5.1 Overview

Autoclaved Aerated Concrete (AAC) is one of the most effective building materials for providing a barrier to fire. AAC has shown itself to be non-combustible and very stable under fire loading, this results in structural systems that have high fire resistance level (FRL) ratings. The properties that highlight the high level performance of AAC under fire loading are presented in this section.

Basically, CSR Hebel manufactures two types of products:

- Blocks; and
- Panels.

These products have different methods for assessing their performance when subjected to fire loading. While blocks are used to construct various types of walls, panels are used in both walls and additionally in horizontal applications of:

- Floors;
- Ceilings; and
- Roofs.

To address the different methods clearly, this "Fire Design" section covers the fire performance of block and panel products in two separate sections:

- Block Products; and
- Panel Products

Each section presents the background of the methods and design charts to assist the designer with the adequacy of the CSR Hebel products.

5.2 Fire Properties of CSR Hebel AAC

Fire Hazard Indices

CSR Hebel blocks have the following early fire hazard indices, determined in accordance with AS1530.3:1990:

- Ignitability Index : 0
- Spread of Flame Index : 0
- Heat Developed Index : 0
- Smoke Developed Index : 0–1

5.3 Fire Resistance Level (FRL) Ratings

The Building Code of Australia regulations express the fire performance of a wall with the rating system called the 'Fire Resistance Level' (FRL). The FRL ratings in the CSR Hebel Technical Manual have been determined by testing in accordance with AS1530.4 – Fire Resistance Tests of Elements of Building Construction - at the CSIRO North Ryde, or opinions issued by the CSIRO based on test results.

The FRL rating consists of three performance criteria, structural adequacy/integrity/insulation. For non-loadbearing walls, there is no requirement to express the 'structural adequacy' criteria.

Example:

The FRL of a non-loadbearing wall may be expressed as - /120/90. The 'dash' indicates no requirement for the 'structural adequacy' criterion, followed by 'integrity' criterion of 120 minutes, and 'insulation' criterion of 90 minutes.

The FRL of a loadbearing wall may be expressed as 180/120/90. Where the 180 is the 'structural adequacy' criterion and indicates that the building component is structurally adequate for 180 minutes,

followed by the 'integrity' criterion of 120 minutes, and the 'insulation' criterion of 90 minutes.

5.4 Fire Certificates and Reports

Copies of the test reports for fire testing performed on the CSR Hebel blocks can be obtained by contacting CSR Hebel. Test certificates can be found in Appendix F.

5.5 Additional Design Considerations

Fire-rated block walls should comply with both strength and robustness requirements, and minimum slenderness ratios outlined in AS3700 - Masonry Structures code.

Block Products

5.6 Design for Fire – Blocks

The capacity of a wall under fire loading depends upon the cross-sectional properties, slenderness of the wall and the lateral support conditions of the edges of the wall, size of openings and magnitude of the applied load.

AAC walls can be designed for fire loading using the requirements outlined in Section 6 of AS3700. The capacity of the wall is expressed in terms of the fire resistance level (FRL), which consists of three terms, these being structural adequacy, integrity and insulation (e.g., 240/240/240). The values of these terms have been determined from the results of tests performed at the CSIRO Fire Testing Laboratory, see Clause 6.2 in AS3700.

Structural Adequacy

Design charts for structural adequacy have been determined in accordance with AS3700 Clause 6.3. Each chart is for a particular wall thickness and loading type (i.e., non-loadbearing, or loadbearing) and presents curves for various structural adequacy FRL values as a function of length and height of wall. The height and length of the wall are the clear dimensions between supports or free edges in all cases. Where the height of an opening is greater than 1/5 of the wall height, then the wall shall be divided into two sub-panels with a free edge at the centre of the opening, see AS3700 Clause 6.3.1 (Refer to Section 5.12 for further information). The structural adequacy FRL of a wall should be equal to or greater than the integrity and insulation FRL requirements for the wall.

AS3700 caters for the various support conditions by the use of slenderness coefficients a_{vf} and a_h as shown in Table 5.1. The limiting slenderness ratio for design of fire resistance, S_{rf} for various FRL values (i.e., 60, 90, 120, 180, 240) have been determined in accordance with the AS3700 Clause 6.3.3. These coefficients, slenderness ratios, S_{rf} and the expressions in AS3700 Clause 6.3.2.2 have been used to generate the design charts. Maximum wall heights are shown in Tables 5.3 and 5.4.

Table 5.1: Slenderness Coefficients for Structural Adequacy (AS3700 Clause 6.3.2.2)

Support Conditions at the Top and Bottom	a_{vf}
Lateral support along the top edge	0.75
Lateral support at bottom only	2.0
Support Conditions at the Sides	a_h
Lateral support on both vertical edges	1.0
Lateral support on one vertical edge	2.5

Table 5.2: Fire Slenderness Ratio, S_{rf}

Block Type	Fire Resistance Level (minutes)	Fire Slenderness Ratio Limit
Non-Loadbearing Block Wall	60	31.8
	90	29.0
	120	26.85
	180	23.72
	240	22.5
Loadbearing Block Wall	60	29.8
	90	16.78
	120	16.26
	180	15.52
	240	15.0

Table 5.3: Maximum Heights for CSR Hebel Non-Loadbearing Walls

Thickness (mm)	Fire Resistance Level, FRL (minutes)	Maximum Wall Height, H_{max} (m)	
		Top Edge Restrained $a_{vf} = 0.75$	Top Edge Free $a_{vf} = 2.0$
75	60	6.49	2.43
100	60	8.65	3.24
	90	7.91	2.96
	120	7.30	2.74
	180	6.45	2.42
	240	6.12	2.29
125	60	10.81	4.05
	90	9.89	3.70
	120	9.13	3.42
	180	8.06	3.02
	240	7.65	2.87
150	60	12.98	4.86
	90	11.86	4.45
	120	10.95	4.11
	180	9.68	3.63
	240	9.18	3.44
175	60	15.14	5.67
	90	13.84	5.19
	120	12.78	4.79
	180	11.29	4.23
	240	10.71	4.01
200	60	17.30	6.49
	90	15.82	5.93
	120	14.61	5.48
	180	12.90	4.84
	240	12.24	4.59
225	60	19.46	7.30
	90	17.80	6.67
	120	16.43	6.16
	180	14.52	5.44
	240	13.77	5.16
250	60	21.63	8.11
	90	19.78	7.41
	120	18.26	6.84
	180	16.13	6.05
	240	15.30	5.74

Table 5.4: Maximum Heights for CSR Hebel Loadbearing Walls

Thickness (mm)	Fire Resistance Level, FRL (minutes)	Maximum Wall Height, H_{max} (m) Top Edge Restrained $a_{vf} = 0.75$
75	60	6.08
100	60	8.10
125	60	10.13
150	60	12.16
	90	6.84
	120	6.63
	180	6.33
	240	6.12
175	60	14.19
	90	7.99
	120	7.74
	180	7.39
	240	7.14
200	60	16.21
	90	9.13
	120	8.84
	180	8.44
	240	8.16
225	60	18.24
	90	10.27
	120	9.95
	180	9.50
	240	9.18
250	60	20.27
	90	11.41
	120	11.06
	180	10.55
	240	10.20

Integrity

Design for integrity has been determined in accordance with AS3700 Clause 6.4. The wall should at least satisfy the structural adequacy requirements for the integrity FRL. The requirements outlined in AS3700 Clause 6.4.3 have been used to determine the integrity values for the various thicknesses of block walls, as shown in Table 6.5. Note, the test results of a non-loadbearing wall can only be applied to a non-loadbearing wall.

Table 5.5:
Integrity Values for Various Block Wall Thicknesses

Block Type	Block Thickness (mm)	Fire Resistance Level (minutes)
Non-Loadbearing Block Wall	75	60
	>100	240
Loadbearing Block Wall	75	60
	100	120
	125	180
	> 150	240

Insulation

Design for insulation has been determined in accordance with AS3700 Clause 6.5. The requirements outlined in AS3700 Clause 6.5.4 have been used to determine the insulation values for the various thicknesses of block walls, as shown in Table 6.6.

Table 5.6:
Insulation Values for Various Block Wall Thicknesses

Block Type	Block Thickness (mm)	Fire Resistance Level (minutes)
Non-Loadbearing Block Wall	75	60
	>100	240
Loadbearing Block Wall	75	60
	100	120
	125	180
	> 150	240

5.7 Loadbearing Walls

The loadbearing block walls have been tested with applied load of 50 percent of the design compression capacity of the wall. No guidelines are set out in AS3700, which addresses the effect of magnitude of the applied compression load on the wall behaviour under fire loading.

5.8 Reinforced AAC Masonry Walls

For the fire design of reinforced blockwalls, the contribution of the reinforcement should be neglected and the wall designed as unreinforced.

5.9 Cavity AAC Masonry Walls

For a cavity wall where both leaves have superimposed axial force with values within 10% of each other, including the case of no superimposed axial force on either leaf, the slenderness ratio shall be based on 2/3 of the sum of the thicknesses of the two leaves and the fixity of the leaf not exposed to the fire and for all other cases the slenderness ratio shall be based on the thickness and fixity of the more heavily loaded leaf."

5.10 Control Joints

A control joint in a wall, or an edge to an opening in a wall, shall be regarded as an unsupported edge to that wall unless specific measures are taken to provide adequate lateral support at that edge

5.11 CSR Hebel Block Walls with Thick Bed Mortar Joints

The charts presented in this publication are not applicable to blockwork constructed with CSR Hebel blocks and conventional 10mm thick mortar joints.

A non-loadbearing fire test has been performed on 100mm thick CSR Hebel blockwork with 10mm thick mortar joints and the test certificate (number 964) can be found in Appendix F. The tested non-loadbearing wall has a fire slenderness ratio (S_{rf}) of 22.5 and a fire resistance level (FRL) rating of 240/240/180.

This test result can be used to determine the fire performance of non-loadbearing walls constructed of CSR Hebel blocks in 10mm thick mortar joints, in accordance with AS3700 requirements.

5.12 Recesses for Services and Chasing for Fire Design

When walls are to be recessed or chased for the provision of services and cabling, these recesses or chases satisfy the requirements presented in AS3700 Clauses 6.6 and 6.7, respectively. All chasing to be approved by Project Engineer.

In addition to these requirements CSR Hebel provides the following information with regards to chasing, which will not be detrimental to the already established levels.

The effect of recesses for services on the fire resistance periods, for structural adequacy, integrity and insulation of a wall shall be ignored, provided that the depth of material removed is not greater than one third of the wall thickness and the total area of recesses is not more than 10,000mm^2 total of both faces within any 5m^2 of wall area.

Where these limits are exceeded, the wall thickness of the masonry (t) shall be taken as the overall thickness of the wall less the depth of recess.

Chases

The effect of chases on structural adequacy

The effect of chases on the fire-resistance period for structural adequacy shall be dealt with as follows:

(a) For vertically spanning walls:

(i) where the chase is vertical – ignored;

(ii) where the chase is horizontal and of length not greater than four times the wall thickness – ignored; and

(iii) where the chase is horizontal and of length greater than four times the wall thickness – considered, using the slenderness ratio of the wall based on the wall thickness at the bottom of the chase.

(b) For horizontally spanning walls –

(i) where the chase is horizontal – ignored;

(ii) where the chase is vertical and of length not greater than four times the wall thickness – ignored; and

(iii) where the chase is vertical and of length greater than four times the wall thickness – considered, using the slenderness ratio of the wall based on the wall thickness at the bottom of the chase.

(c) For walls spanning vertically and horizontally (panel action)

(i) where the length, L, of chase is not greater than half the height, h, (for a vertical chase) or half the length (for a horizontal chase)—ignored;

(ii) where the length, L, of chase is greater than half the length (for a horizontal chase)—considered, using the slenderness ratio of the wall based on the wall thickness at the bottom of the chase

(iii) where the length, L, of chase is greater

than half the height, h (for a vertical chase)—considered, the chase may be regarded as an unsupported edge and the panel designed as two subpanels using the slenderness ratio of the wall based on the wall thickness.

The effect of chases on integrity and insulation

The effect of chases on the fire-resistance periods for integrity and insulation shall be dealt with as follows:

(i) the effects shall be ignored, where the depth of material removed is not greater than the lesser of one third of the wall thickness or 30mm, the cross-sectional area (normal to the plane of the wall) of the chase is not greater than 1000mm^2, and the total face area of the chase is not greater than 100,000mm^2 total on both faces of the wall on any 5m^2 area; and

(ii) the effects shall be taken into account for other chases by calculating the integrity and insulation based on the thickness of the wall at the base of the chase.

Chart FR1: 75mm Non-Loadbearing CSR Hebel Block Wall
All Edges Laterally Restrained

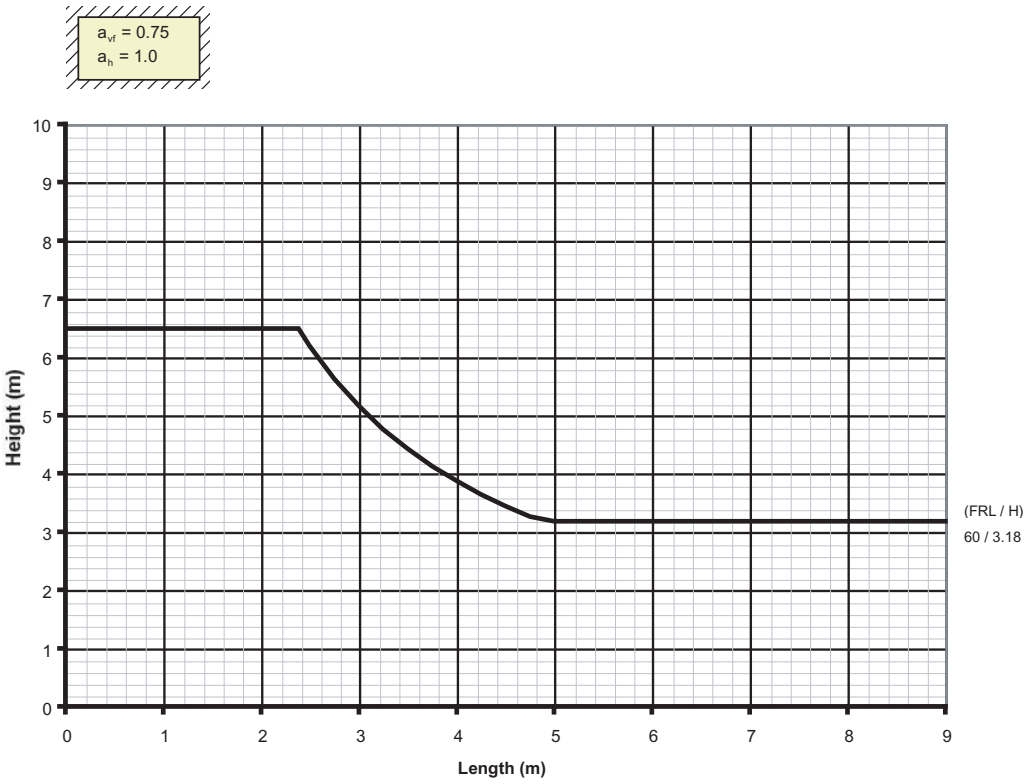


Chart FR2: 75mm Non-Loadbearing CSR Hebel Block Wall
One Vertical Side Free

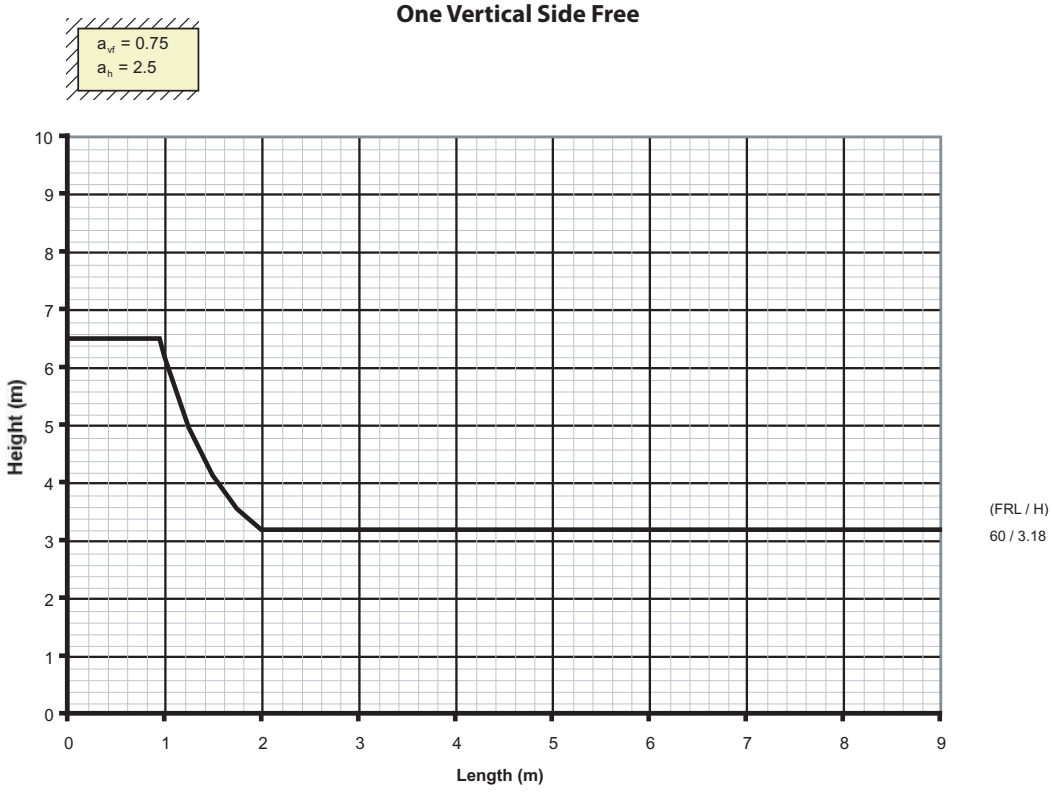


Chart FR3: 75mm Non-Loadbearing CSR Hebel Block Wall Top Edge Free

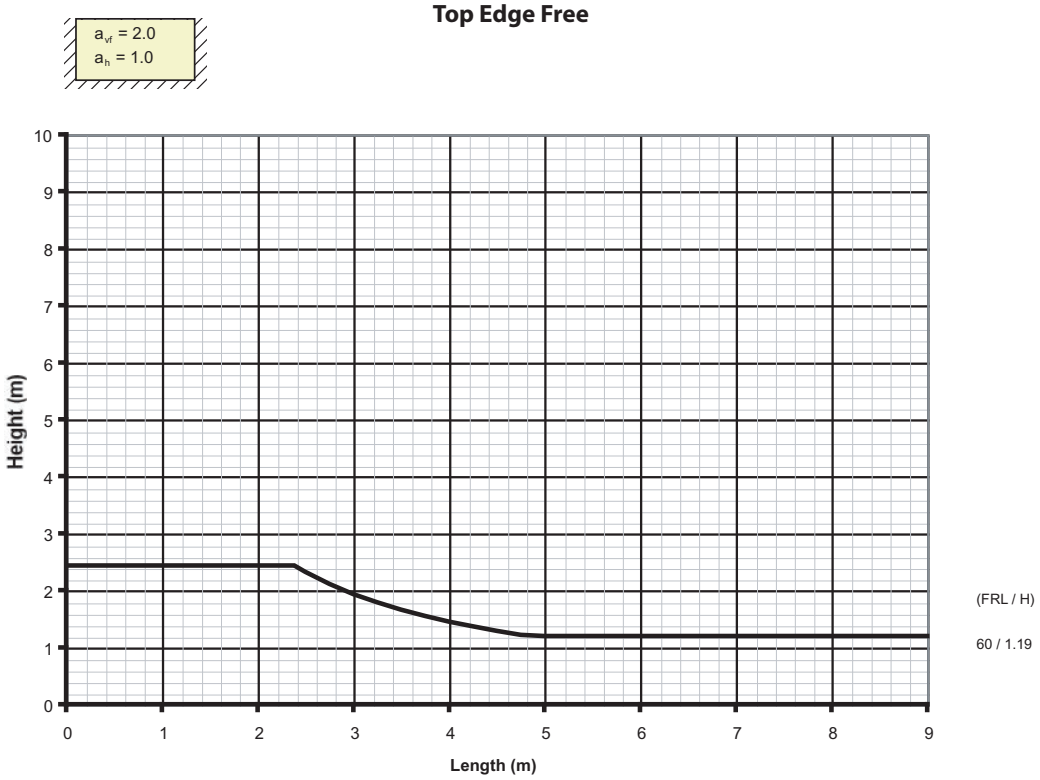


Chart FR4: 75mm Non-Loadbearing CSR Hebel Block Wall One Vertical Side and Top Edge Free

