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Fire resistance of Obeco glass block wall systems in accordance with AS 1530.4-2014

Assessment Report

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Client: Obeco Glass Blocks Pty Limited

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31 October 2019	31 October 2019	31 October 2019

Copyright and disclaimer

Important disclaimer

Contents

1 Introduction

This report is an assessment of the fire resistance of Obeco glass block wall systems in accordance with AS1530.4-2014.

This report is prepared for the purpose of meeting the evidence of suitability requirements of NCC Schedule 5 as appropriate for FRL.

This report reviews and confirms the extent to which the reference fire resistance tests listed in section 2 meet the requirements of the standard fire test standards listed in section 4 of the report. The proposed variations to the tested construction presented in section 3 are subject to an analysis in Appendix B and the conclusions are presented in Section 5 of this report.

The field of applicability of the results of this assessment report is presented in Section 6.

2 Supporting Data

This assessment report refers to various test reports to support the analysis and conclusions of this report. They are listed below;

Report Reference	**Test Standard**	**Outline of Test Specimen**
Efectis France report no. 08-V-064	NF EN 1363-1	A full-scale fire-resistance test on a La Rochère “198 Bricks” glass brick wall incorporating 190-mm x 190-mm x 80-mm deep glass bricks.
CSTB report no. 87.26109	The provisions of the order of 21 April 1983 from the French Ministry of the Interior Fire Resistance of a Building Element.	A full-scale fire-resistance test on a La Rochère “3010 brick” glass brick wall incorporating 300-mm x 300-mm x 100-mm deep glass bricks.
CTICM report no. 02-V-299	NF EN 1363-1	A full-scale fire-resistance test on a La Rochère “HALTOFEU 30” type glass brick wall incorporating 190-mm x 190-mm x 100-mm deep glass bricks.
CTICM report no. 05-V-136	NF EN 1363-1	A full-scale fire-resistance test on a La Rochère “TF 60a” type glass brick wall incorporating 190-mm x 190-mm x 150-mm deep glass bricks.
MPA 2101/419/16	DIN EN 1363-1	A full-scale fire-resistance test on a Fuchs Design GmbH glass brick wall incorporating 190-mm x 190-mm x 200-mm deep glass bricks.

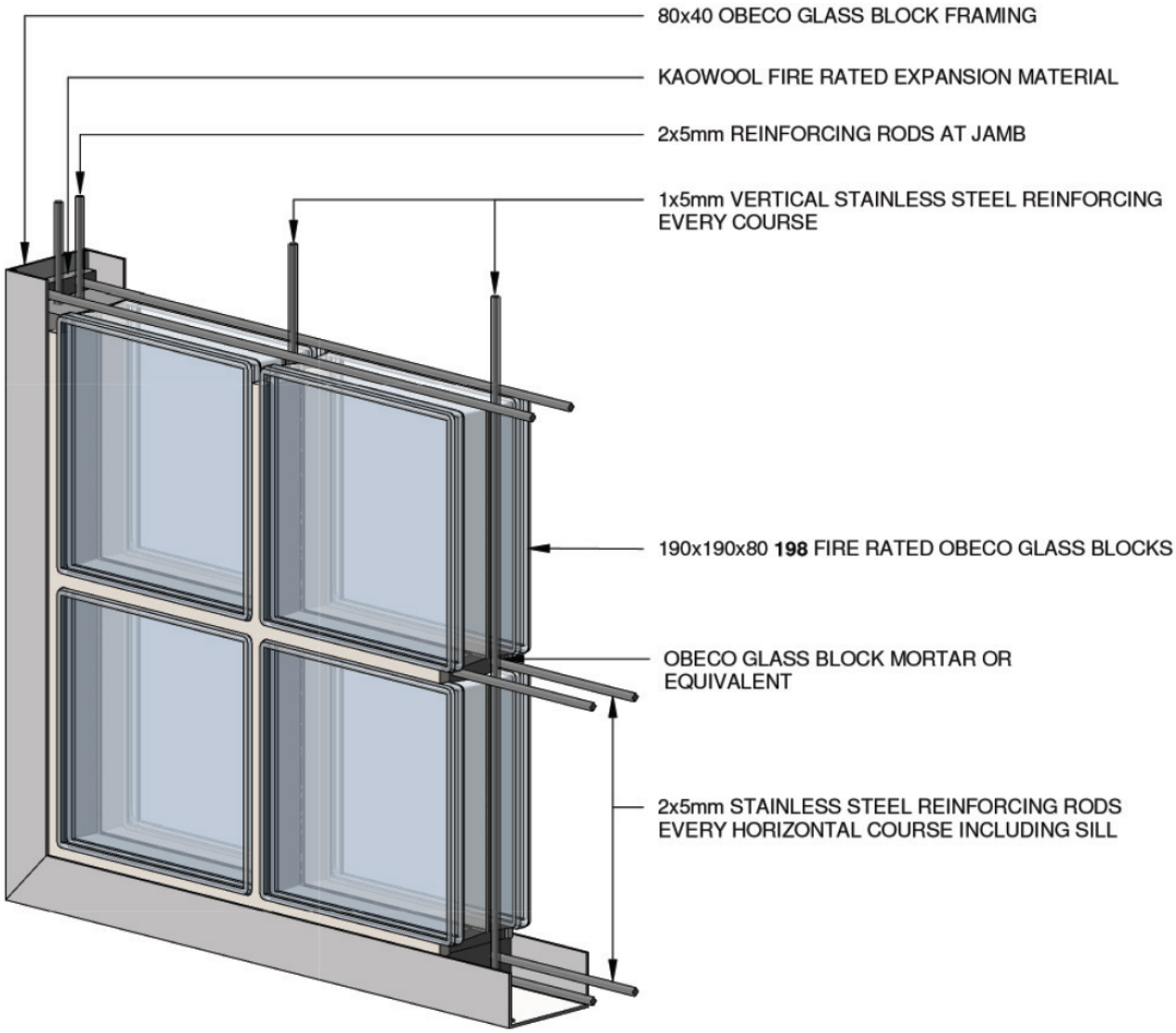
CSTB report no. 87.26109, Efectis France report no. 08-V-064, CTICM report no. 02-V-299 and CTICM report no. 05-V-136 were sponsored by La Rochère and La Rochère has provided permission to use the test data in these reports for this assessment.

