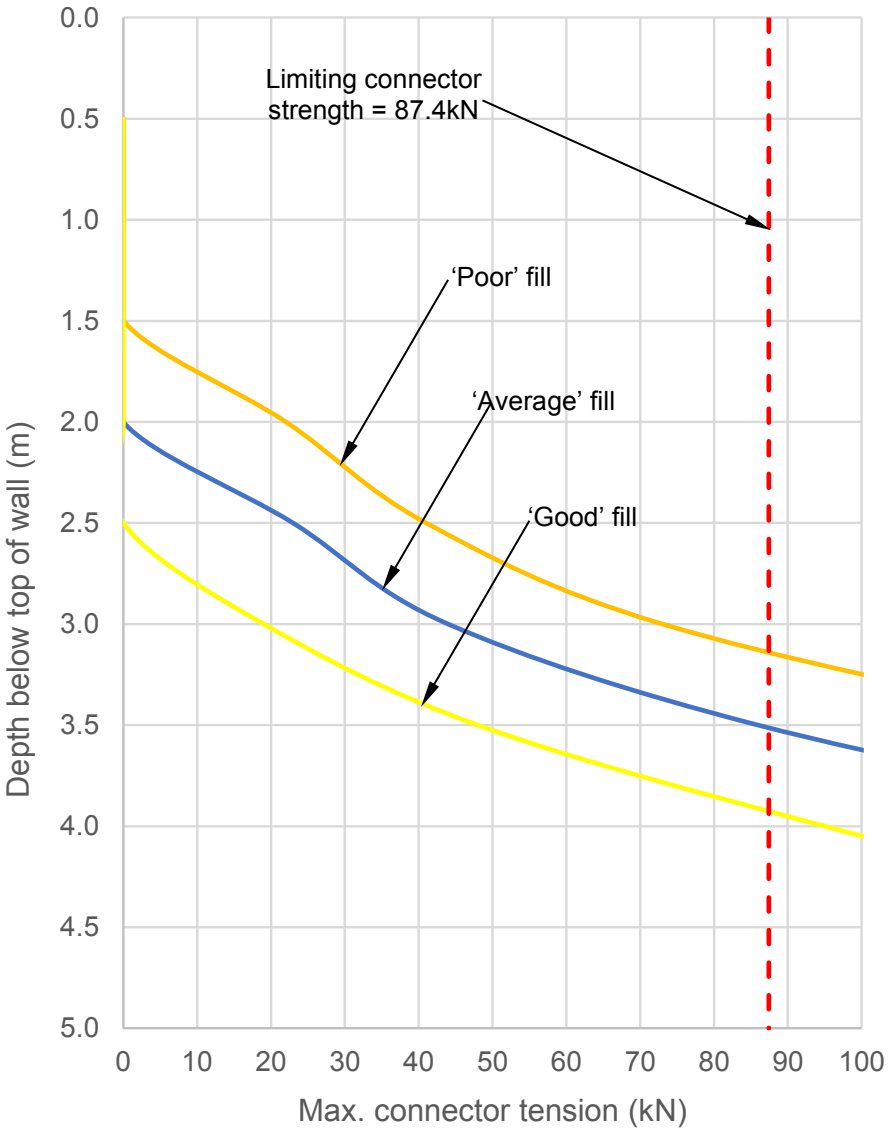




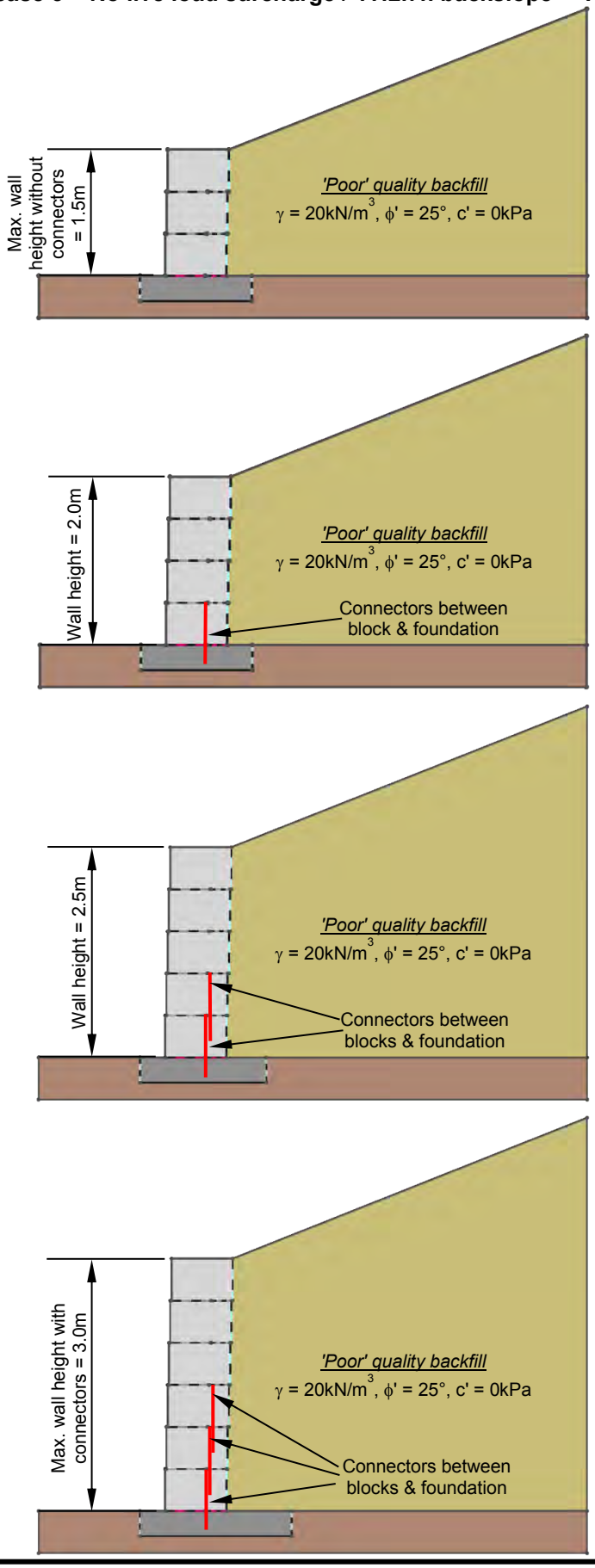
Design case 3 – No live load surcharge / 1v:2.7h backslope for 'Poor' quality fill/ 1v:2.5h backslope for 'Average' & 'Good' quality fill

No. of blocks	Wall height (m)	'Poor' quality fill		'Average' quality fill		'Good' quality fill	
		Connected blocks	Tension (kN)	Connected blocks	Tension (kN)	Connected blocks	Tension (kN)
1	0.5	0	0	0	0	0	0
2	1.0	0	0	0	0	0	0
3	1.5	0	0	0	0	0	0
4	2.0	1	22	0	0	0	0
5	2.5	2	41	1	23	0	0
6	3.0	3	73	2	44	1	19
7	3.5	4	**133**	3	86	2	48
8	4.0	5	**210**	4	**150**	3	**95**
9	4.5	6	**310**	5	**220**	4	**151**
10	5.0	7	**440**	6	**330**	5	**225**