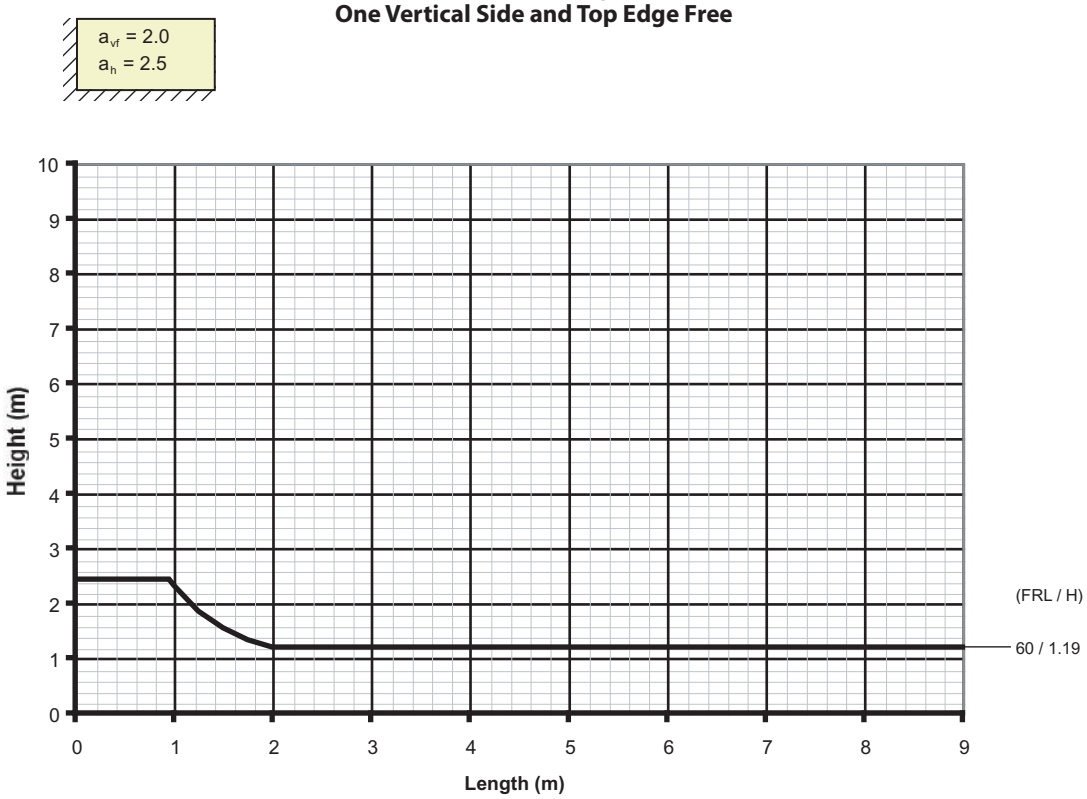
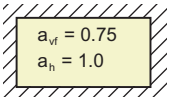


Chart FR5: 100mm Non-Loadbearing CSR Hebel Block Wall
All Edges Laterally Restrained



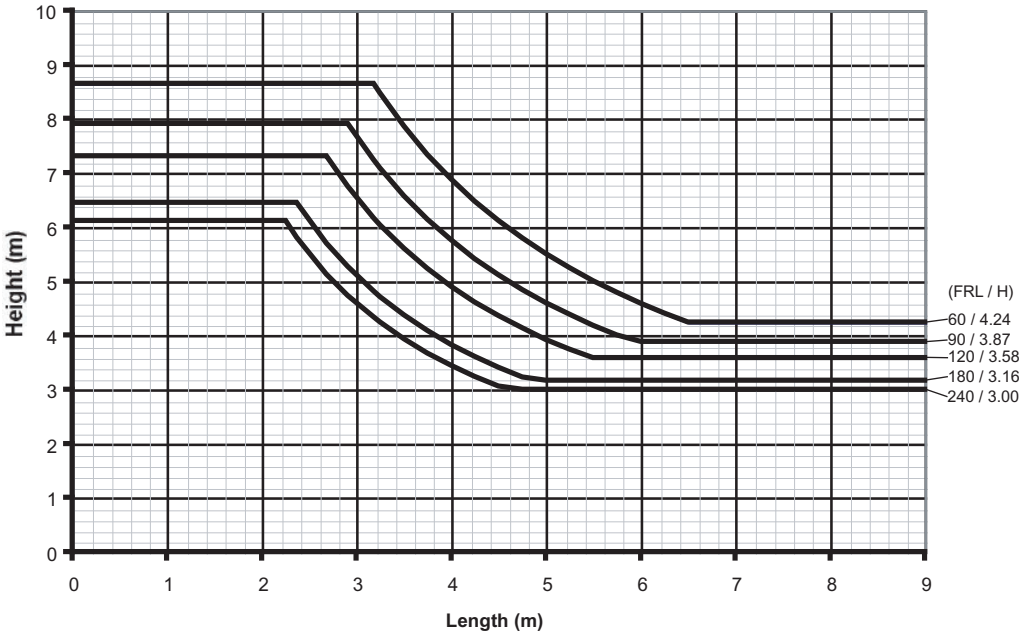
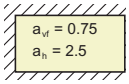
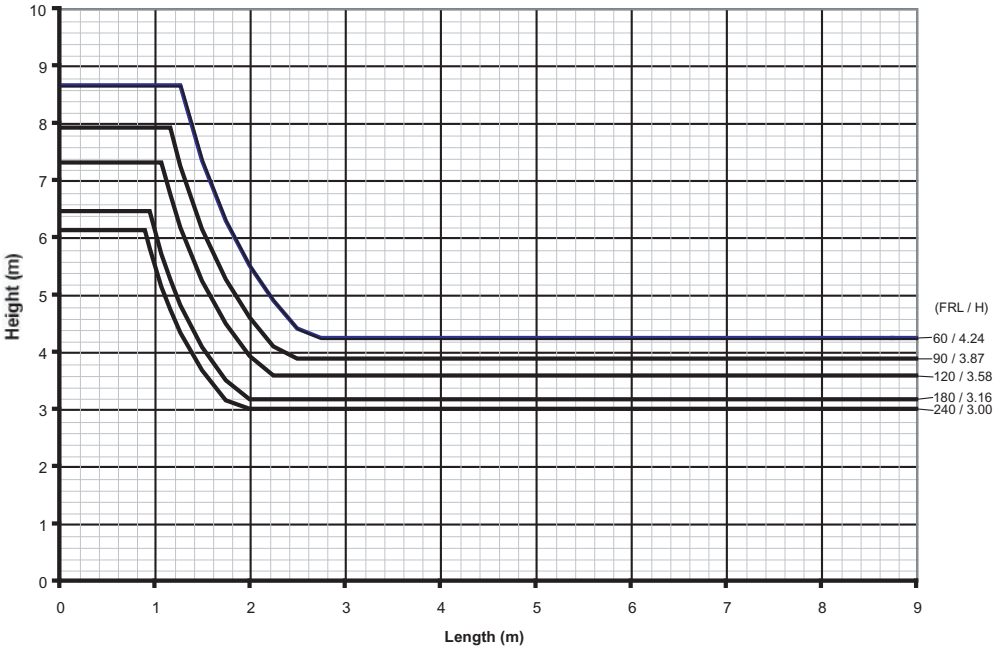


Chart FR6: 100mm Non-Loadbearing CSR Hebel Block Wall
One Vertical Side Free





Section 5

Chart FR7: 100mm Non-Loadbearing CSR Hebel Block Wall Top Edge Free

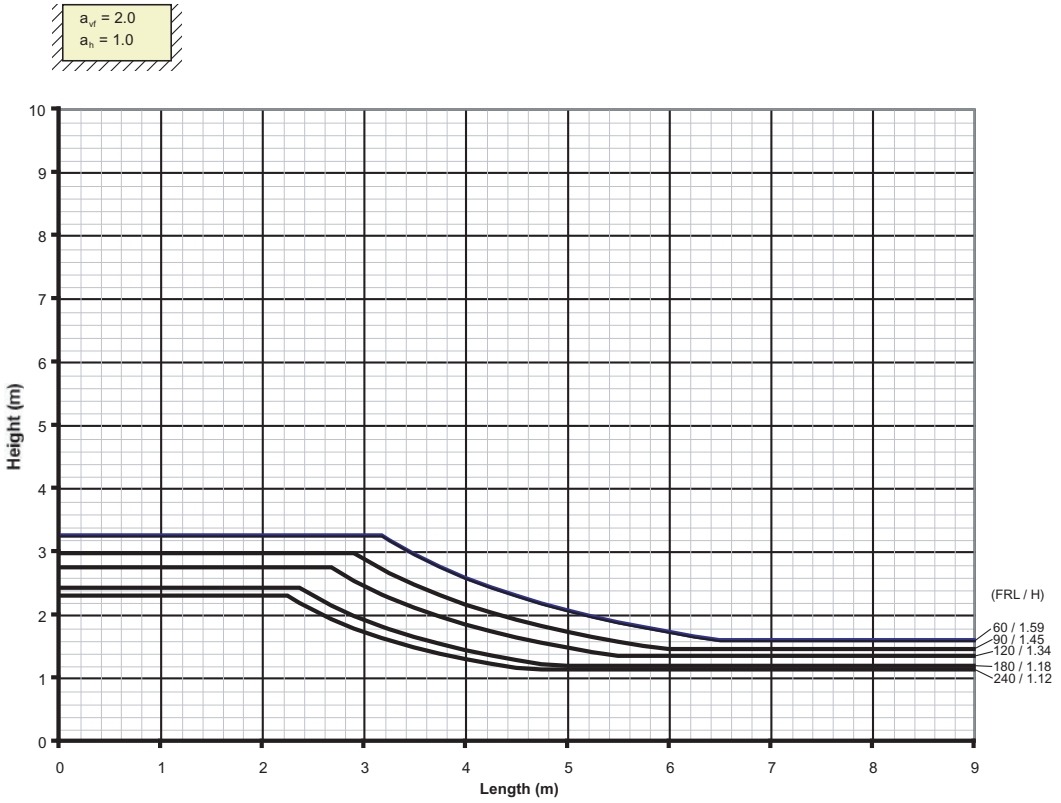


Chart FR8: 100mm Non-Loadbearing CSR Hebel Block Wall One Vertical Side and Top Edge Free

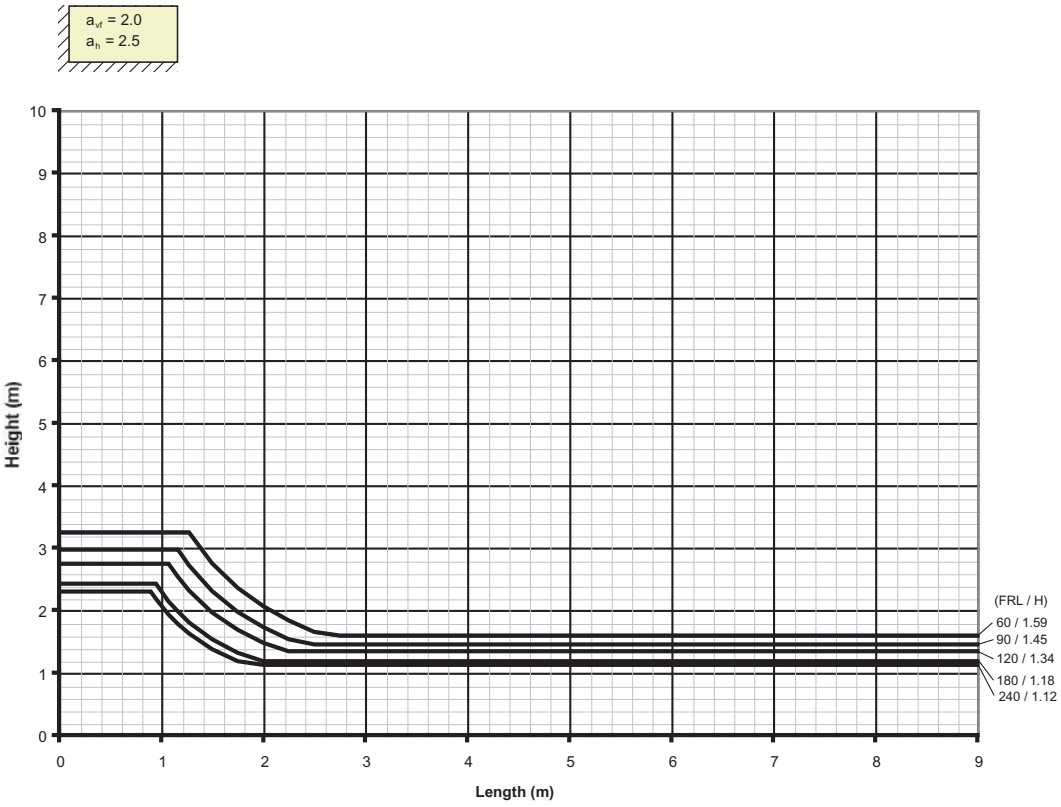


Chart FR9: 125mm Non-Loadbearing CSR Hebel Block Wall
All Edges Laterally Restrained