Report 2101/419/16 was sponsored by Fuchs Design GmbH and Fuchs Design GmbH has provided permission to use the test data in this report for this assessment.

3 Proposed Variations

The proposed construction shall be the glass block walls CSTB report no. 87.26109, Efectis France report no. 08-V-064, CTICM report no. 02-V-299, CTICM report no. 05-V-136 and MPA 2101/419/16, and subject to the variations listed below:

- Glass thickness to be as tested or thicker
- Decrease the size of glass block as tested in CSTB report no. 87.26109 to 190 x 190 x 100mm.
- Inclusion of wall with 2 x leaves of 1910 blocks and a minimum 50mm gap.
- Reinforcement arrangements varied as per Figures 1 - 7.
- The spacing for dowels shall be a minimum of 400mm for all restrained edges.
- Height and length of the wall increased from that tested.
- The support construction to remain as tested for the required FRL.
- The minimum embedment for dowel in support contraction (masonry concrete) the 50mm and a 10mm expansion gap at ends (60mm deep hole).
- Sealant to be assessed to the perimeter details and specified as
    - Sealant shall be supported by test or assessment demonstrating the sealant can achieve an FRL of -/120/120 as a wall or floor-protecting a gap of 10-20mm wide and 10mm deep.
- Kaowool specified as the infill.