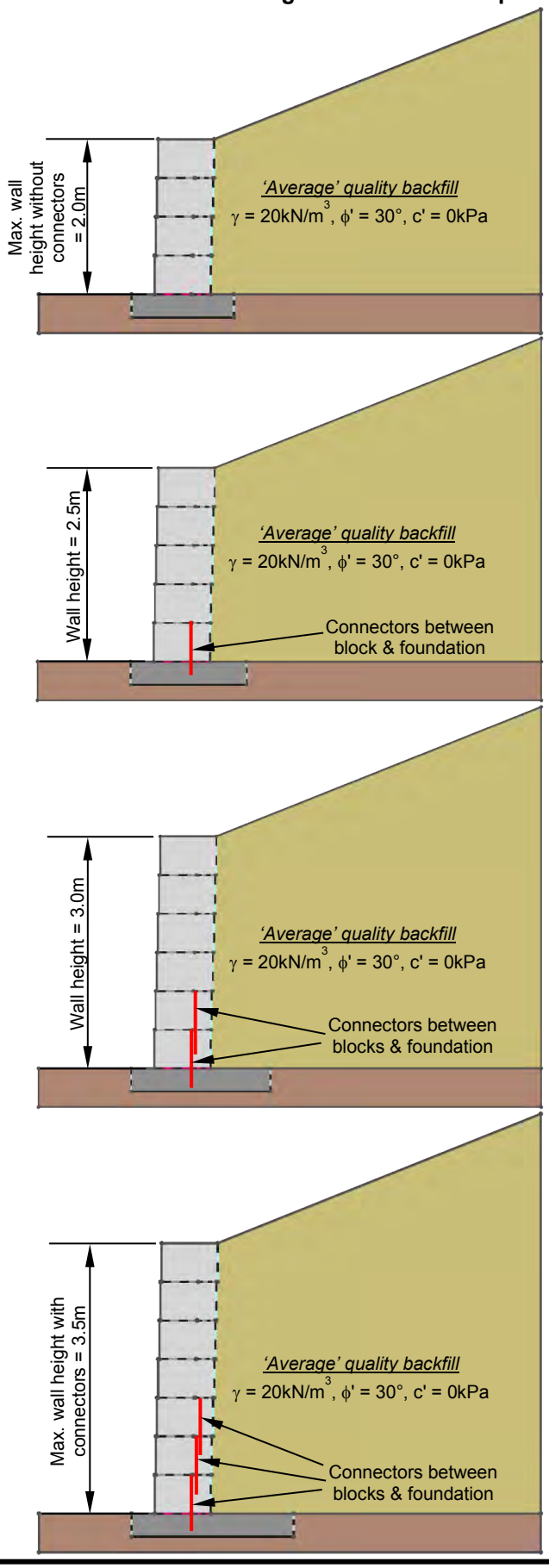
Design case 3 – Connector tension with depth below top of wall



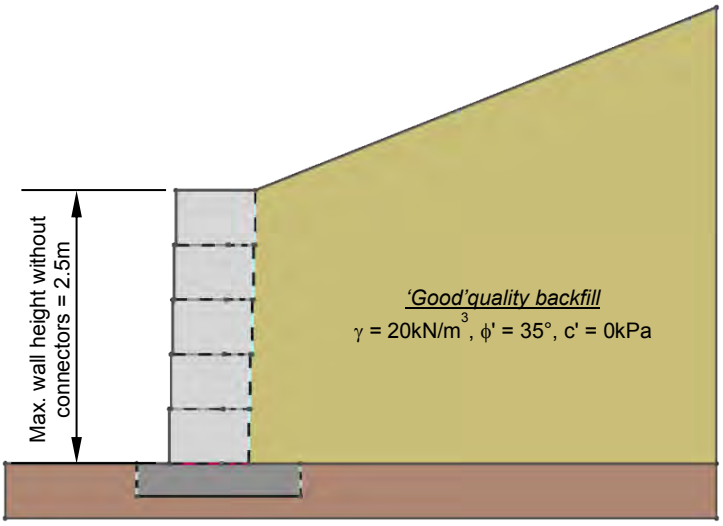
Design case 3 – No live load surcharge / 1v:2.7h backslope – 'Poor' quality fill