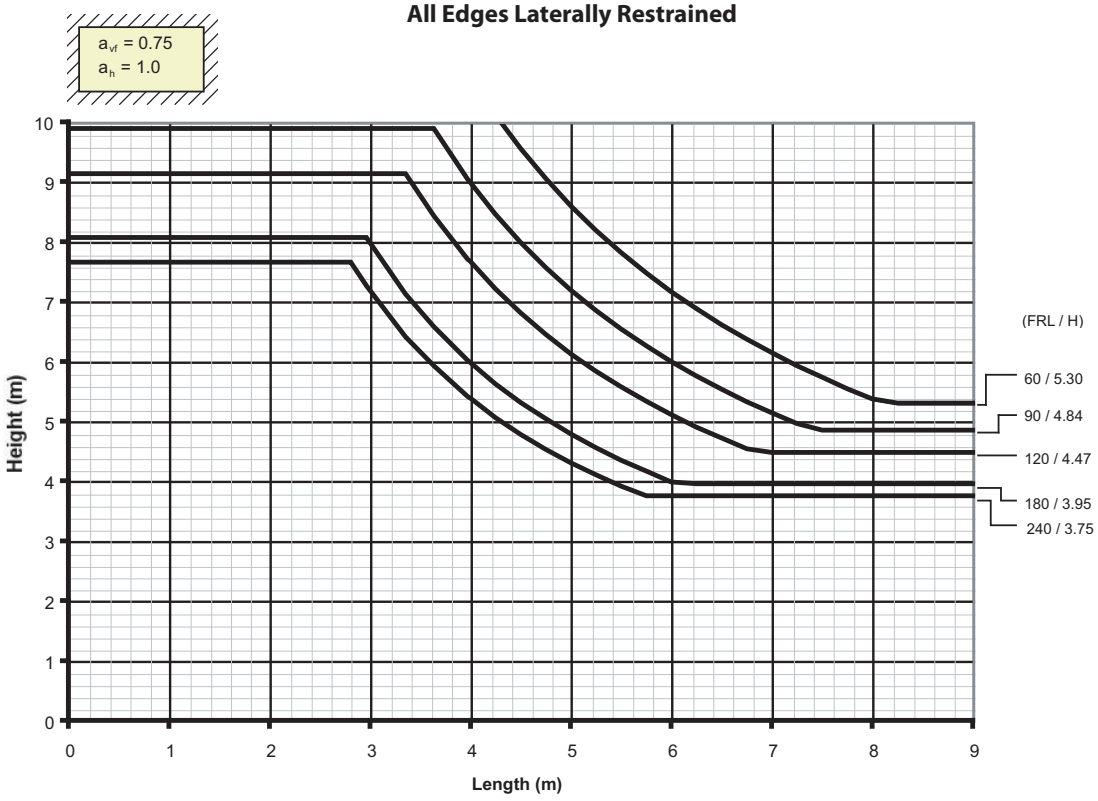


Chart FR10: 125mm Non-Loadbearing CSR Hebel Block Wall
One Vertical Side Free

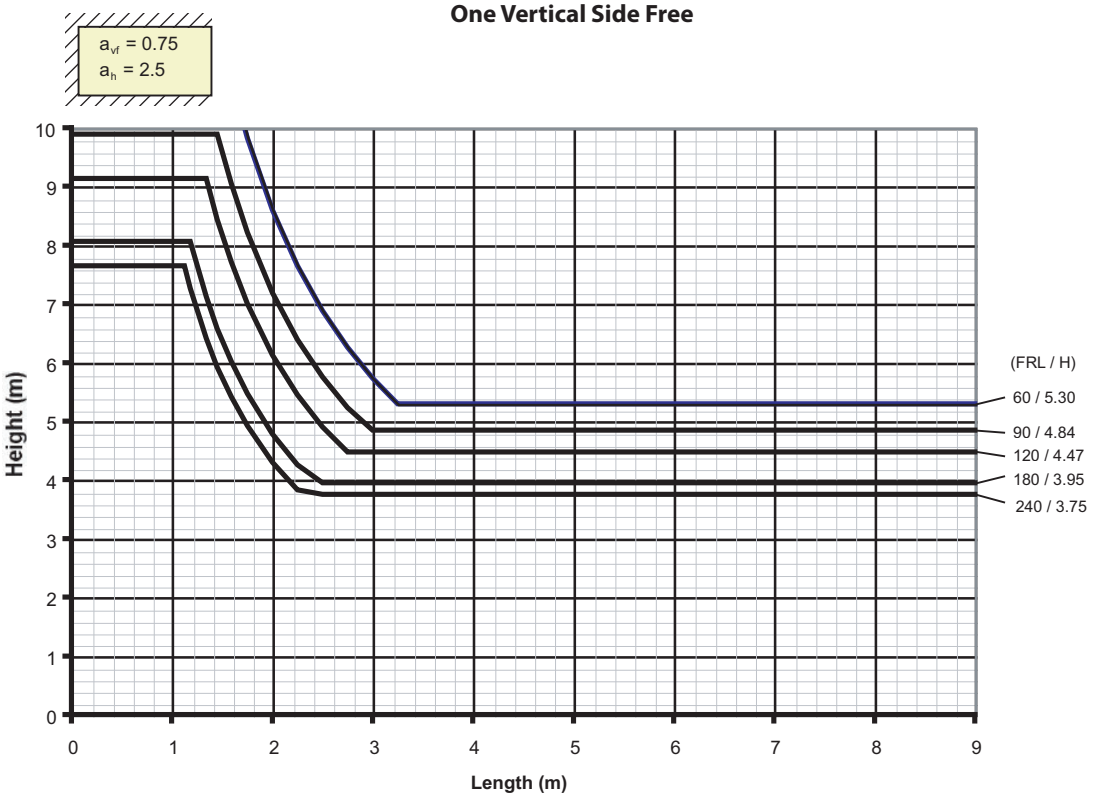


Chart FR11: 125mm Non-Loadbearing CSR Hebel Block Wall
Top Edge Free

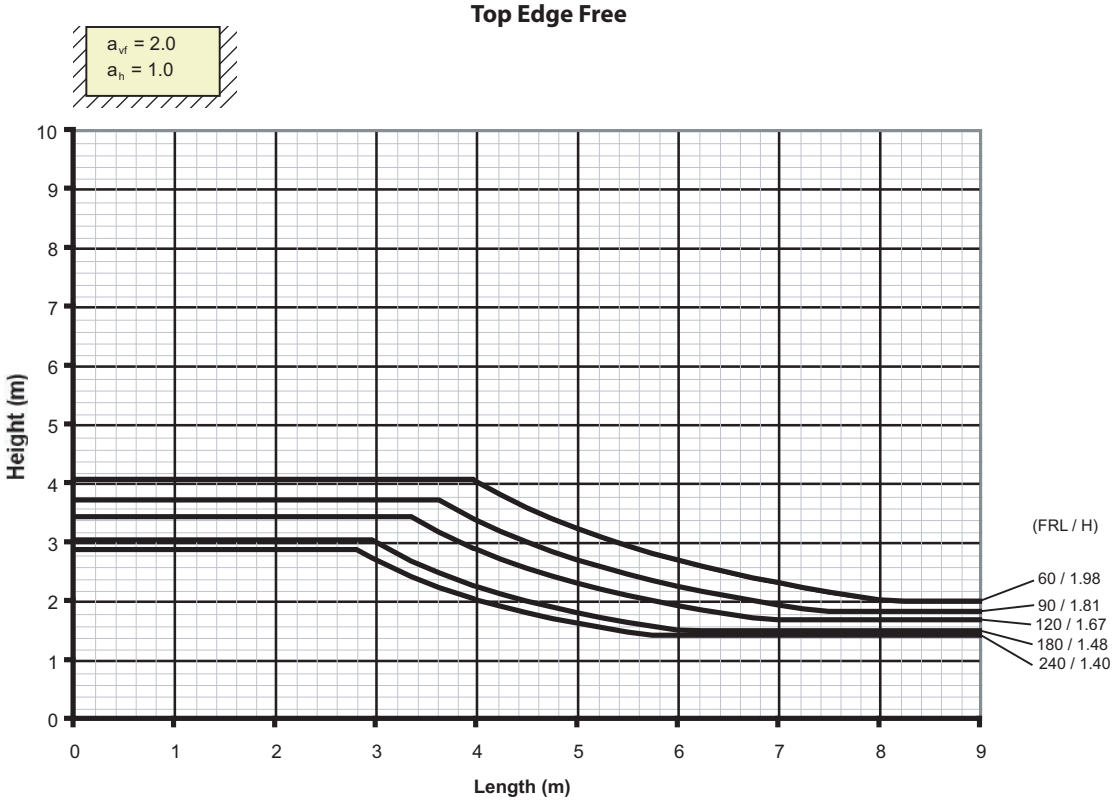


Chart FR12: 125mm Non-Loadbearing CSR Hebel Block Wall
Top Edge and Side Free

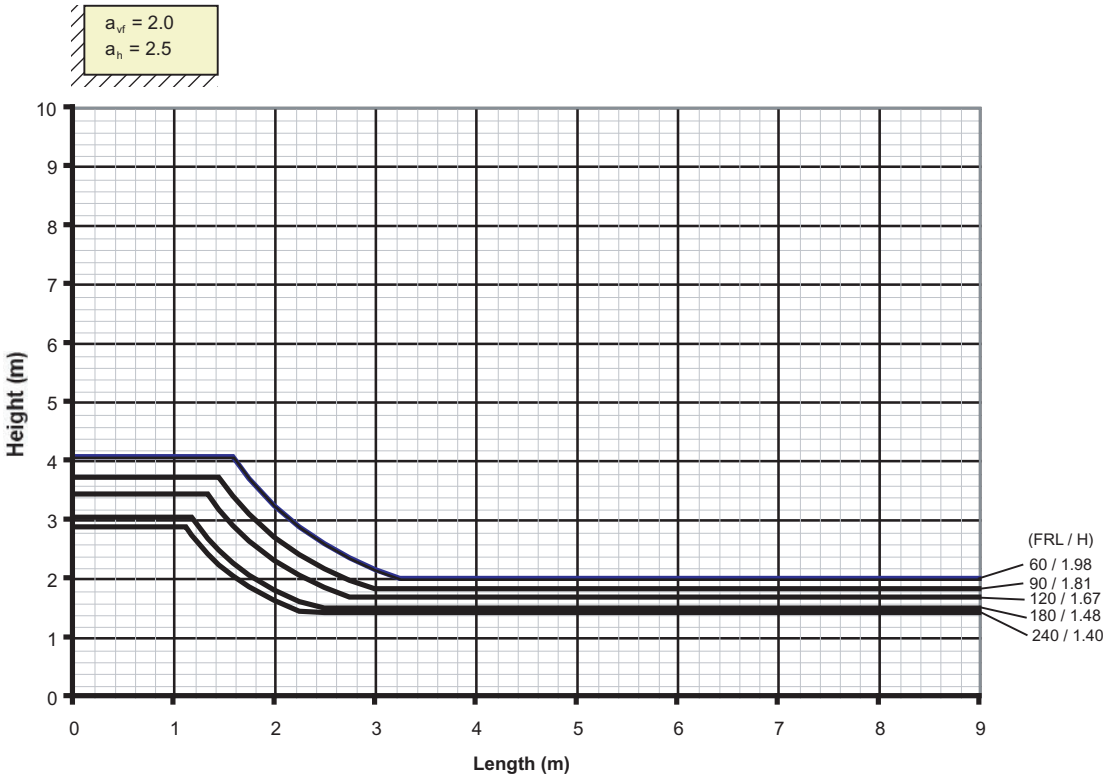


Chart FR13: 150mm Non-Loadbearing CSR Hebel Block Wall
All Edges Laterally Restrained