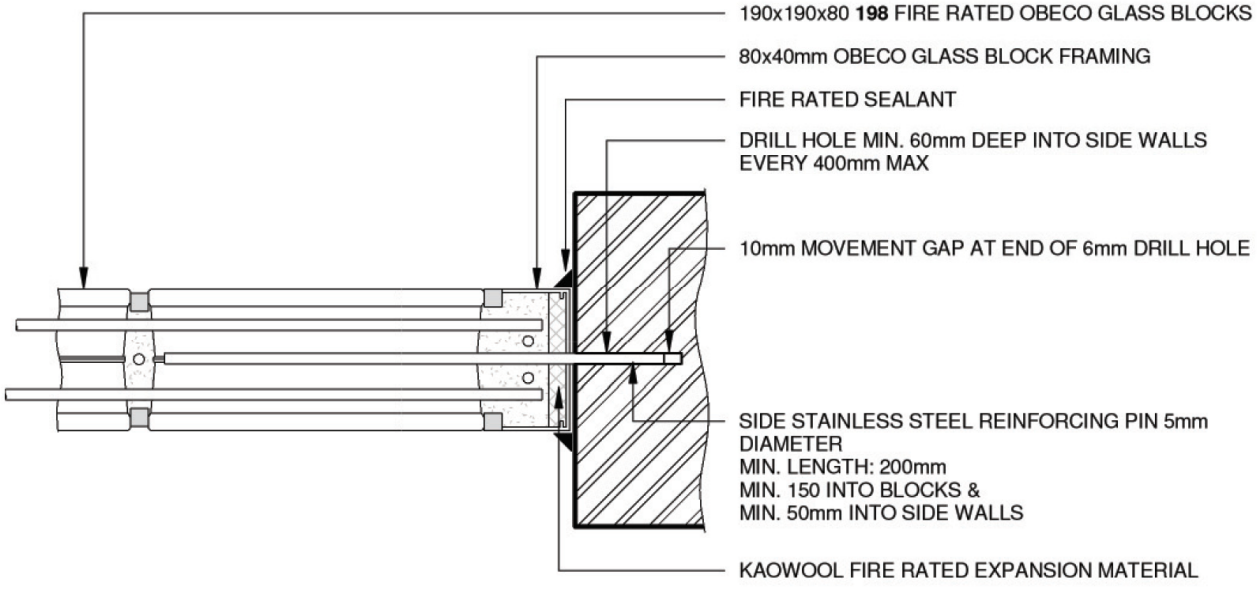


Figure 1: 80mm thick Obeco glass block wall of maximum height of 2.65m

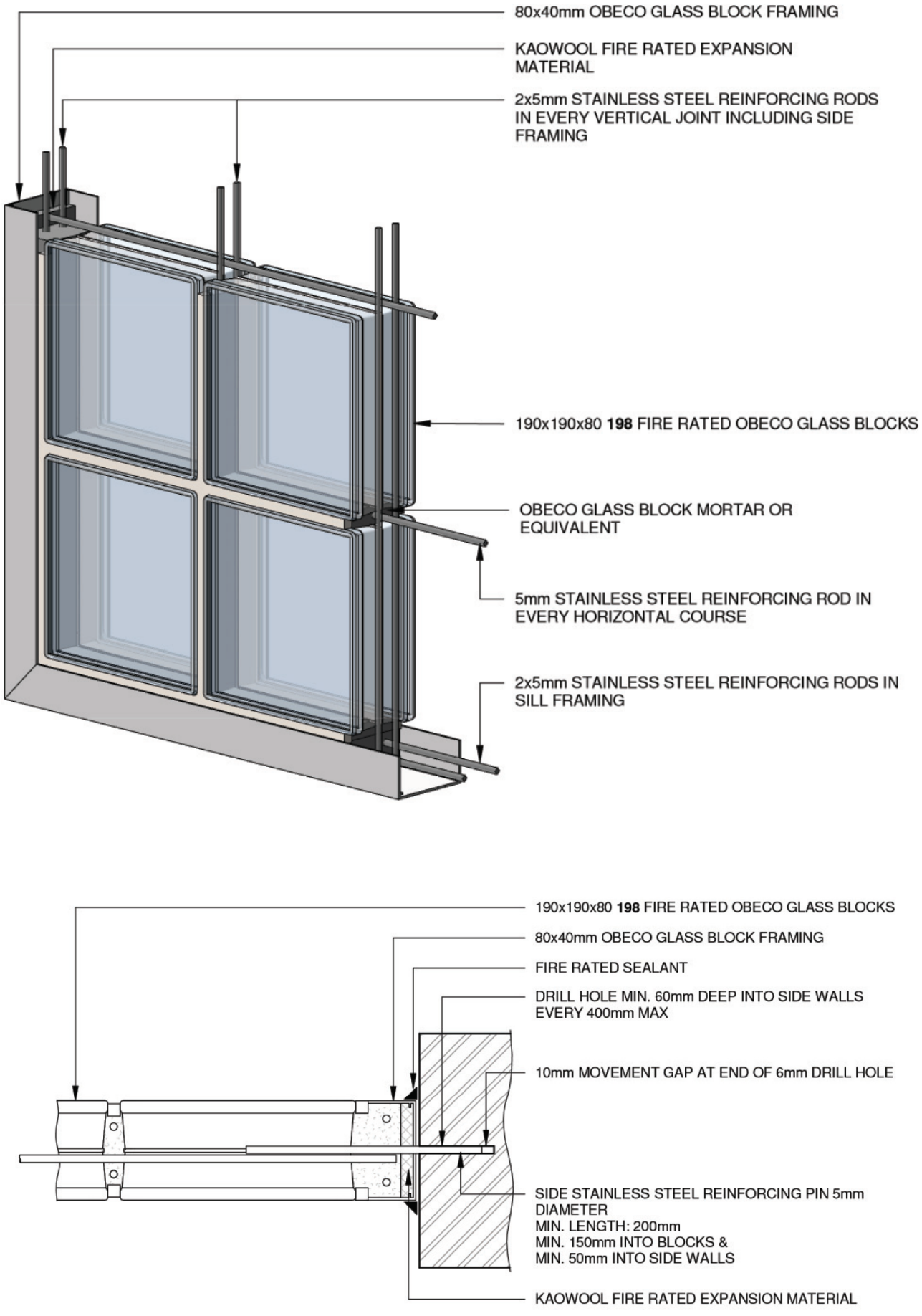


Figure 2: 80mm thick Obeco glass block wall of maximum height of 4m

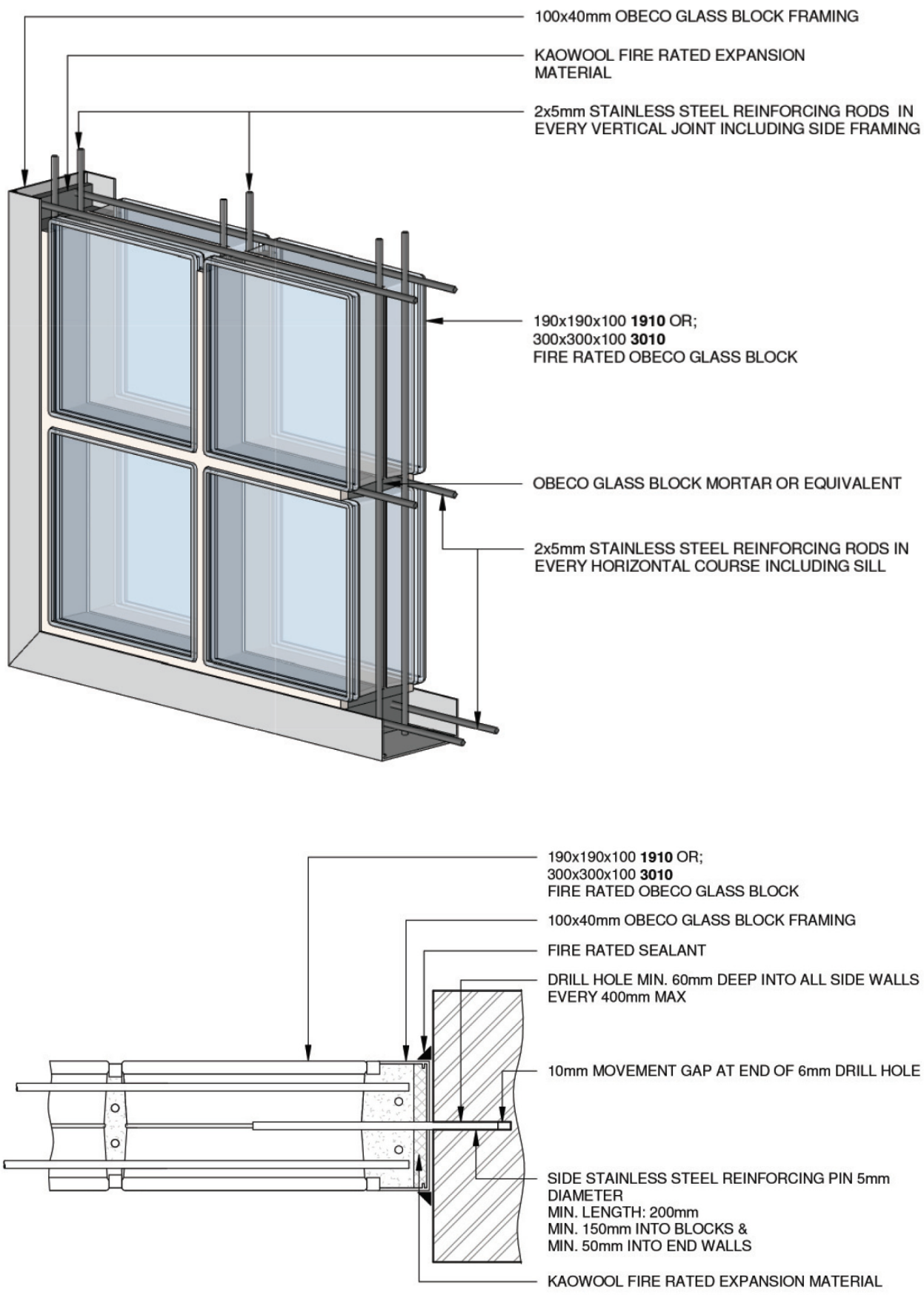