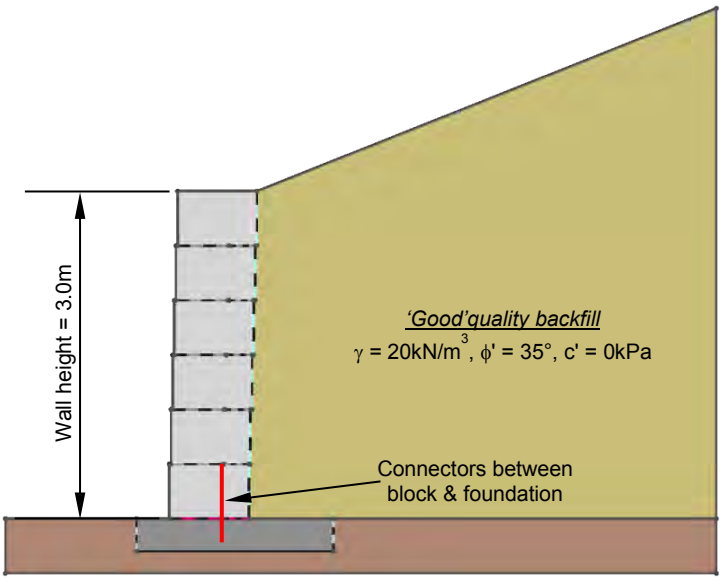


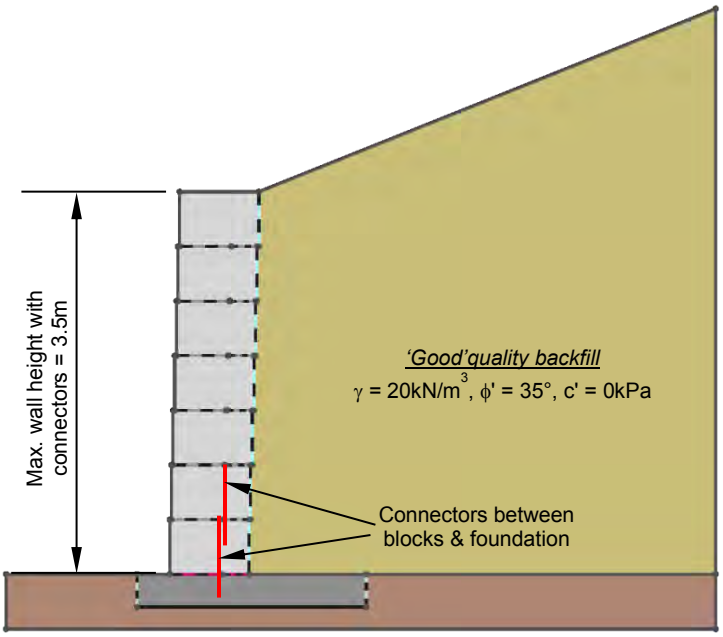
Design case 3 – No live load surcharge / 1v:2.5h backslope – 'Average' quality fill