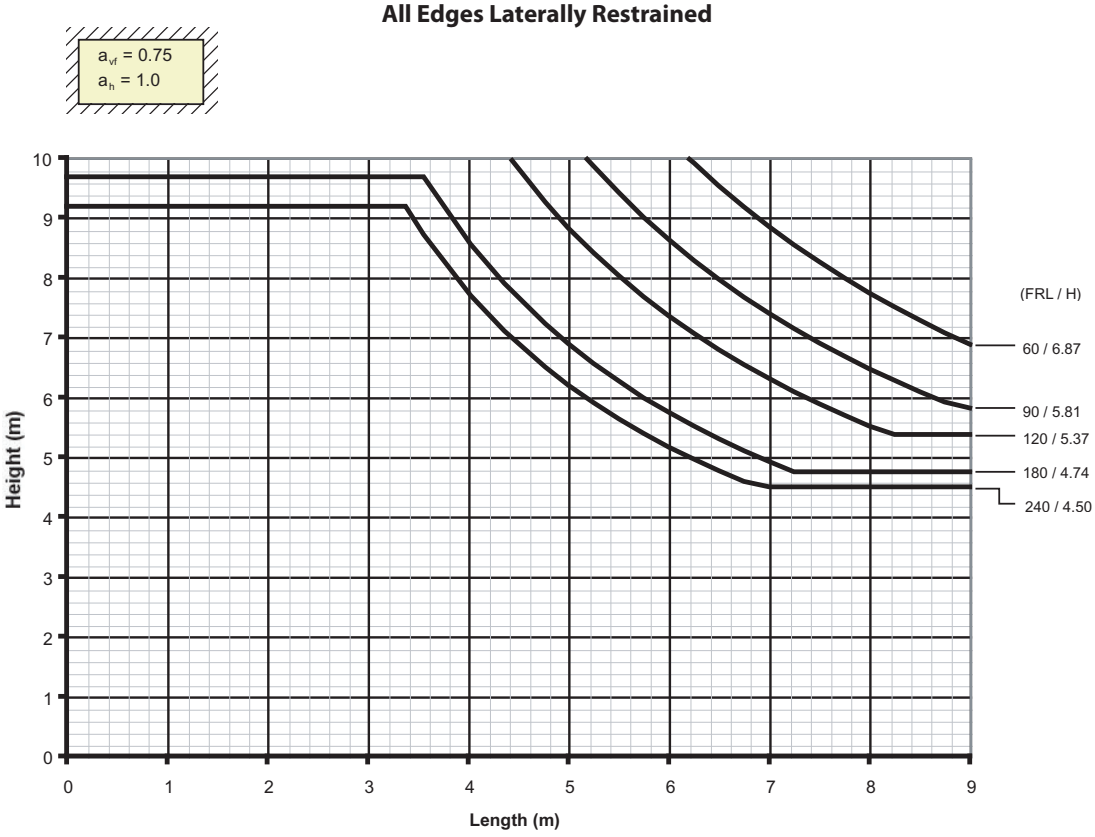


Chart FR14: 150mm Non-Loadbearing CSR Hebel Block Wall
One Vertical Side Free

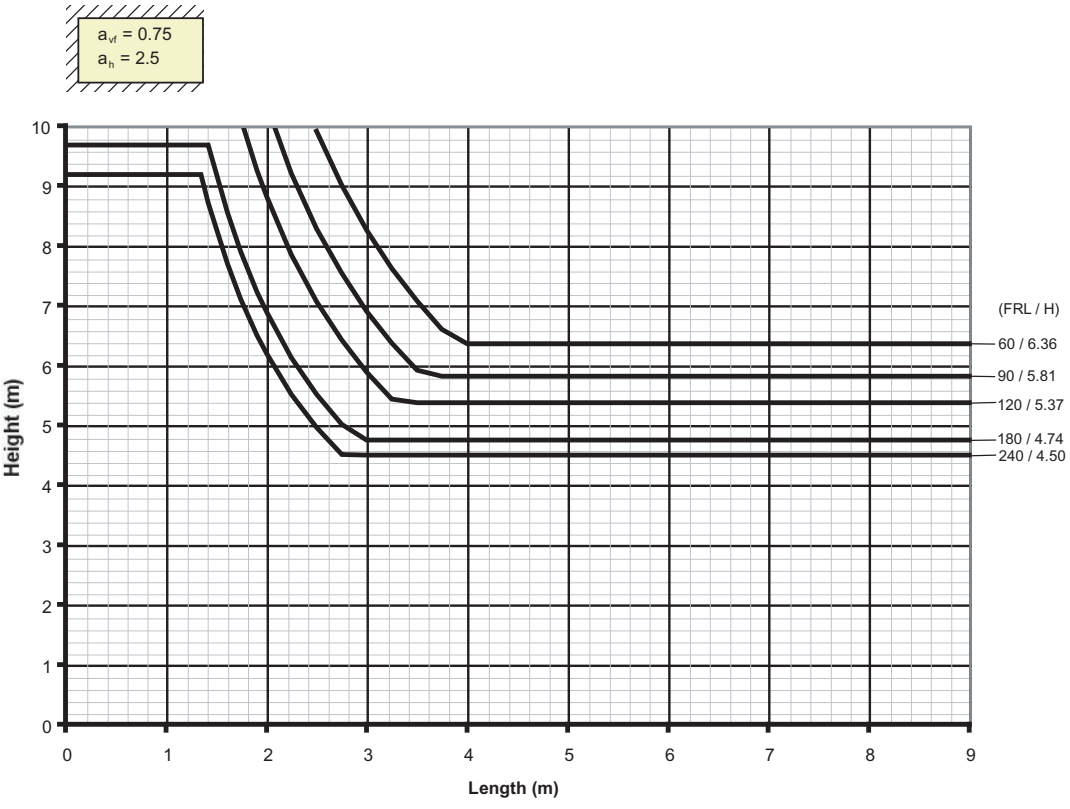


Chart FR15: 150mm Non-Loadbearing CSR Hebel Block Wall Top Edge Free

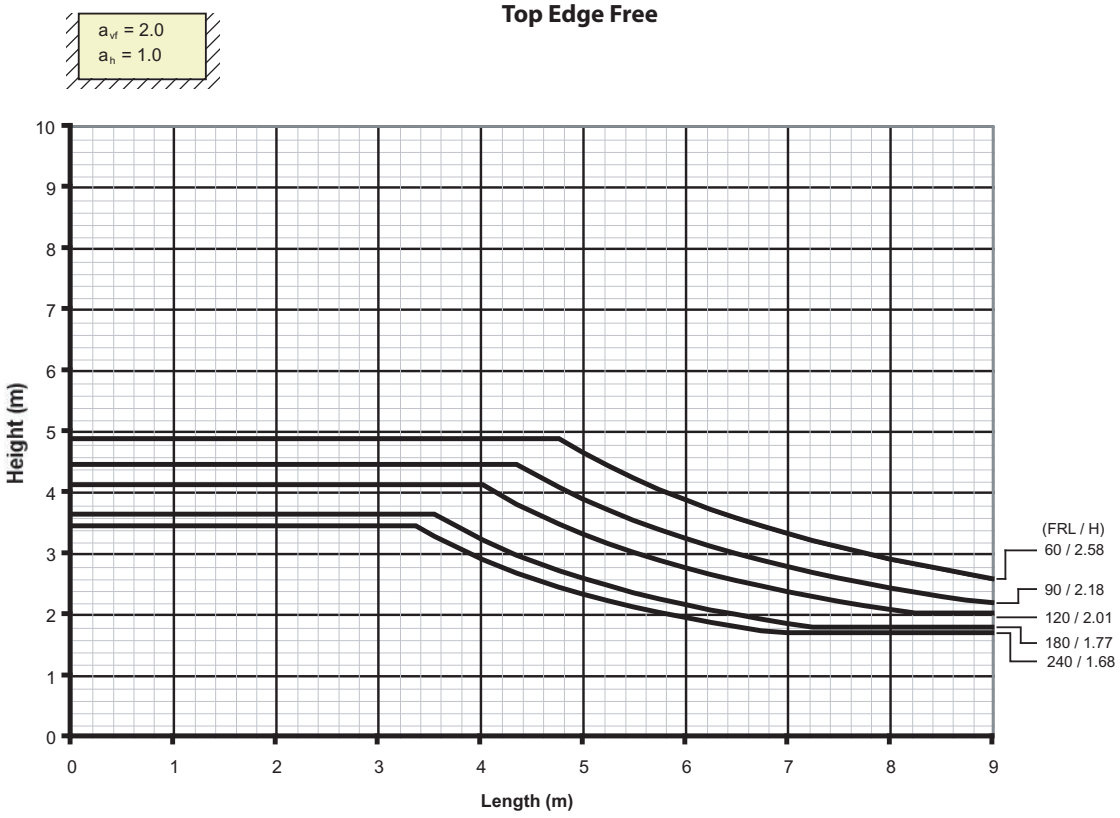


Chart FR16: 150mm Non-Loadbearing CSR Hebel Block Wall Top Edge and Side Free

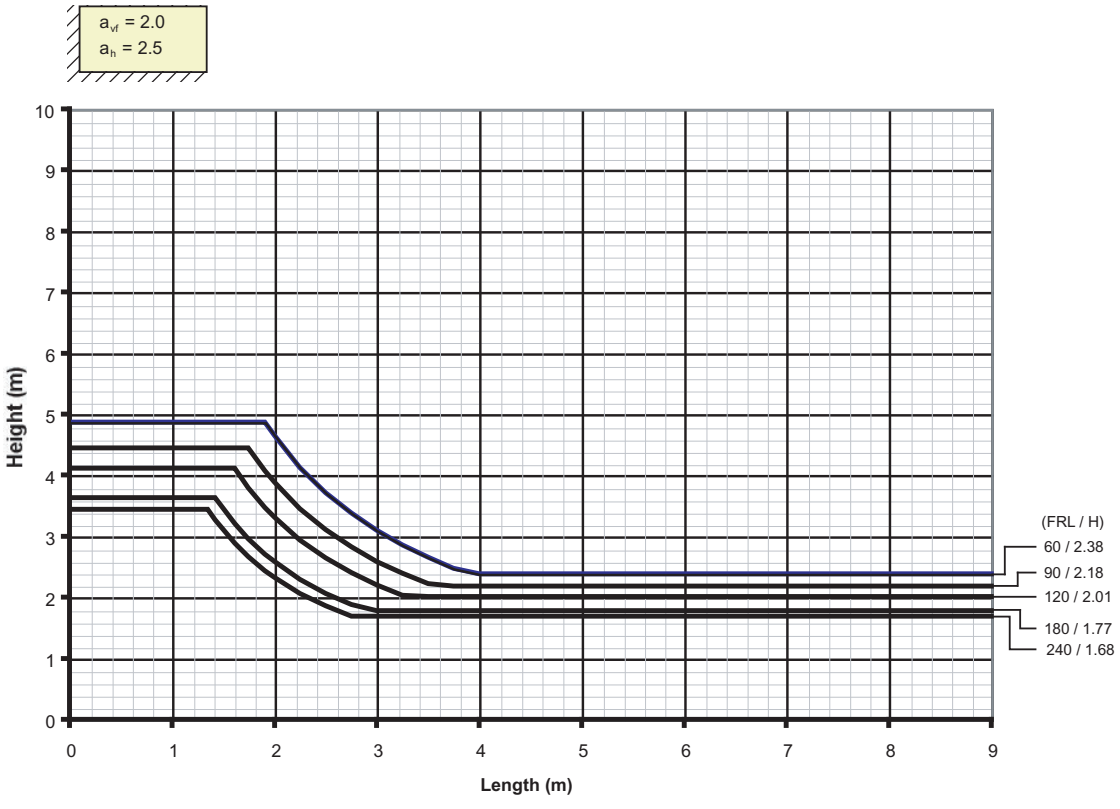


Chart FR17: 175mm Non-Loadbearing CSR Hebel Block Wall All Edges Laterally Restrained

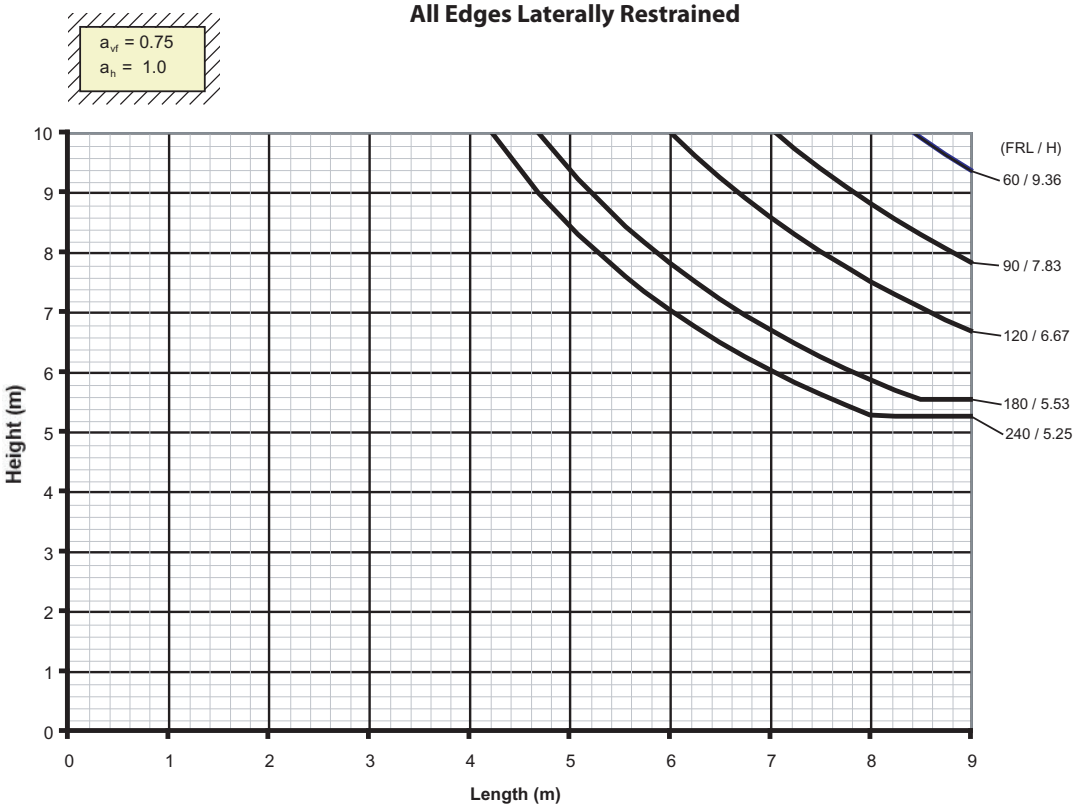


Chart FR18: 175mm Non-Loadbearing CSR Hebel Block Wall One Vertical Side Free

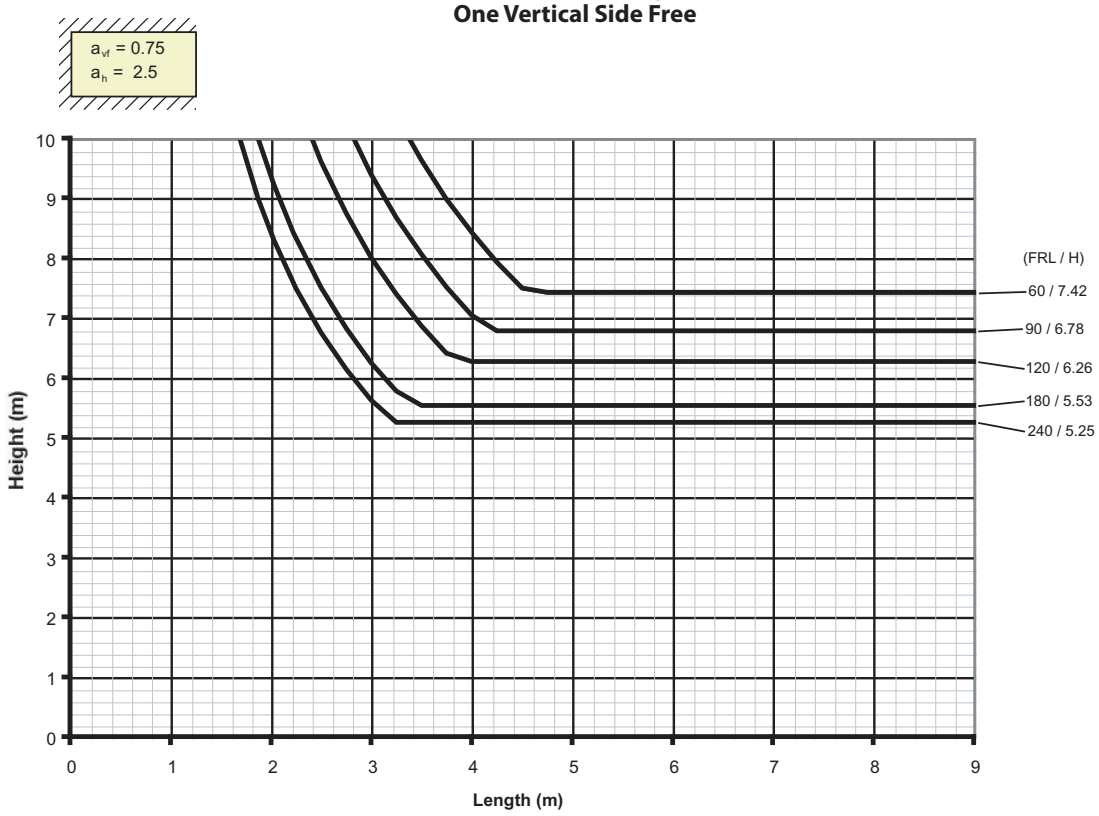


Chart FR19: 175mm Non-Loadbearing CSR Hebel Block Wall Top Edge Free

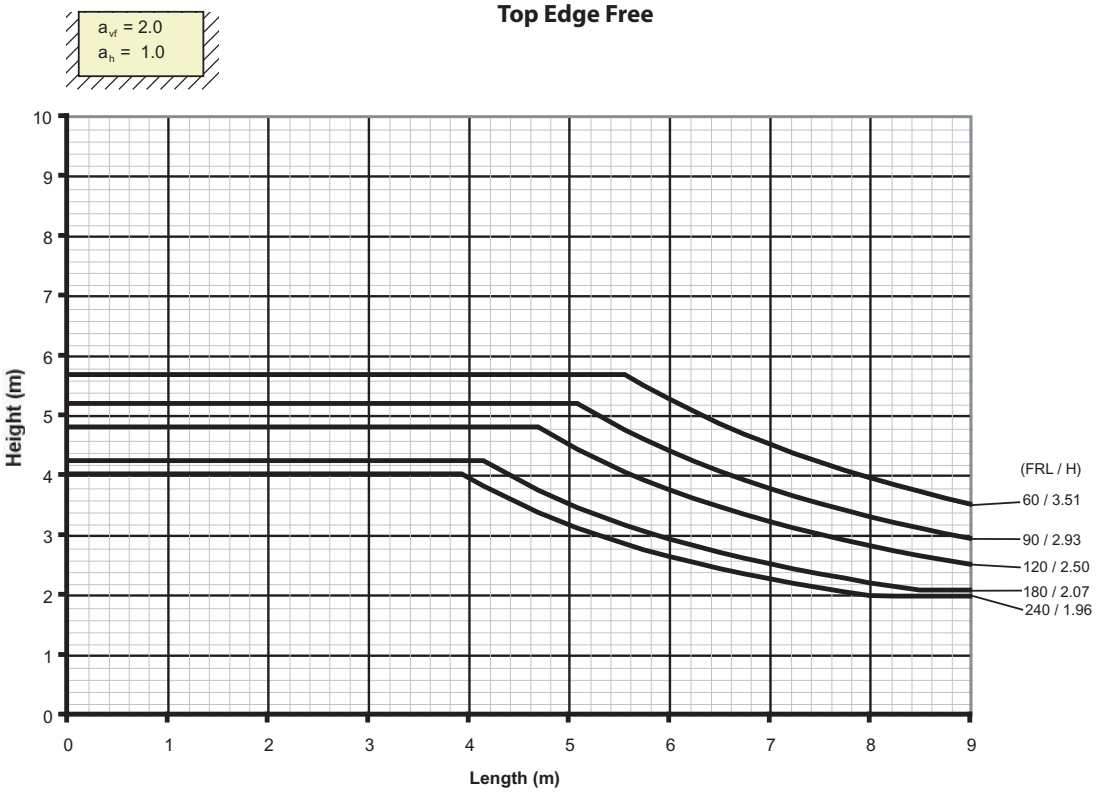


Chart FR20: 175mm Non-Loadbearing CSR Hebel Block Wall Top and One Side Free

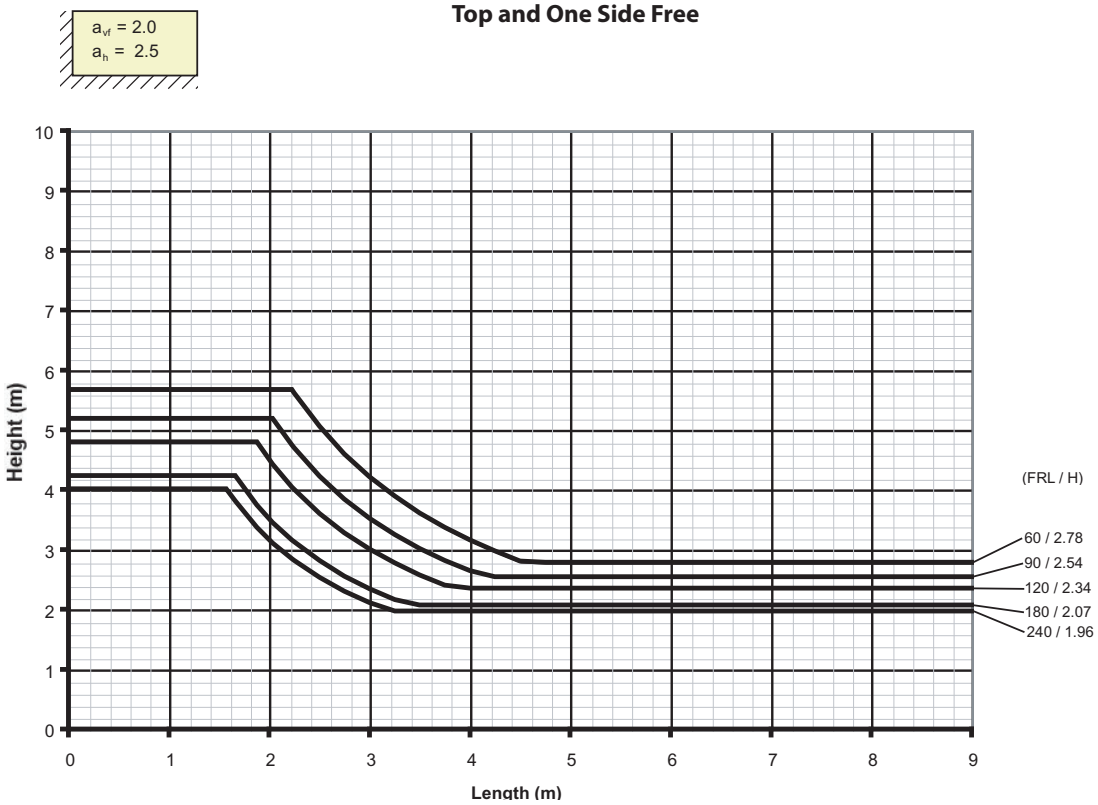
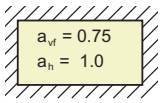


Chart FR21: 200mm Non-Loadbearing CSR Hebel Block Wall
All Edges Laterally Supported



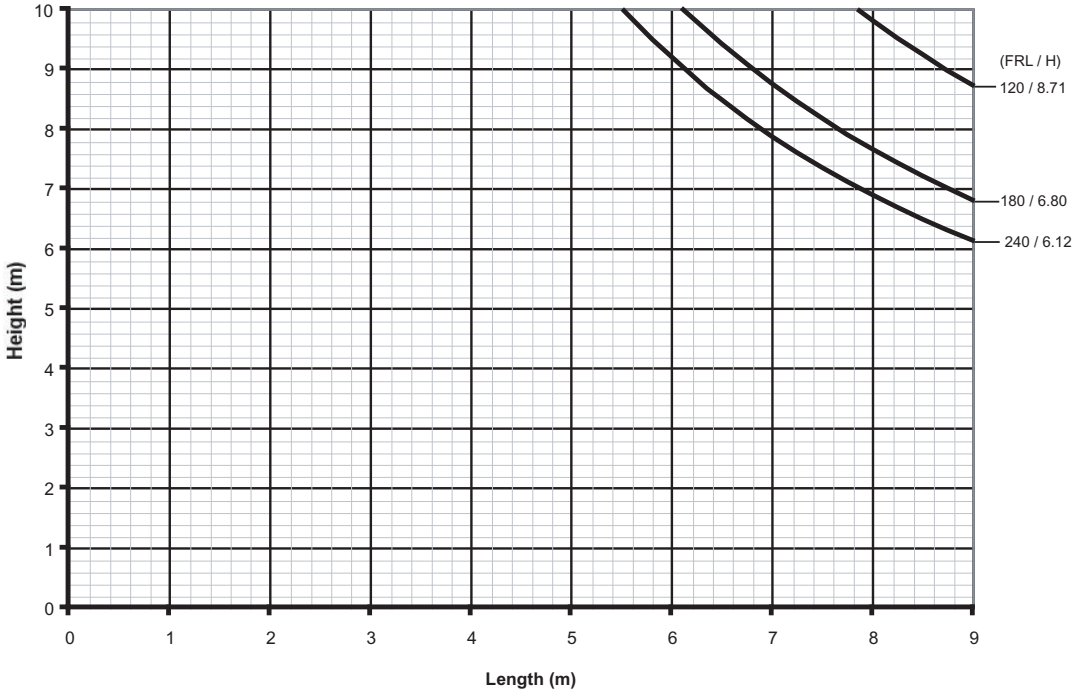
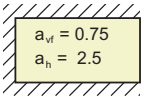