Figure 3: 100mm thick 1910 or 3010 Obeco glass blocks

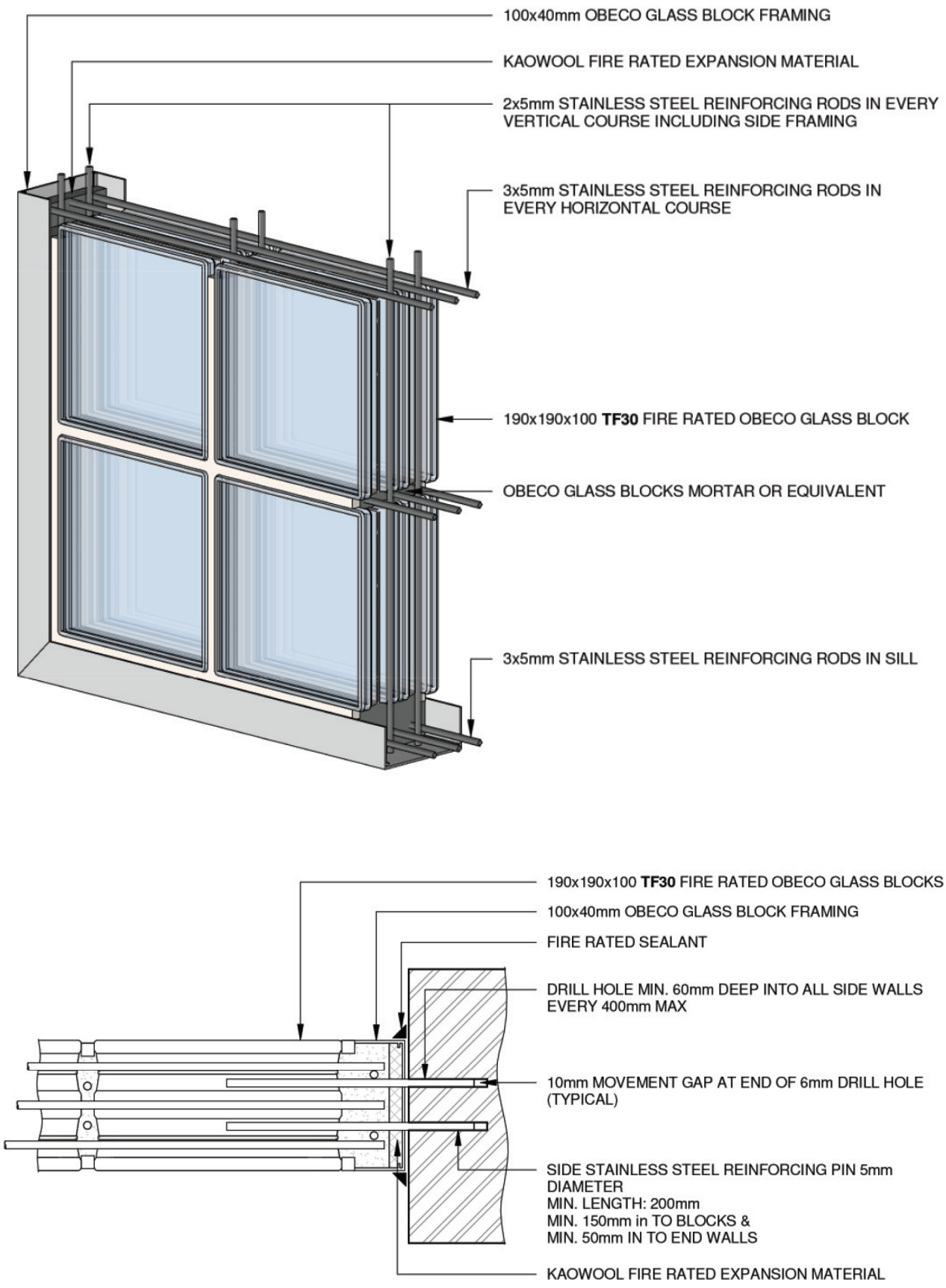


Figure 4: 100mm thick TF30 Obeco glass blocks

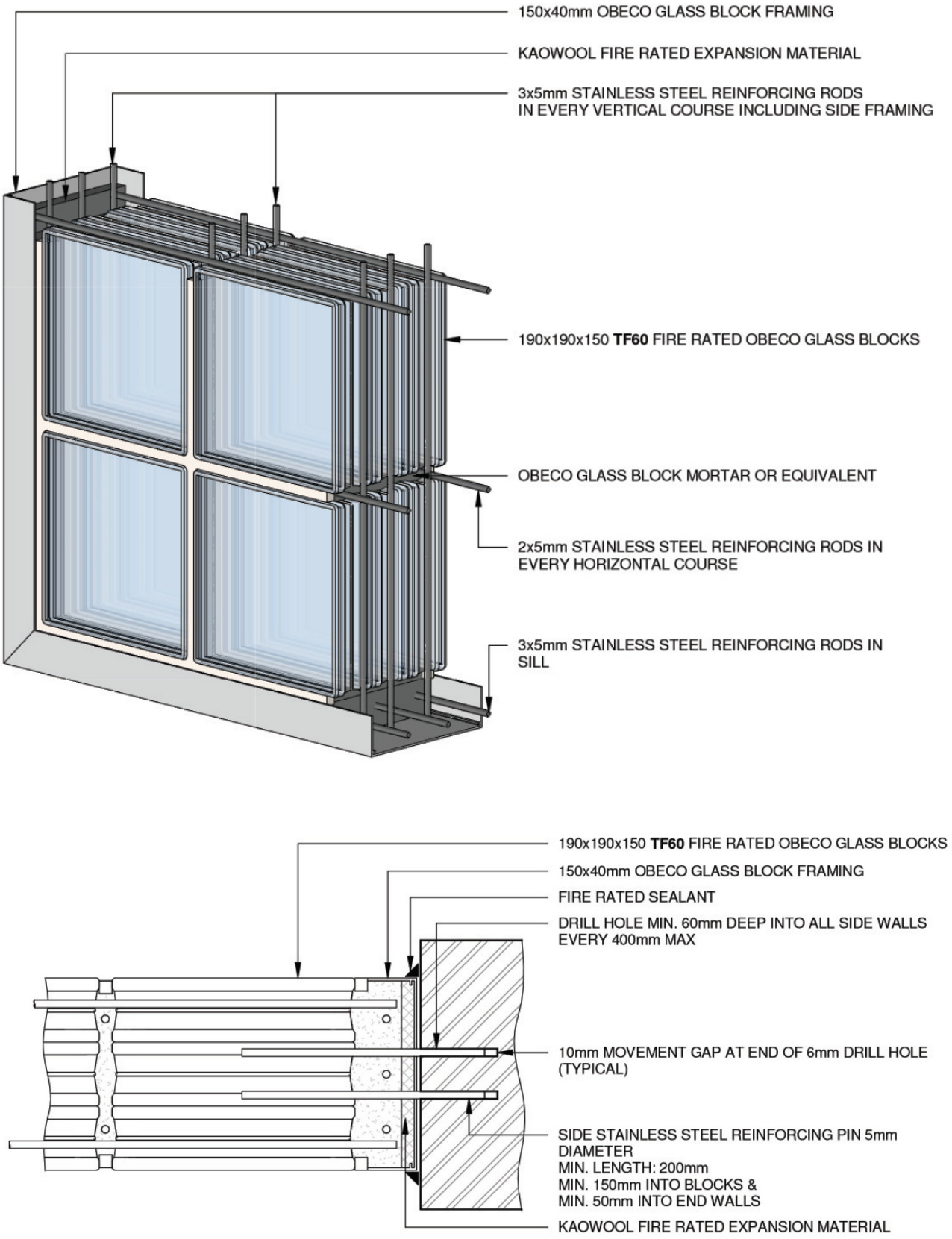


Figure 5: 150mm thick Obeco glass blocks