Design case 3 – No live load surcharge / 1v:2.5h backslope – 'Good' quality fill



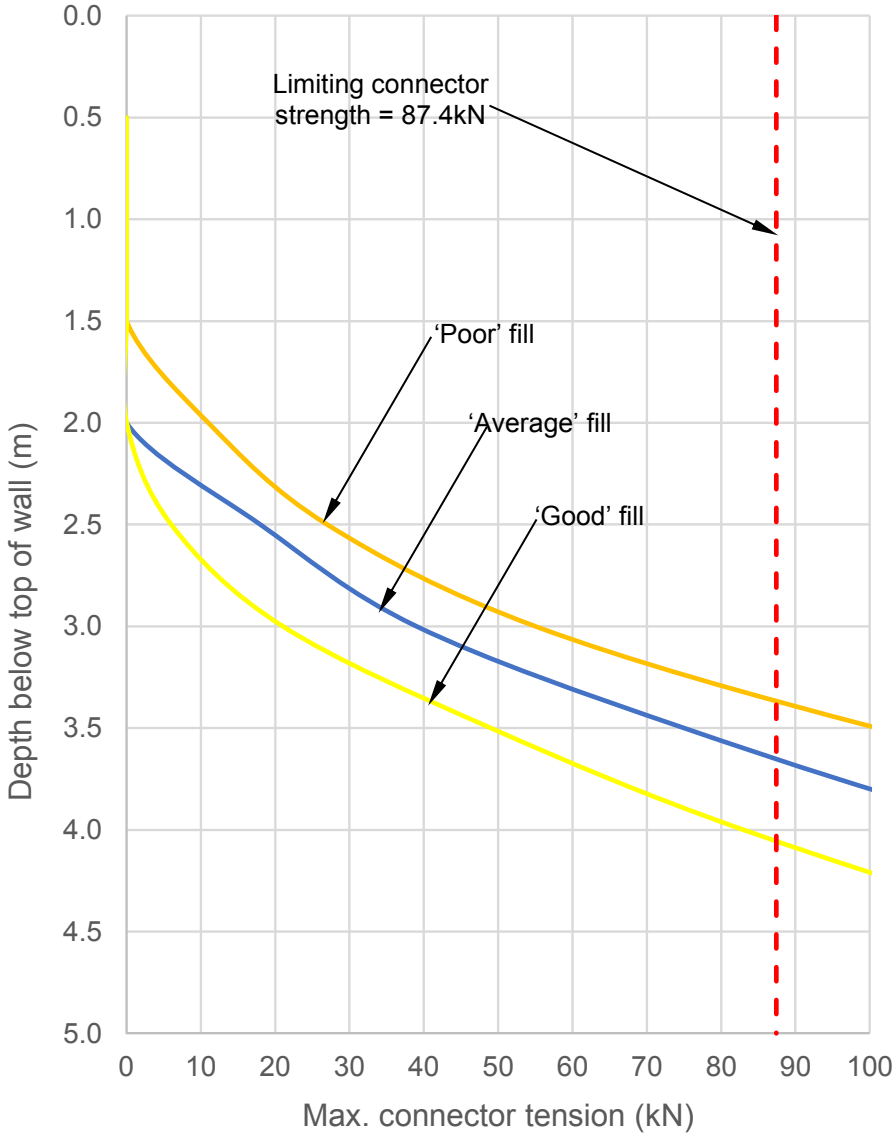




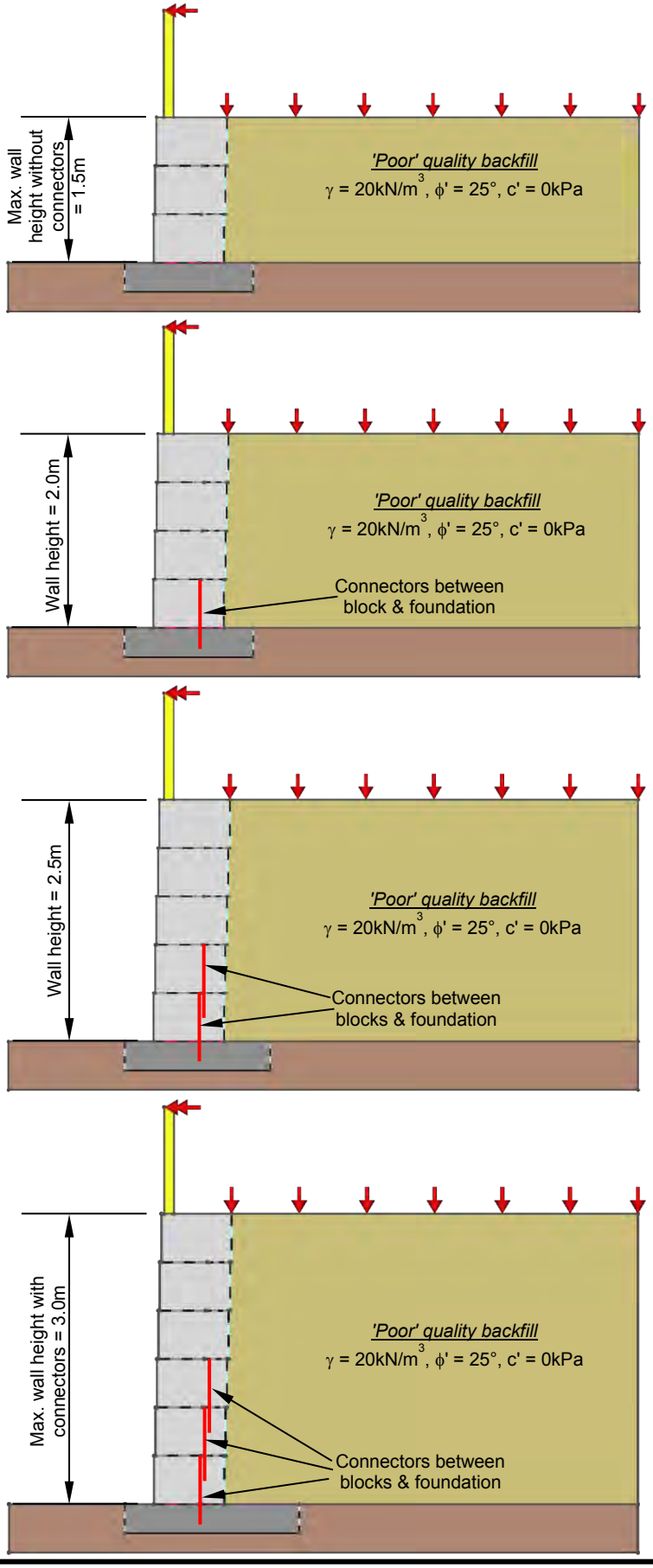
Design case 4 – 5kPa live load surcharge / No backslope / Handrail loading

No. of blocks	Wall height (m)	'Poor' quality fill		'Average' quality fill		'Good' quality fill	
		Connected blocks	Tension (kN)	Connected blocks	Tension (kN)	Connected blocks	Tension (kN)
1	0.5	0	0	0	0	0	0
2	1.0	0	0	0	0	0	0
3	1.5	0	0	0	0	0	0
4	2.0	1	11	0	0	0	0
5	2.5	2	27	1	18	1	6
6	3.0	3	55	2	39	2	21
7	3.5	4	**101**	3	75	3	49
8	4.0	5	**160**	4	**119**	4	83
9	4.5	6	**240**	5	**176**	5	**127**
10	5.0	7	**345**	6	**255**	6	**185**