Chart FR22: 200mm Non-Loadbearing CSR Hebel Block Wall
One Vertical Side Free



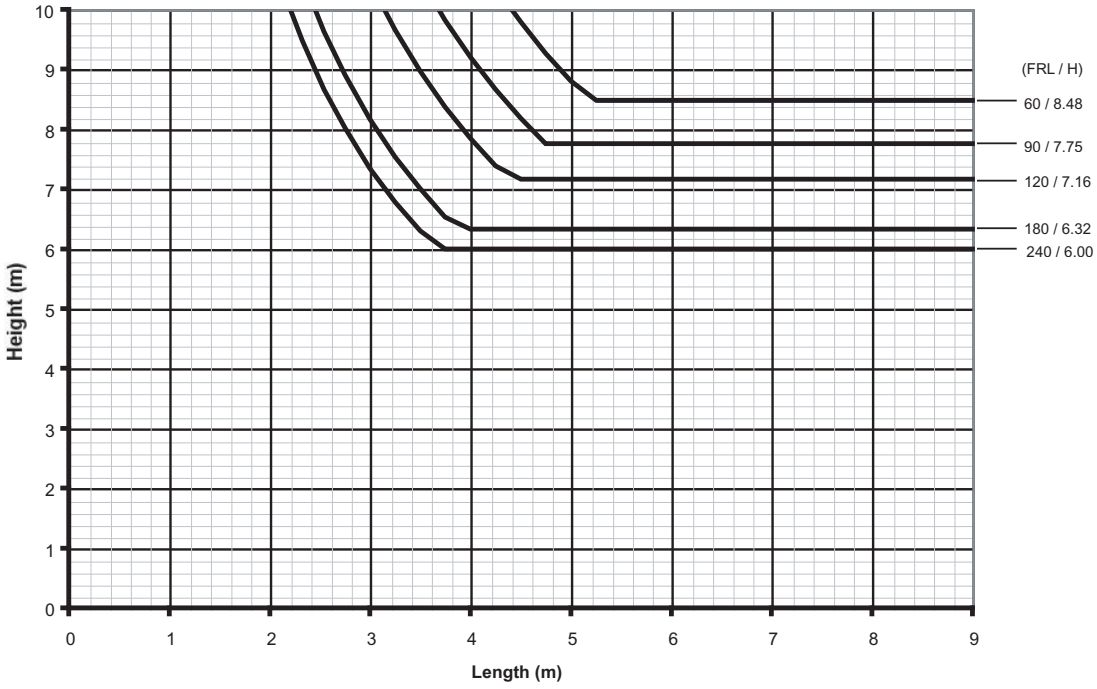
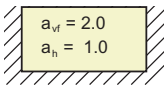


Chart FR23: 200mm Non-Loadbearing CSR Hebel Block Wall Top Edge Free



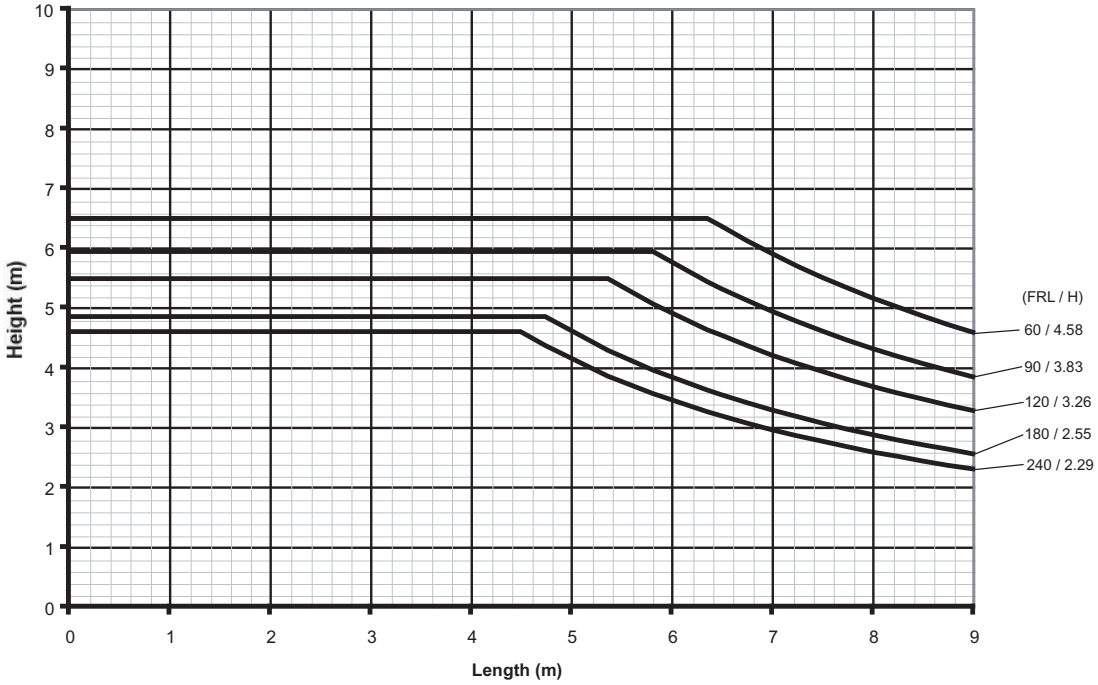
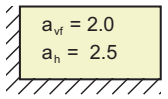
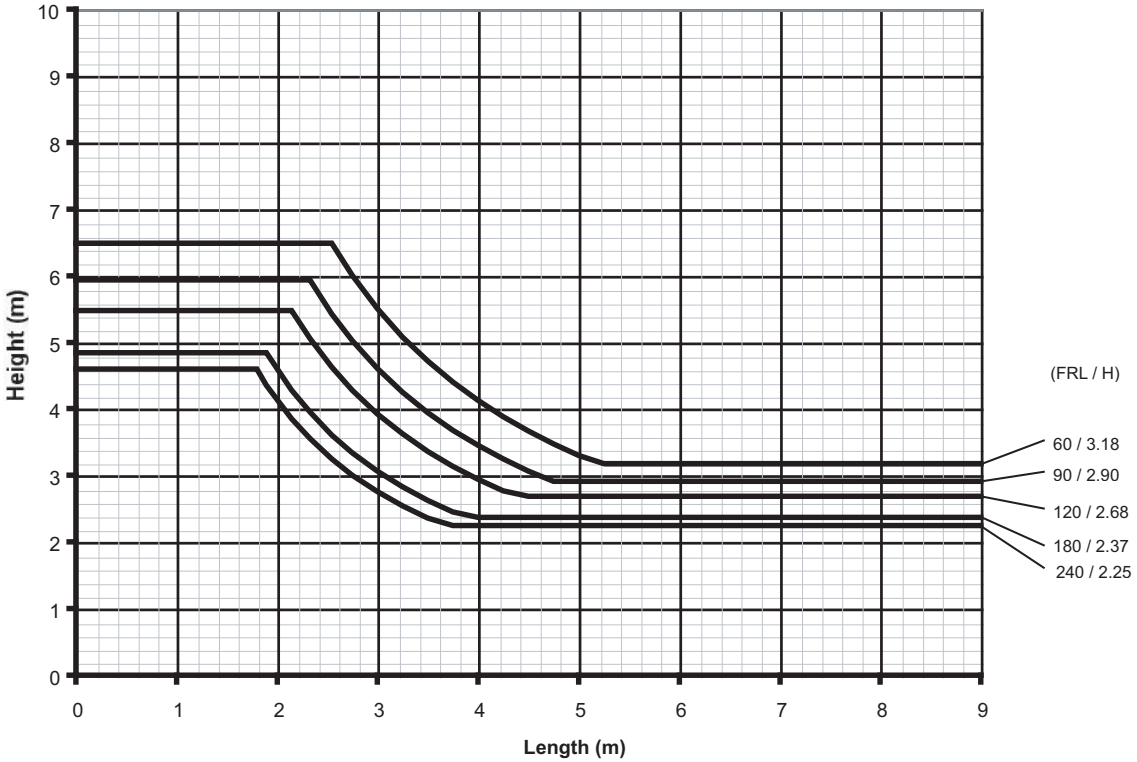


Chart FR24: 200mm Non-Loadbearing CSR Hebel Block Wall Top and One Side Free





Section 5

Chart FR25: 225mm Non-Loadbearing CSR Hebel Block Wall
All Edges Laterally Restrained

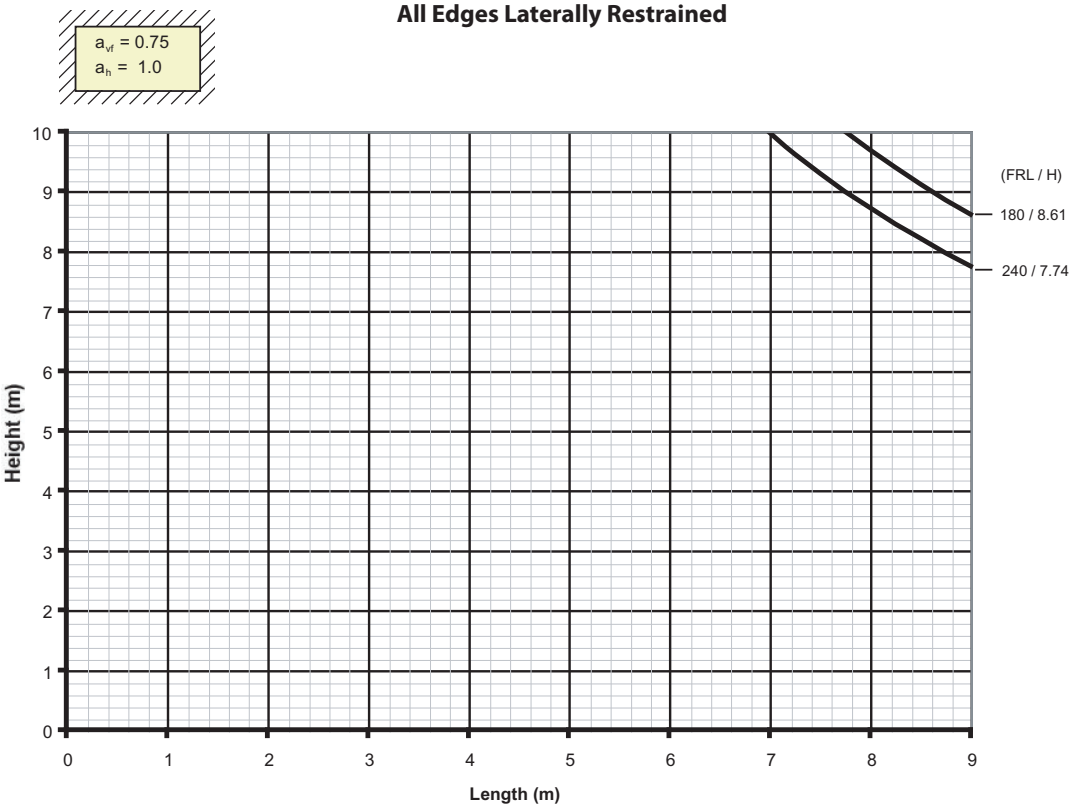


Chart FR26: 225mm Non-Loadbearing CSR Hebel Block Wall
One Vertical Side Free

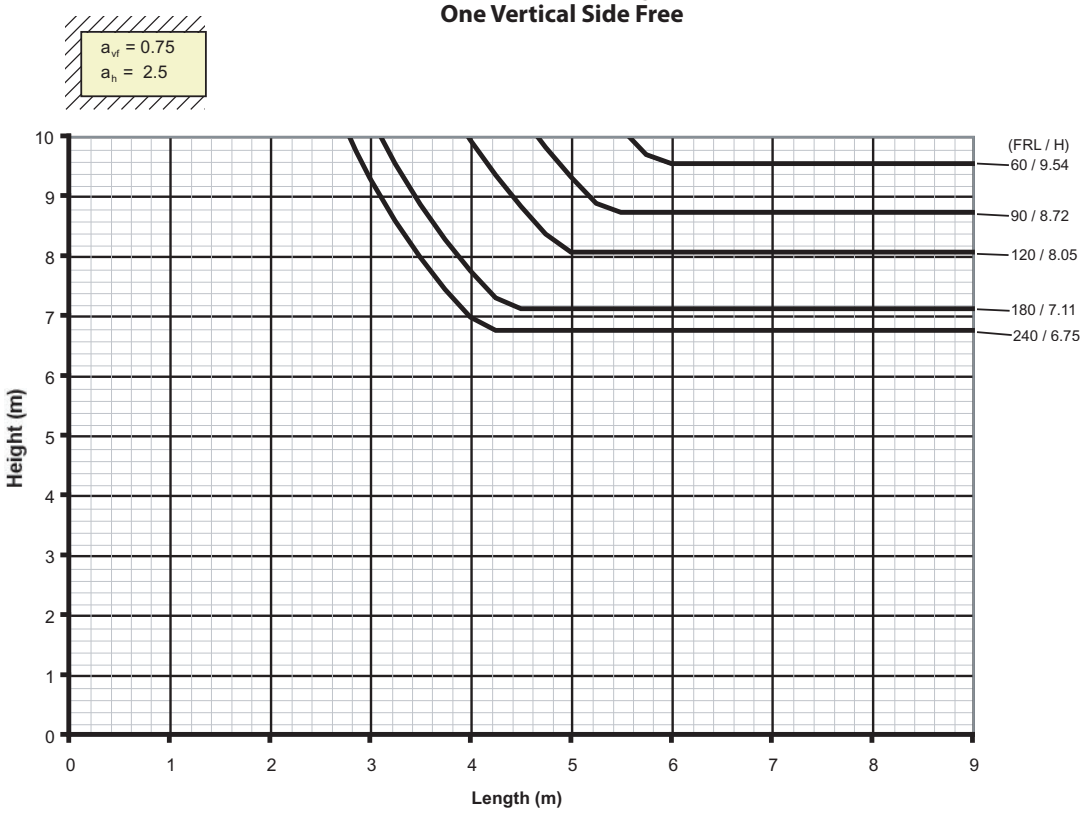


Chart FR27: 225mm Non-Loadbearing CSR Hebel Block Wall Top Edge Free

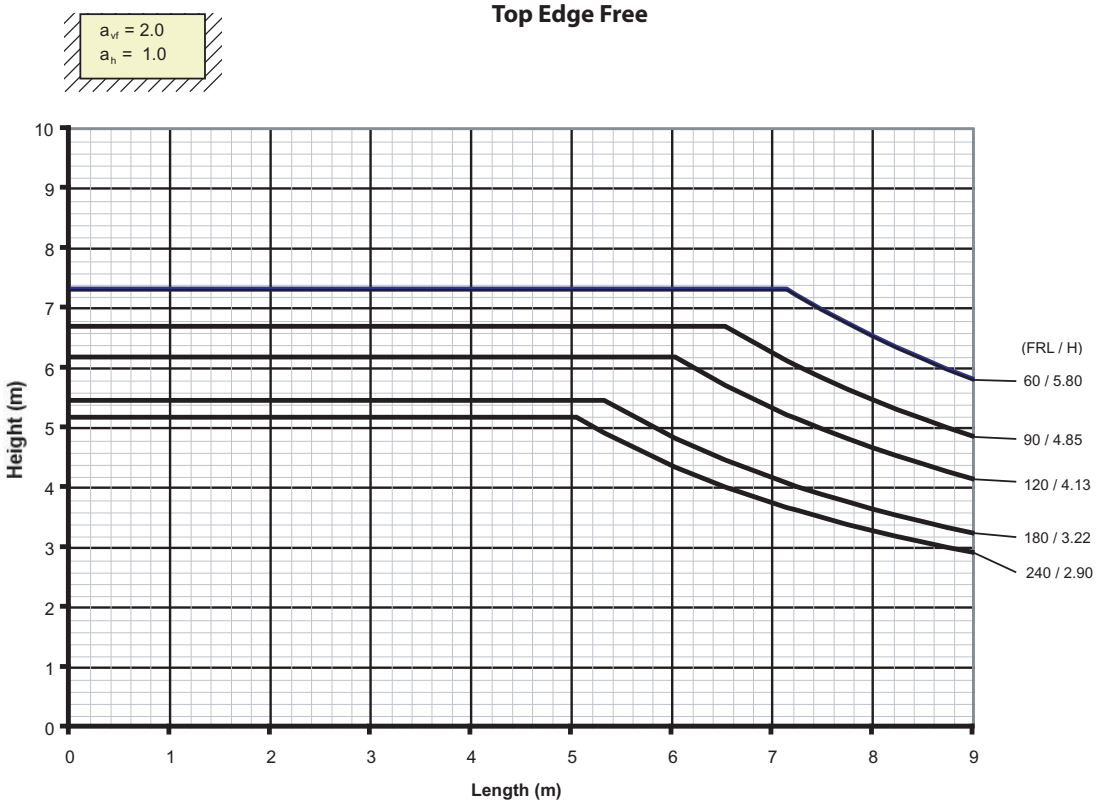
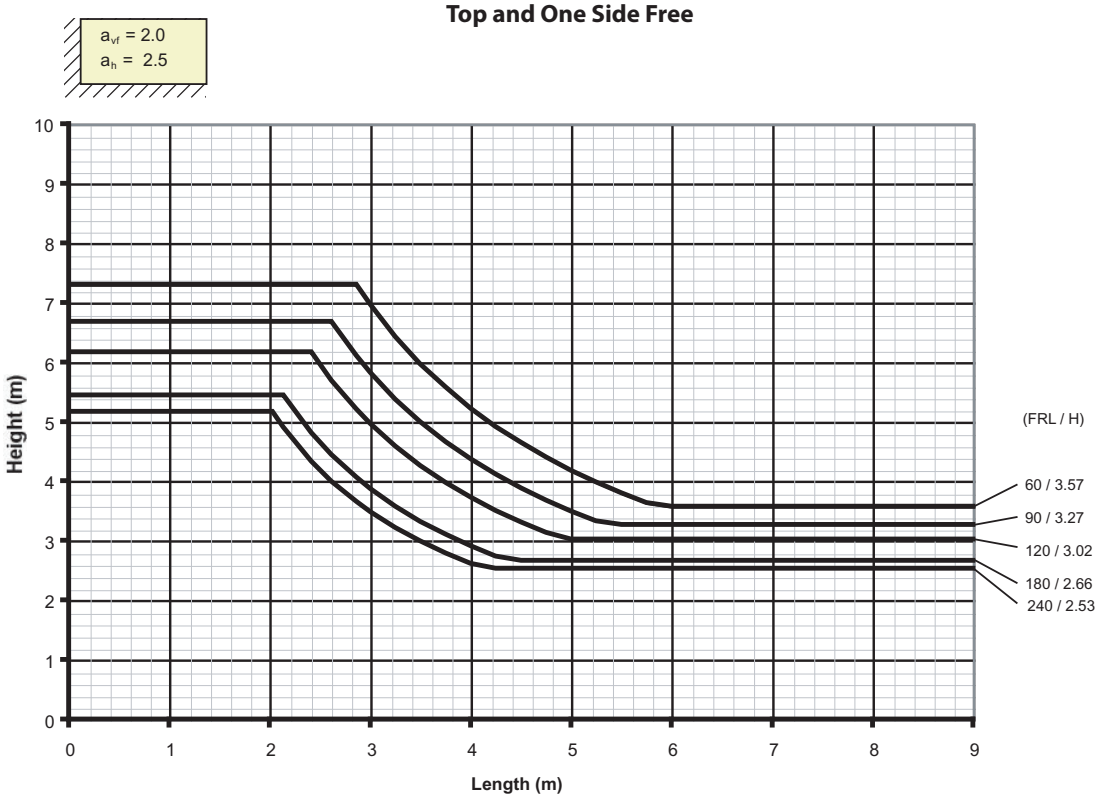