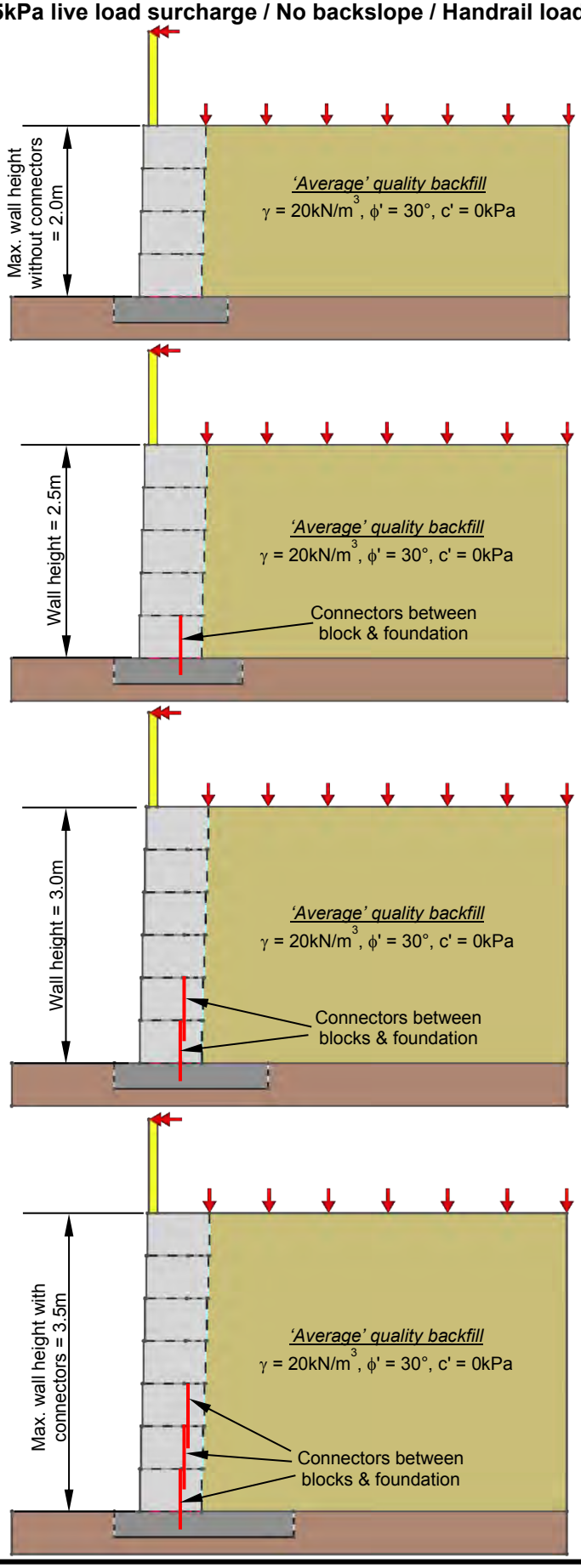
Design case 4 – Connector tension with depth below top of wall



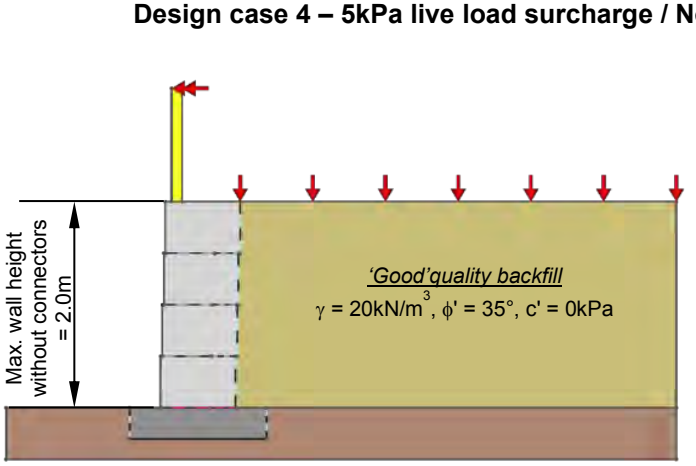
Design case 4 – 5kPa live load surcharge / No backslope / Handrail loading – 'Poor' quality fill