Chart FR28: 225mm Non-Loadbearing CSR Hebel Block Wall Top and One Side Free



Section 5

Chart FR29: 250mm Non- Loadbearing CSR Hebel Block Wall
All Edges Laterally Restrained

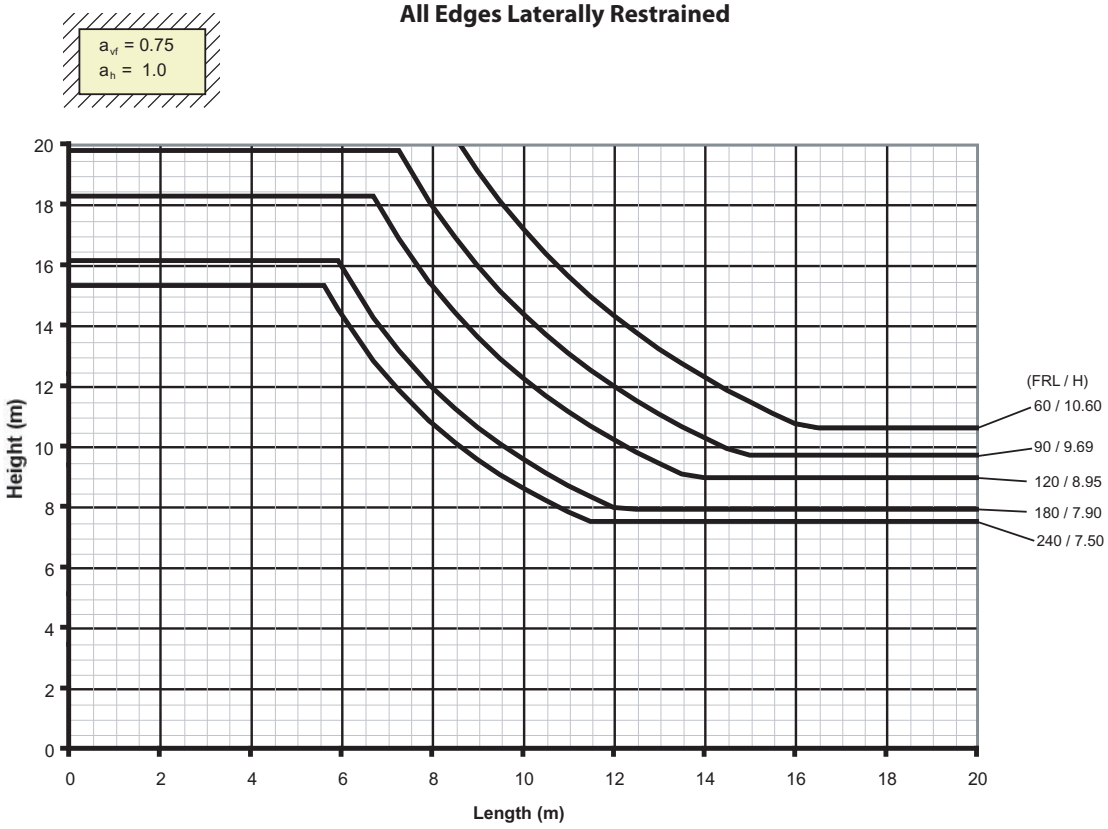


Chart FR30: 250mm Non-Loadbearing CSR Hebel Block Wall
One Vertical Side Free

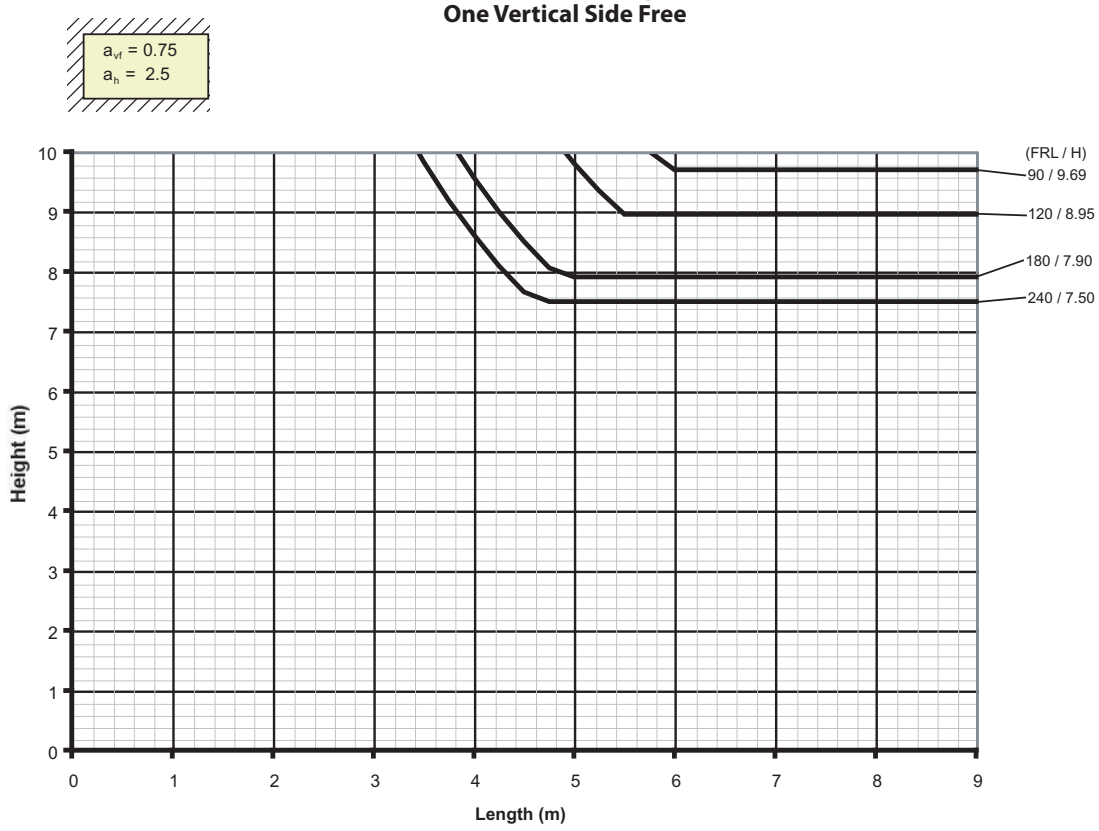


Chart FR31: 250mm Non-Loadbearing CSR Hebel Block Wall Top Edge Free

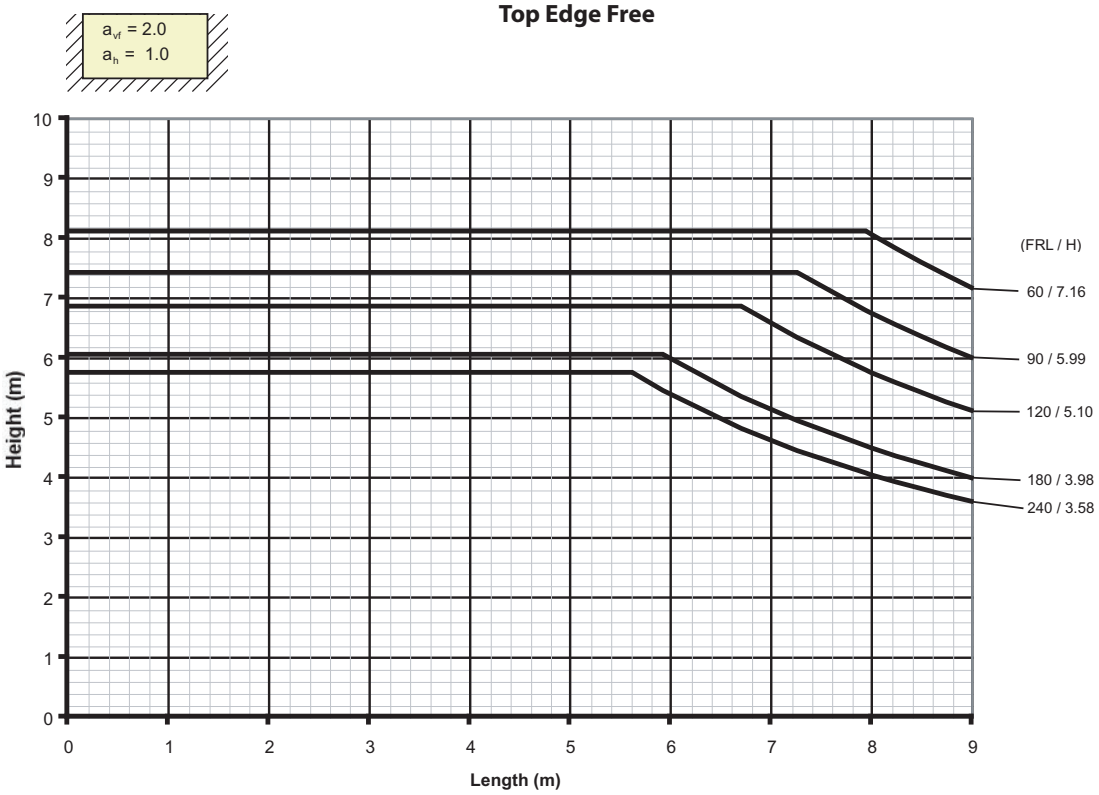


Chart FR32: 250mm Non-Loadbearing CSR Hebel Block Wall Top and One Side Free

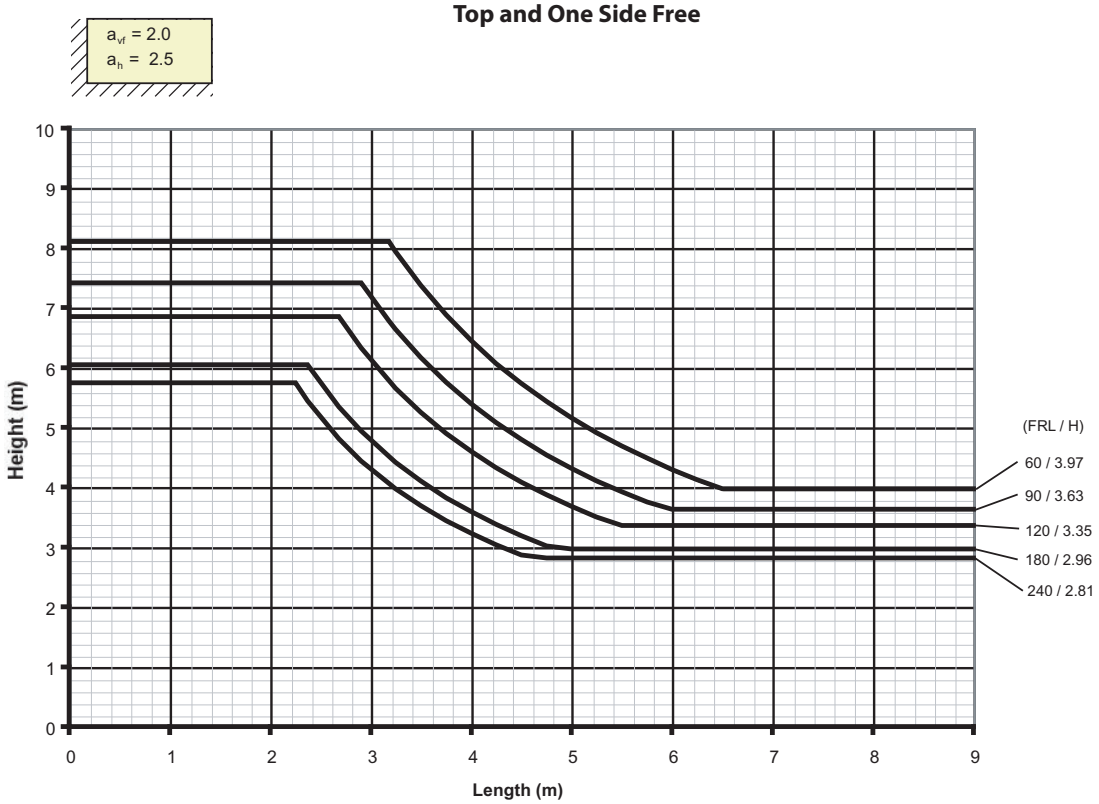


Chart FR33: 75-125mm Loadbearing CSR Hebel Block Wall All Edges Laterally Restrained

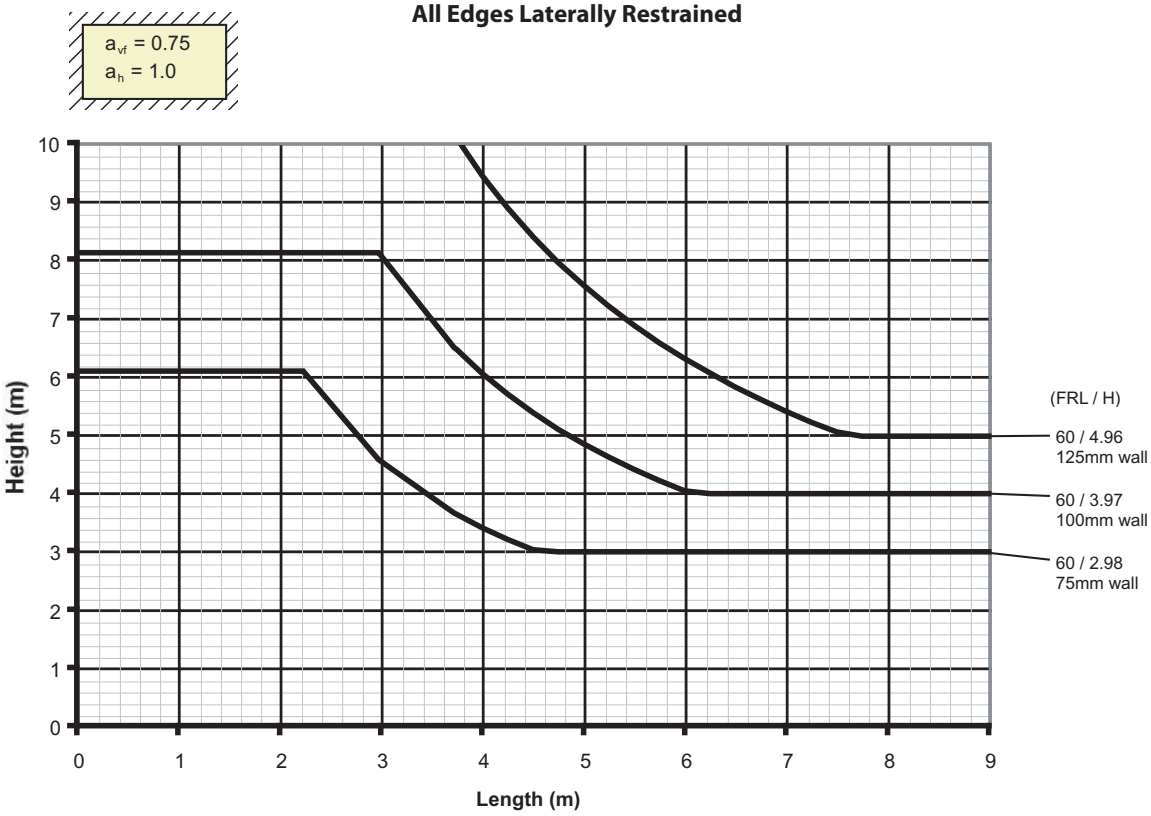


Chart FR34: 75-125mm Loadbearing CSR Hebel Block Wall One Vertical Side Free

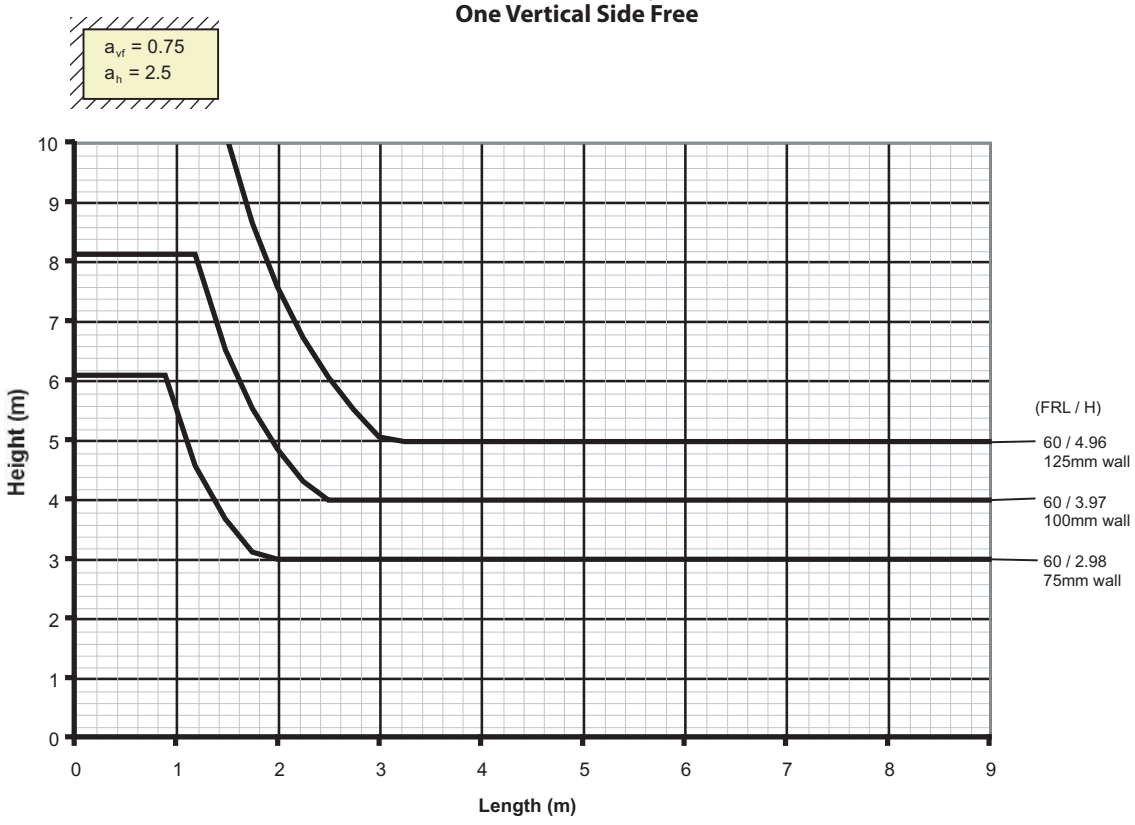


Chart FR35: 150mm Loadbearing CSR Hebel Block Wall
All Edges Laterally Restrained

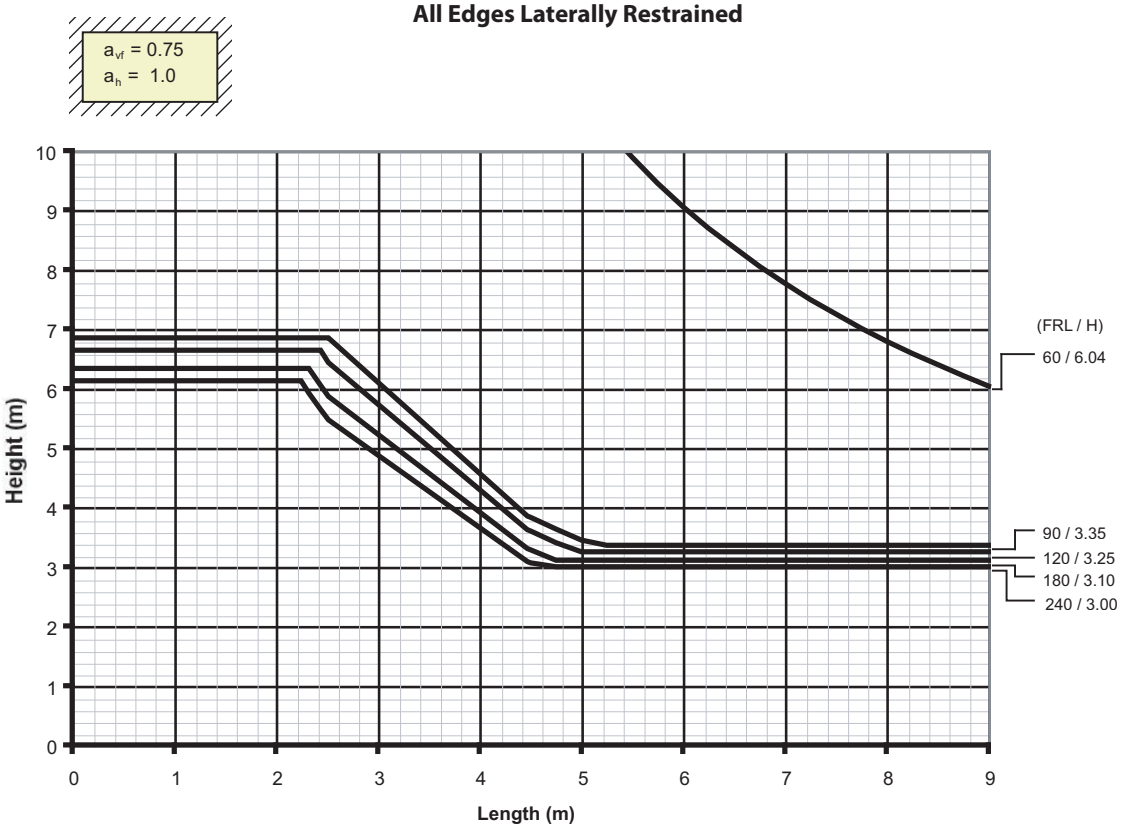


Chart FR36: 150mm Loadbearing CSR Hebel Block Wall
One Vertical Side Free

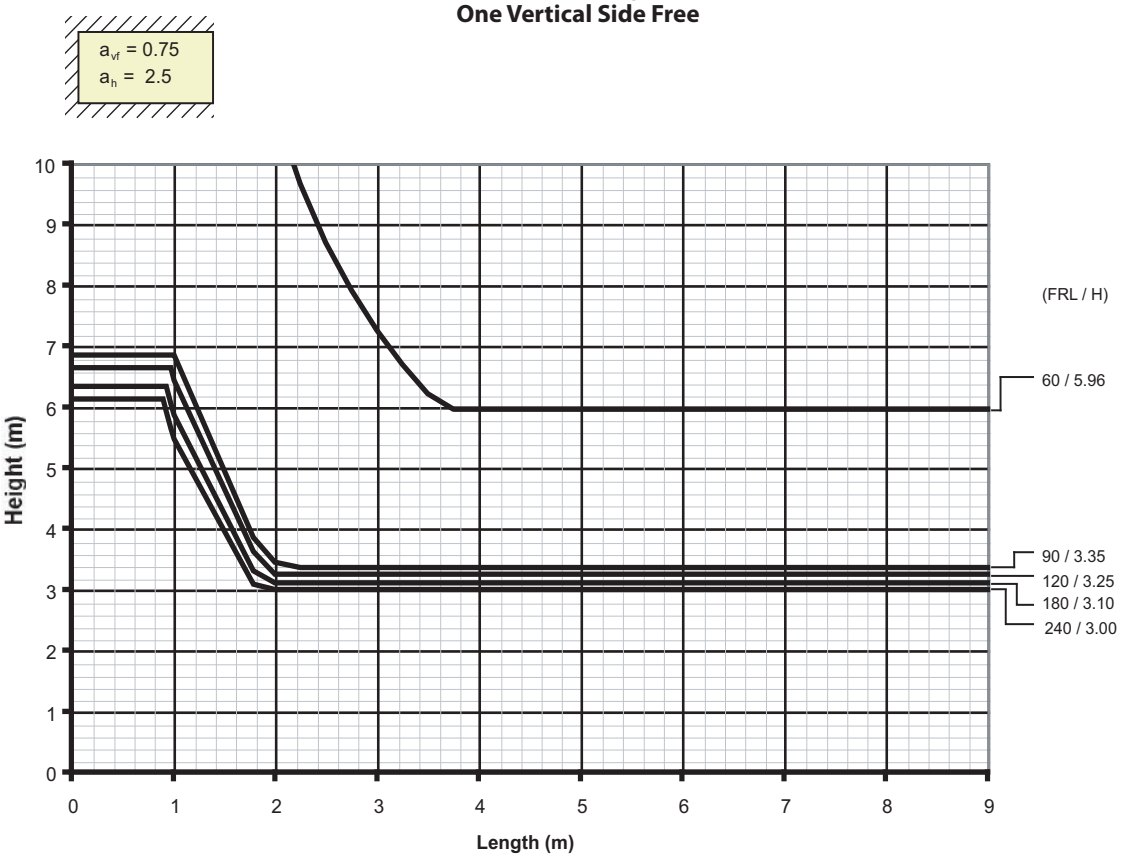


Chart FR37: 175mm Loadbearing CSR Hebel Block Wall
All Edges Laterally Restrained

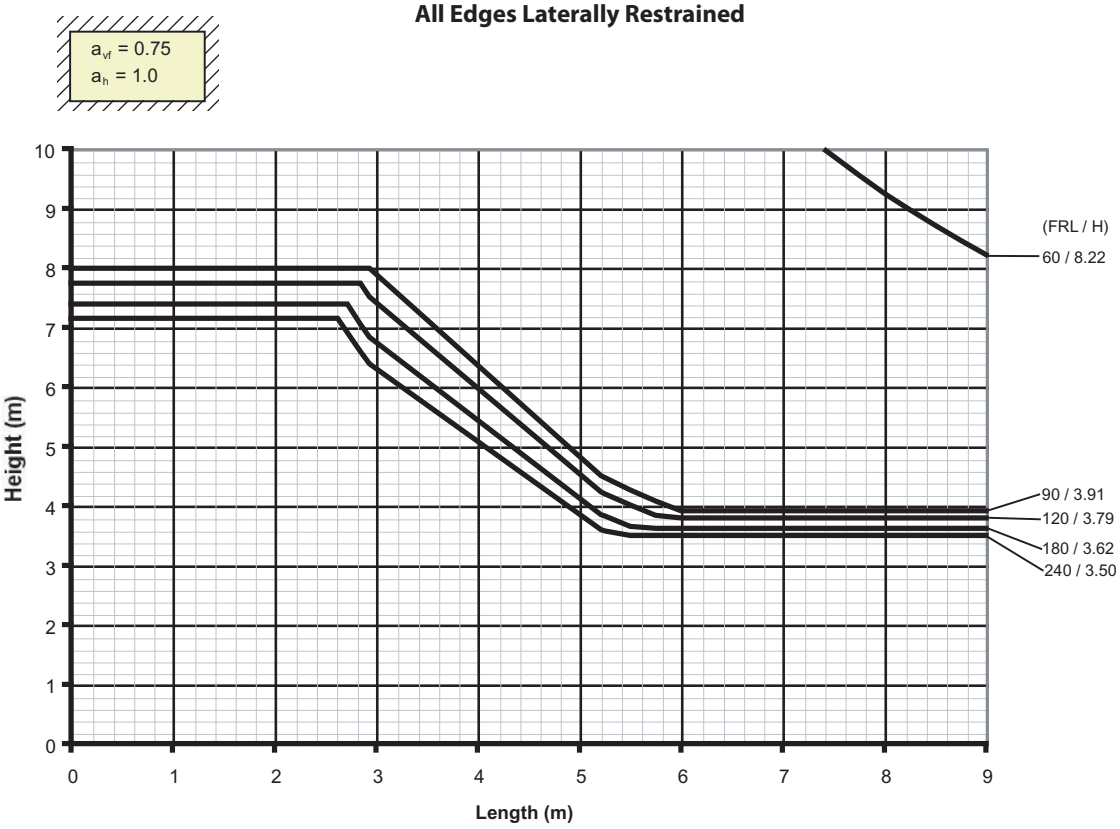


Chart FR38: 175mm Loadbearing CSR Hebel Block Wall
One Vertical Side Free

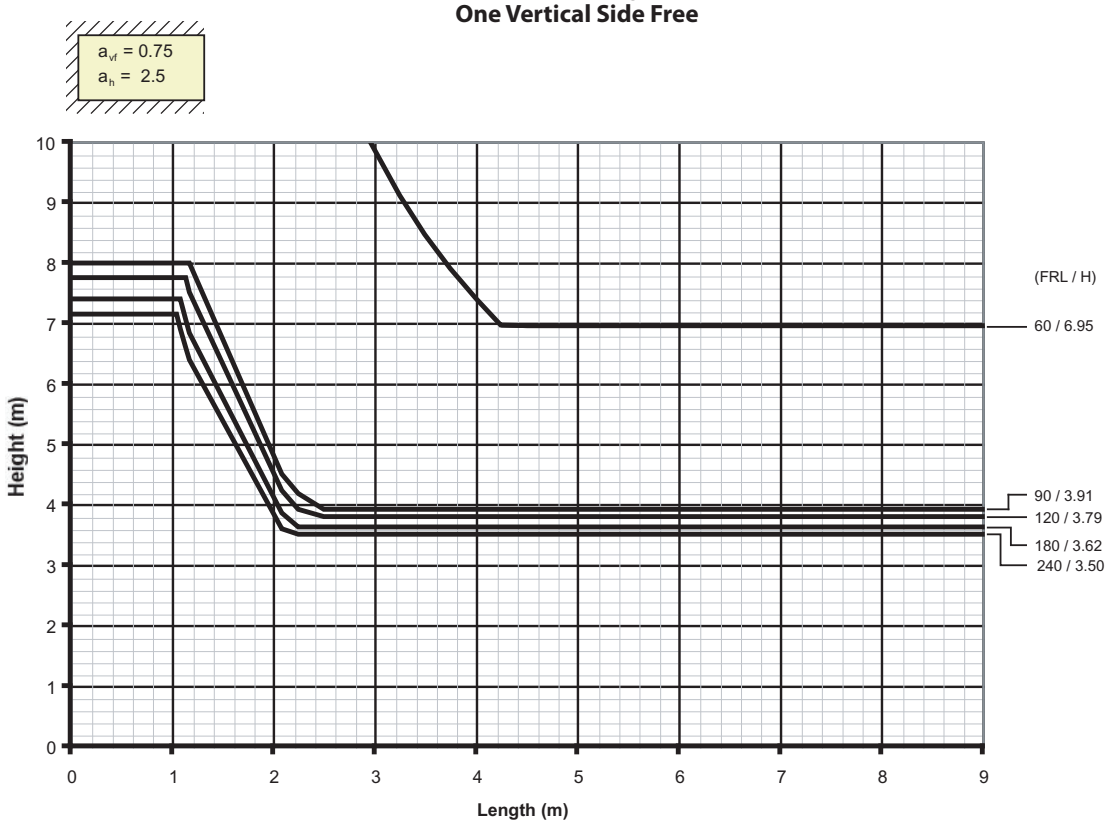


Chart FR39: 200mm Loadbearing CSR Hebel Block Wall All Edges Laterally Restrained

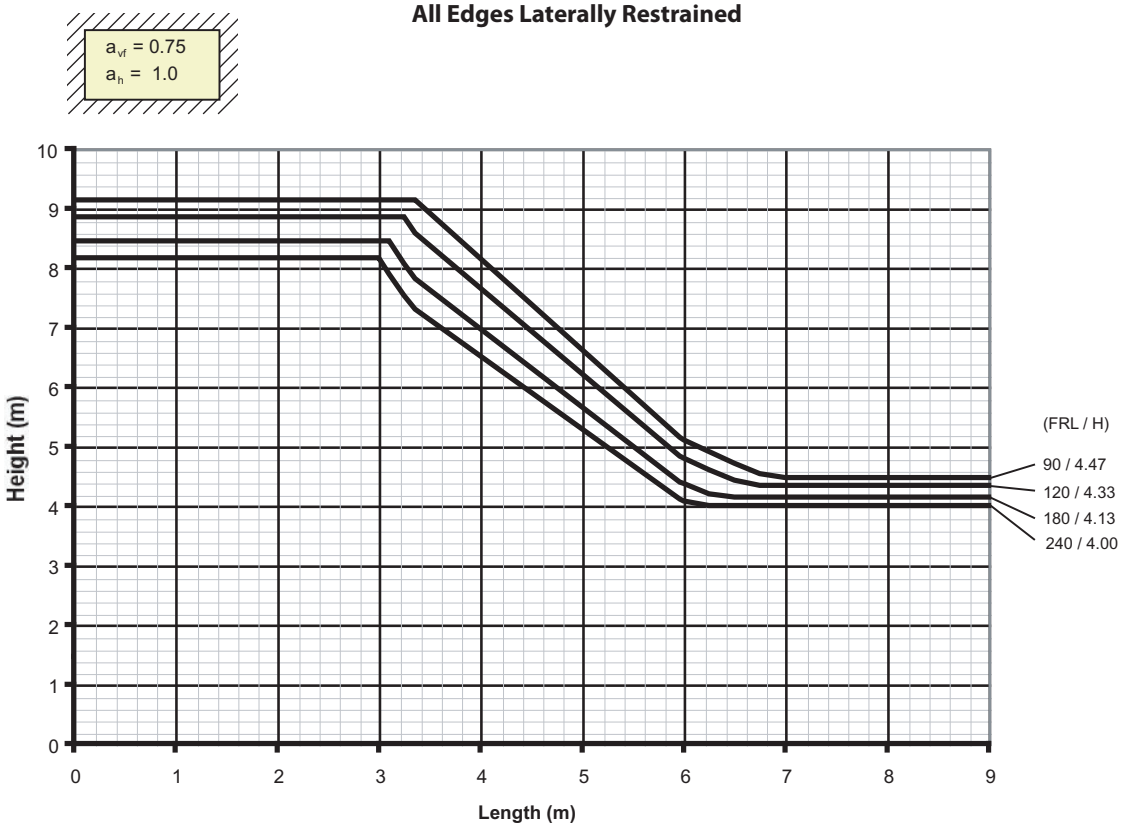


Chart FR40: 200mm Loadbearing CSR Hebel Block Wall One Vertical Side Free

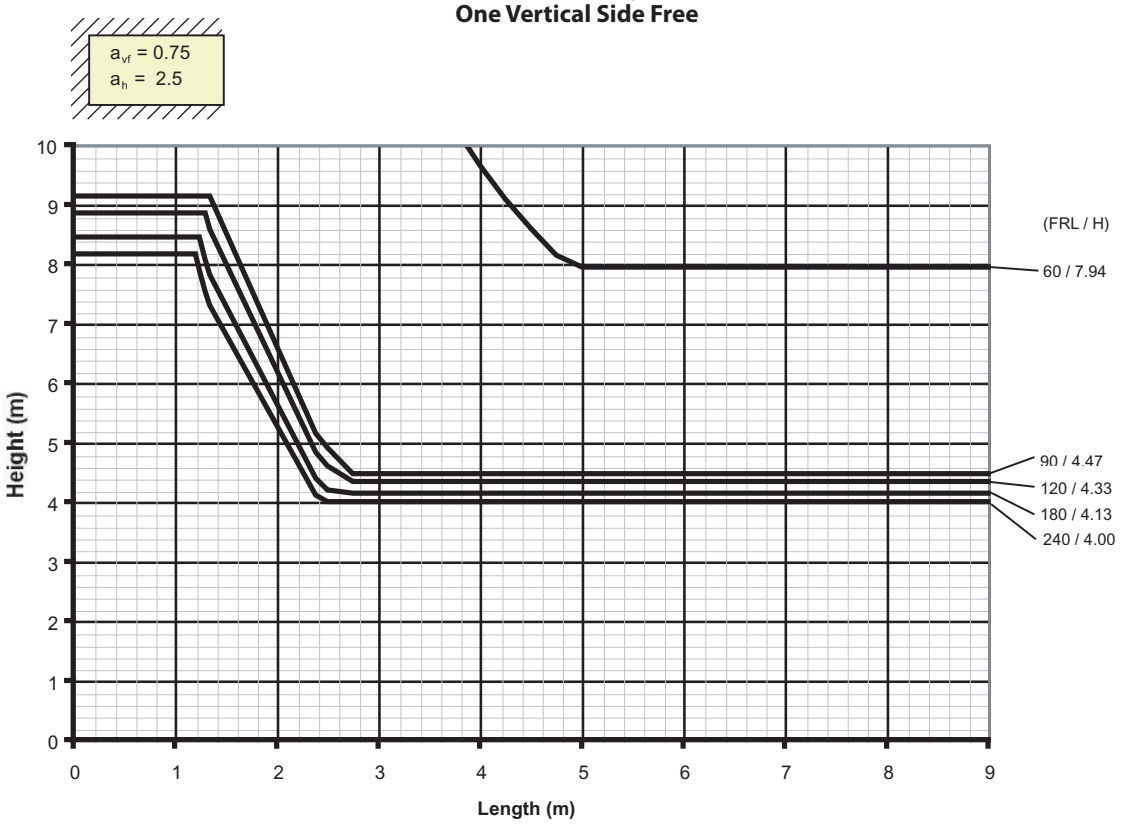


Chart FR41: 225mm Loadbearing CSR Hebel Block Wall
All Edges Laterally Restrained