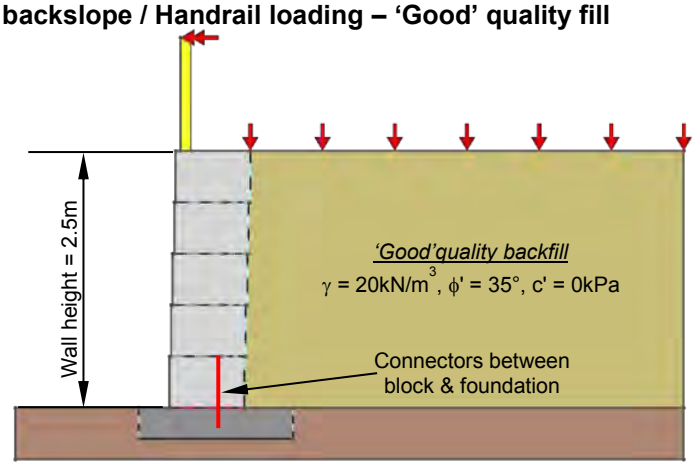


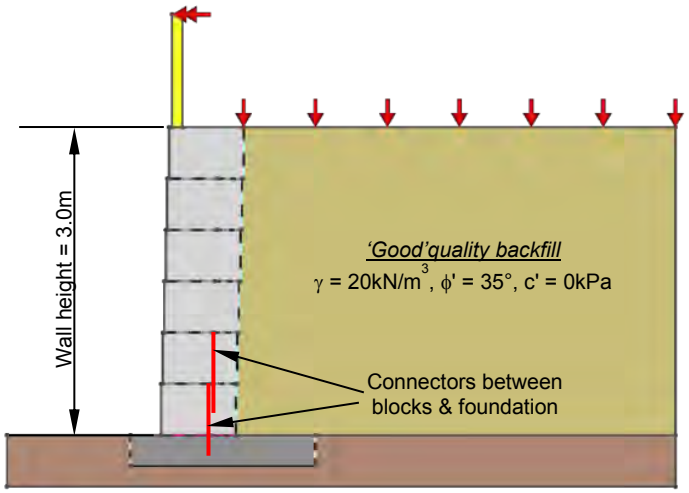
Design case 4 – 5kPa live load surcharge / No backslope / Handrail loading – 'Average' quality fill

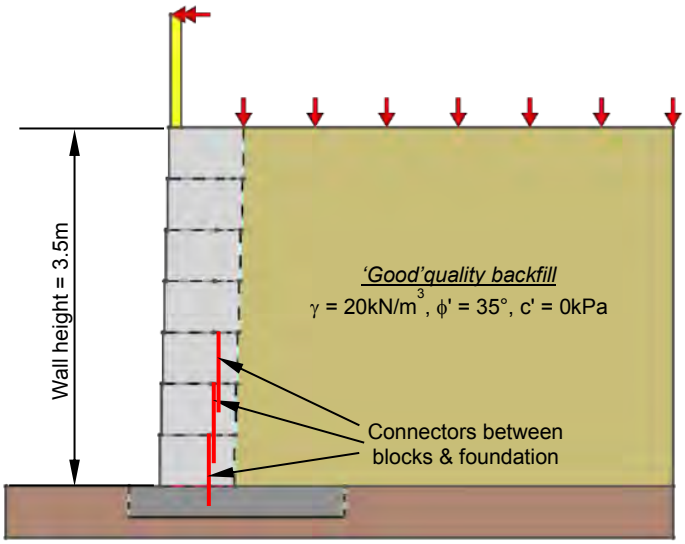


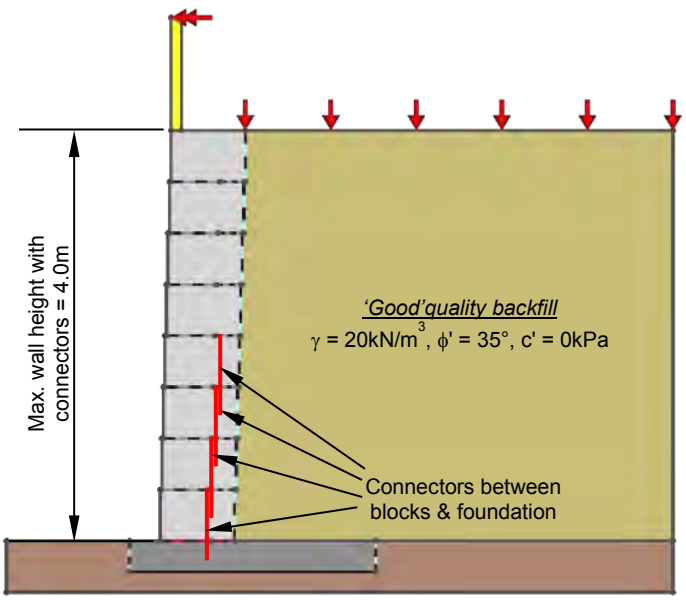
Design case 4 – 5kPa live load surcharge / No backslope / Handrail loading – 'Good' quality fill











END