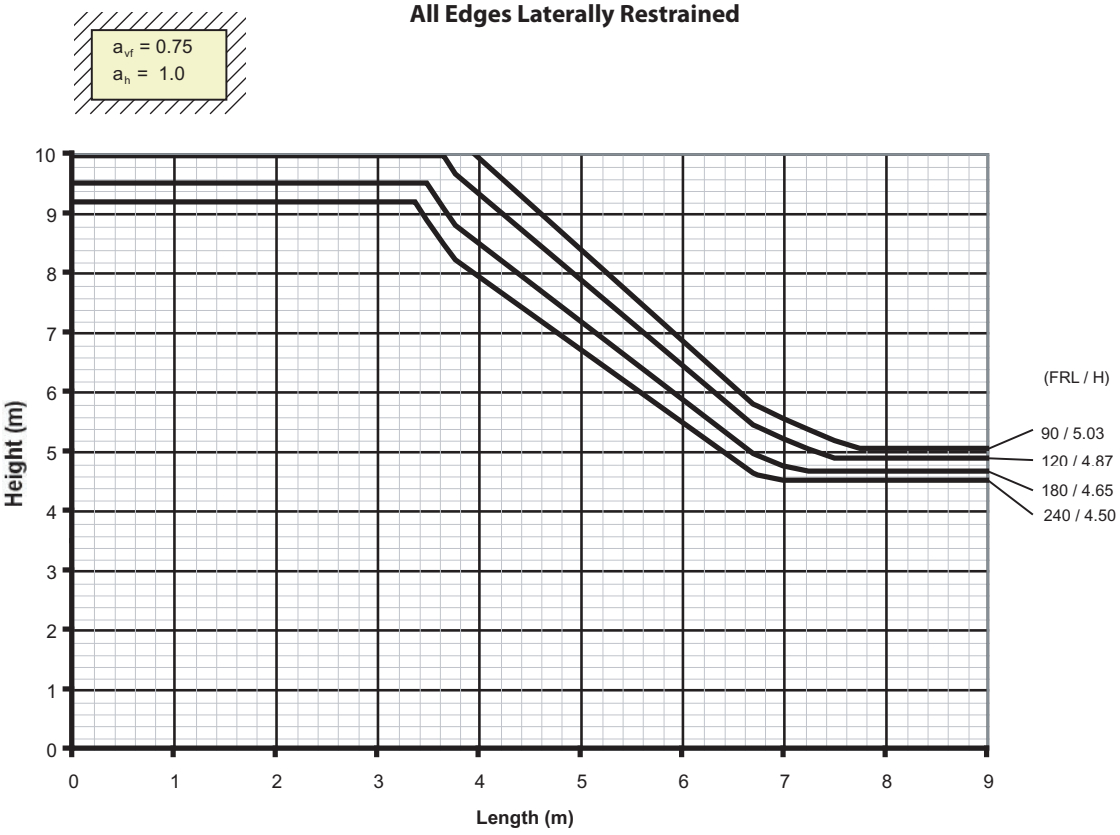


Chart FR42: 225mm Loadbearing CSR Hebel Block Wall
One Vertical Side Free

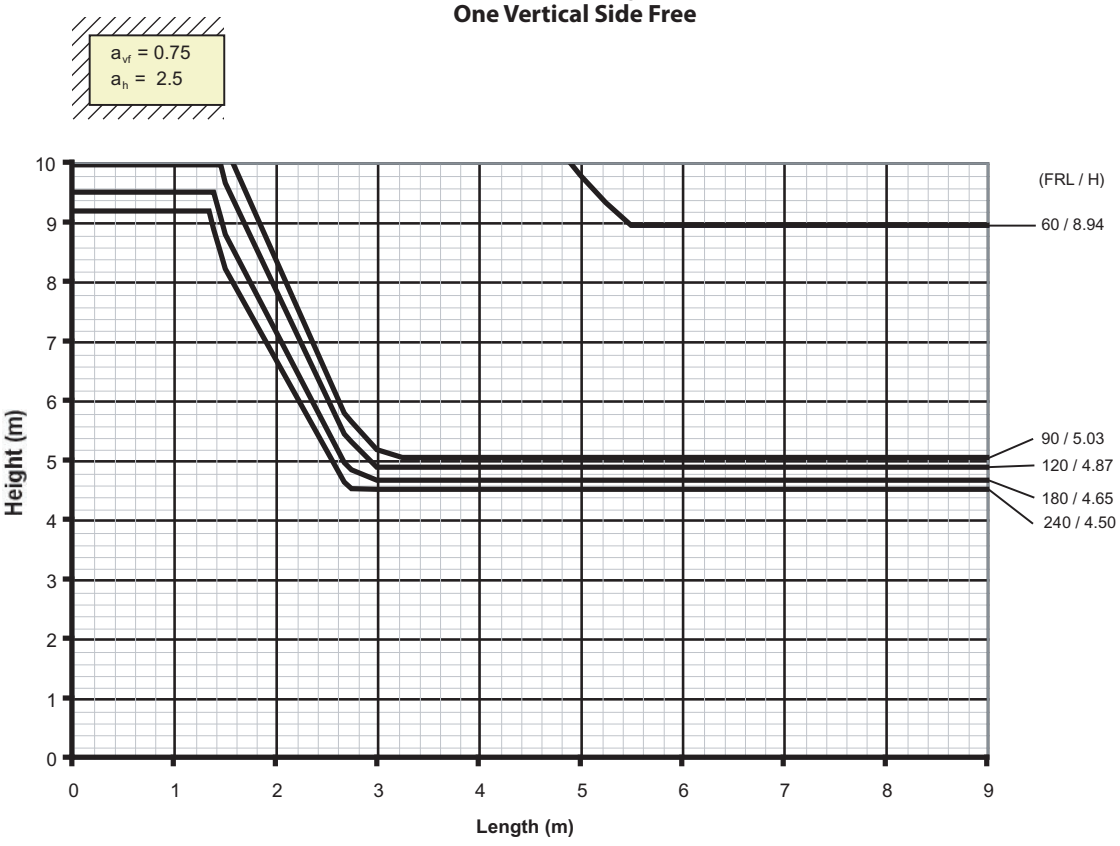


Chart FR43: 250mm Loadbearing CSR Hebel Block Wall
All Edges Laterally Restrained

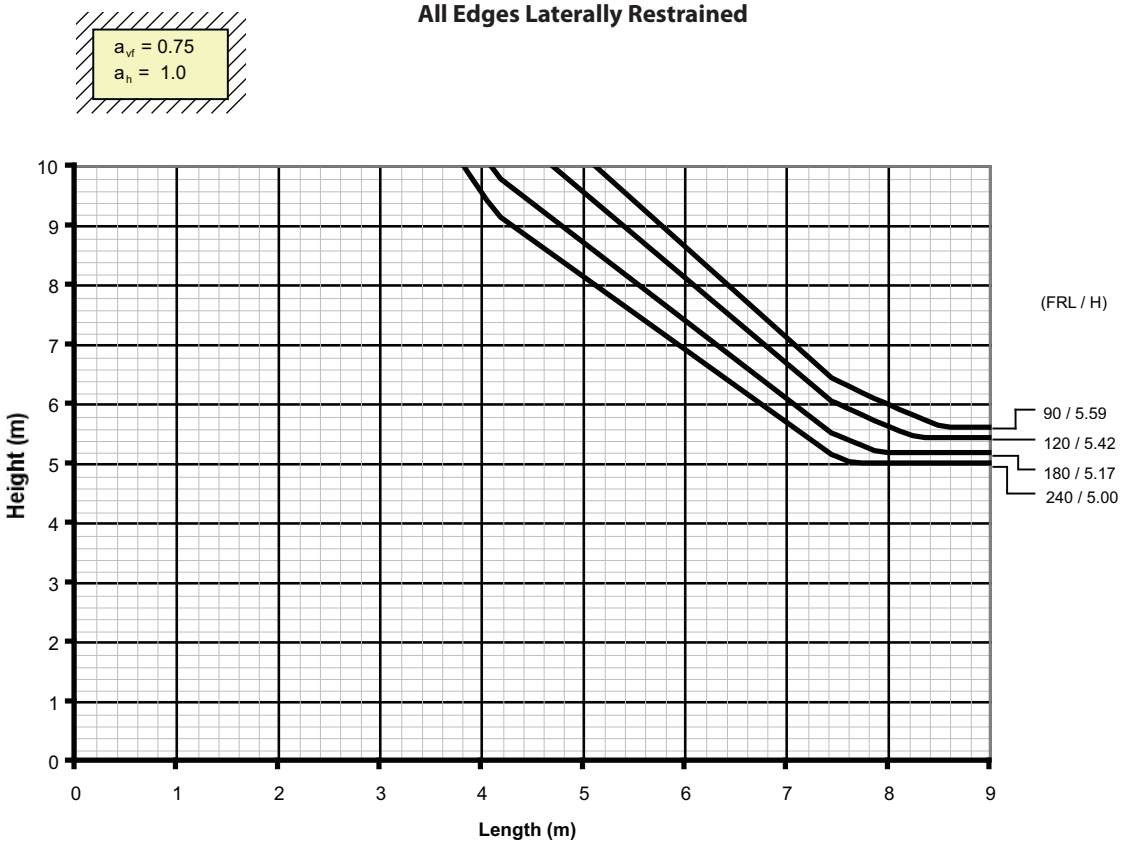
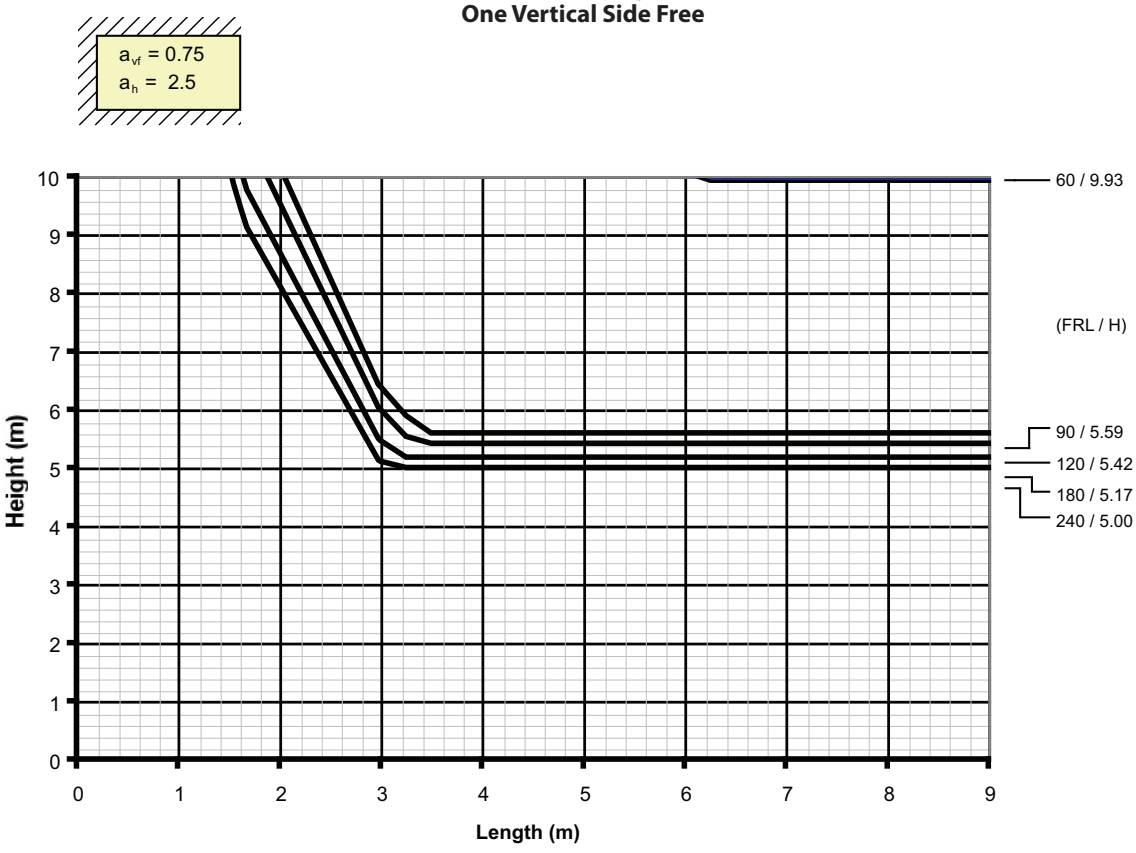


Chart FR44: 250mm Loadbearing CSR Hebel Block Wall
One Vertical Side Free



Panel Products

5.13 Design for Fire – Panels

Overview

The inherent heat insulation quality of autoclaved aerated concrete (AAC) provide structural panels with exceptional fire resistance characteristics.

CSR Hebel manufacture a range of panels to suit a arrange of applications, these being wall, floor, ceiling and roof applications, for both loadbearing and non-loadbearing configurations.

This section will present the fire design methodology background and design detailing requirements to be considered when selecting a CSR Hebel AAC panel. To simplify the presentation of panel design information, the fire performance characteristics of the various panel types have been incorporated in the panel capacity tables presented in Section 7 of this publication.

Determining the Fire Performance Characteristics of the Panel

For non-loadbearing wall panels, the fire resistance level (FRL) ratings have been established by the AS1530.4.

For loadbearing wall panels, the knowledge of CSIRO with regards to the performance of AAC panels and block masonry have allowed them to provide opinions on the likely performance of loadbearing panels when subjected to fire loading. These opinions have been issued on a project by project basis, as no global design methods have been determined.

Along with fire loading, other loadings conditions have to be checked. Currently, there are no documented design methods to assist in checking the performance of the loadbearing panel system. The loadbearing panel wall system can be designed from engineering principles and is the responsibility of an appropriate structural engineer.

For horizontal panels, such as floor, wall, ceiling and roof applications, the fire performance characteristics of these panels are a function of:

- Location of the fire source.
- Span of the panel.
- Magnitude of load applied.
- Thickness of AAC (cover) protecting the reinforcement.

When determining the adequacy of the panel there are two approaches depending on the location of the fire source. For the fire source located above the panel, a depth of AAC is deemed to be structurally ineffective. The structural adequacy of the panel subjected to the fire loadings is checked for a reduced effective panel thickness.

For a fire source located below, the panel will be structurally adequate if the reduced tensile strength of the reinforcement is greater than the strength required to support the applied load. The longer a panel is subjected to a fire and the smaller the cover of AAC the more likely the reinforcement strength will be reduced.

The CSIRO have established a relationship between duration of exposure to fire source and cover of AAC, which provides a reduced maximum stress capacity (strength) of the reinforcement, and a relationship between FRL rating and the depth of AAC to be considered ineffective.

End Protection of Cut Panels to Maintain FRL

The ends of the panels need to be protected in both cases as the cover to the tensile reinforcement may be as low as 20mm. The

recommended method is to glue 100mm blocks to the ends of the panels using Hebel Adhesive. Refer to Appendix F for some test results and certificates.

Connections

Some connection systems – typically exposed and not concealed within the panel width - require secondary fire protection systems to maintain their performance when subjected to a fire loading. Connection that require fire protection:

- Tension Tie
- Bolted Connection (cleats and angles)

The conventional right angle bracket connection is located within the width of the wall and the panel provides the fire protection of the bracket.

Edge Profile on the Panel

For horizontal panels a T&G profile is not compulsory as the weight of the panels over prevent the joint from opening. Unlike vertical panels where the heat of the fire and subsequent shrinkage of the panels results in a vertical crack occurring at the joint- ideally a T&G profile should be adopted as a the tongue resists the flow of heat through the crack and hence results in a higher FRL rating. Contact CSR Hebel Engineering Services for available information.

5.14 Recesses for Services and Chasing for Fire Design

When walls are to be recessed or chased for the provision of services and cabling, these recesses or chases satisfy the requirements presented in AS3700 Clauses 6.6 and 6.7, respectively. All chasing to be approved by Project Engineer.

In addition to these requirements CSR Hebel provides the following information with regards to chasing, which will not be detrimental to the already established levels.

Vertically orientated chases

- the depth of the chase to be less than 1/3 of the thickness of the wall;
- thickness of the material remaining after forming the chase is not less than 60mm;
- the width of the chase is not greater than 100mm;
- for panels, reinforcement shall not be cut, which will restrict the maximum possible chase depth; and
- the chase is backfilled after the installation of the services with suitable material which would adhere to the wall (e.g. Hebel Patch).

Horizontally orientated chases

- the depth of the chase to be less than 1/3 of the thickness of the wall;
- thickness of the material remaining after forming the chase is not less than 60mm;
- the width of the chase is not greater than 100mm;
- the horizontal length of the chase is not greater than 300mm or 3 times the thickness of the wall;
- for panels, reinforcement shall not be cut, which will restrict the maximum possible chase depth; and
- the chase is backfilled after the installation of the services with suitable material which would adhere to the wall (e.g. Hebel Patch).