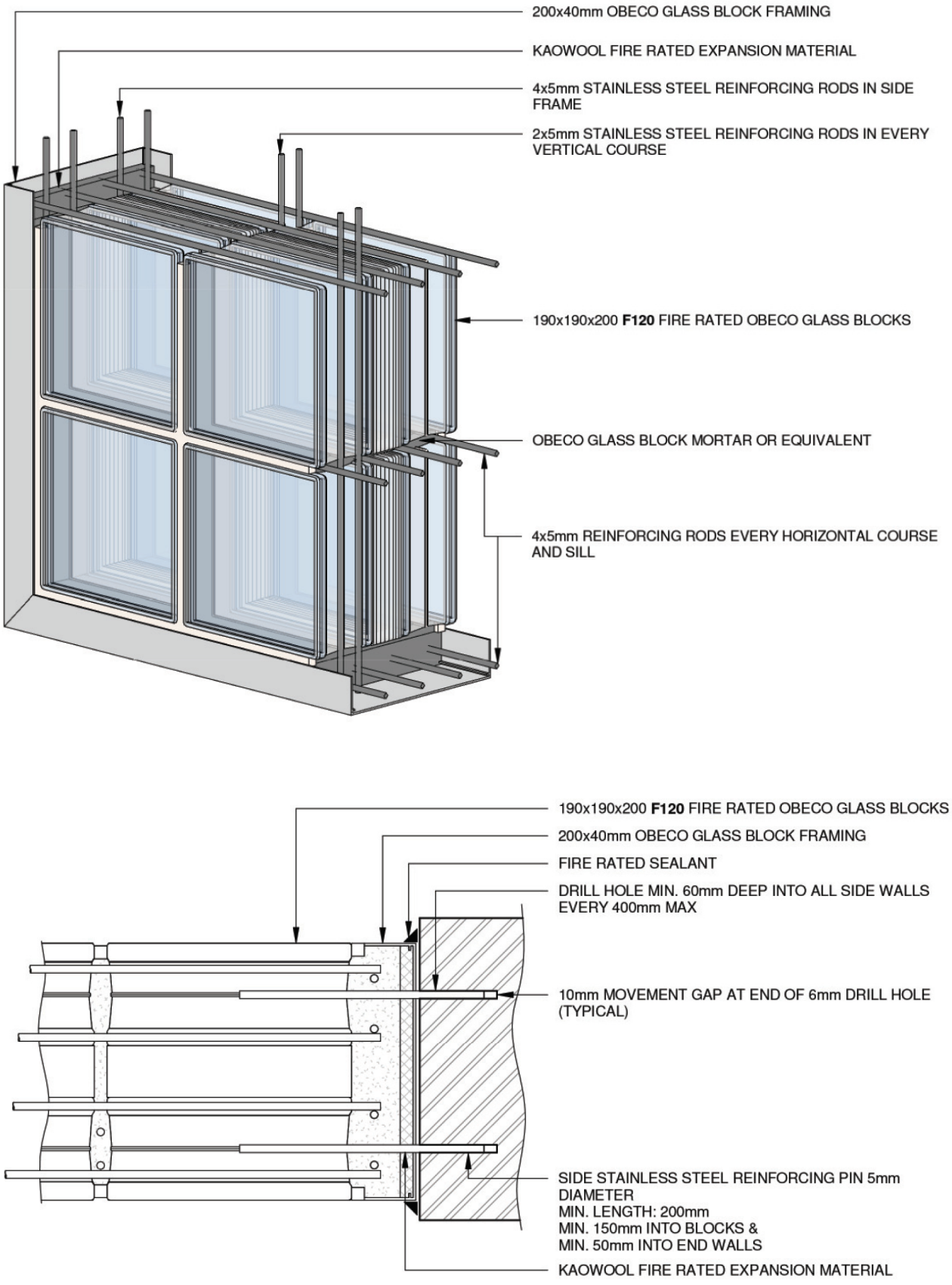


Figure 6: 200mm thick Obeco glass blocks

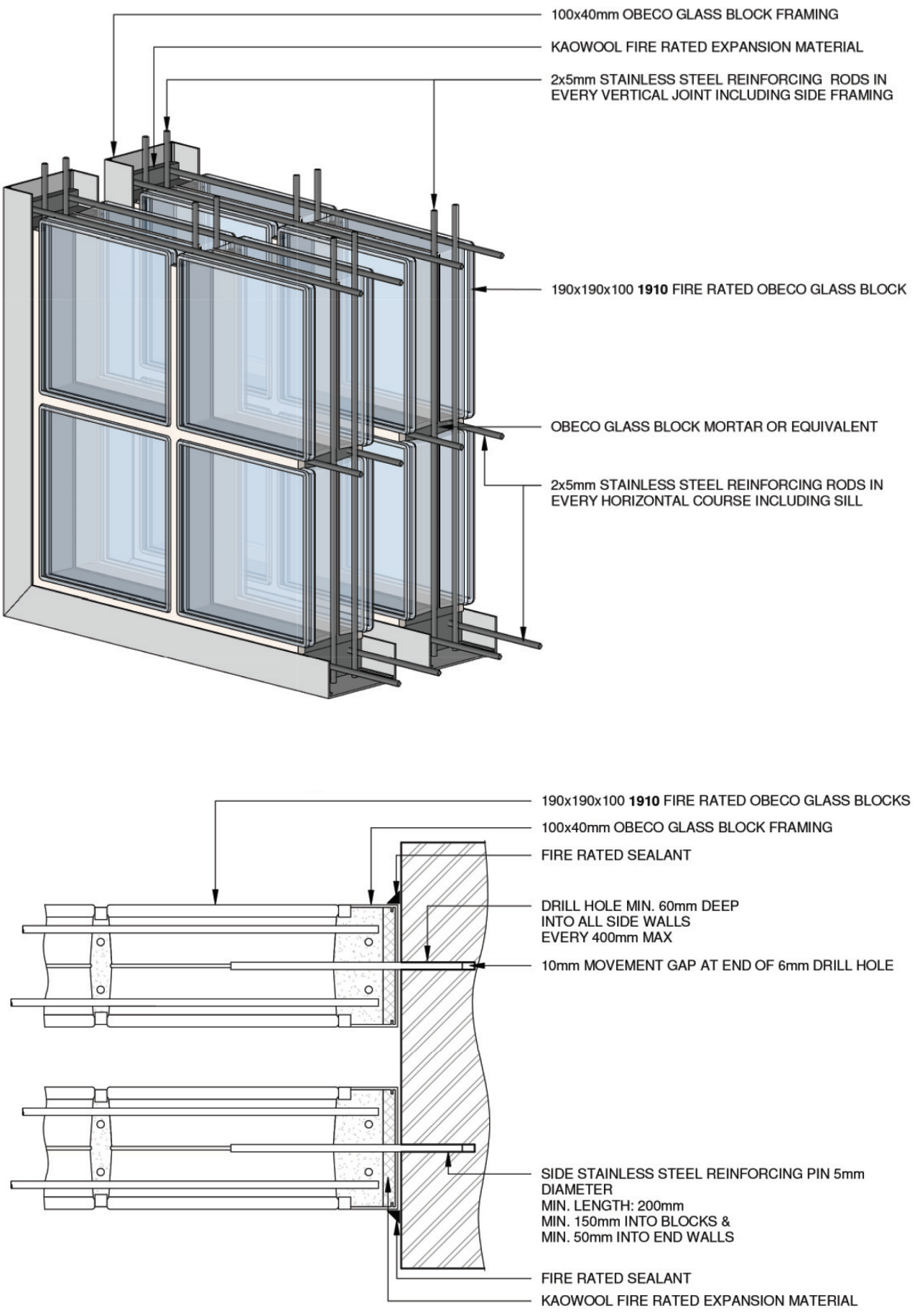


Figure 7: 100mm thick Obeco glass blocks as a double leaf wall

4 Referenced Standards

Standards:

AS 1530.4-2014 Methods for fire tests on building materials, components and structures Part 4: Fire resistance tests of elements of building construction.

5 Conclusion

On the basis of the analysis presented in this report, it is the opinion of this Testing Authority that the tested prototypes described in Section 2 when varied as described in Section 3 will achieve the Fire Resistance stated below when submitted to a standard fire test in accordance with the test methods referenced in Section 4 and subject to the requirements of section 7, validity of section 8 and limitation of section 9.

Table 3: FRL of glass block walls

Block name and size (mm)	Total wall thickness (mm)	Figure number	Maximum height curve area ID	FRL
La Rochère 198 190 x 190 x 80	80	1	Figure 8, Zone A1	-/60/-
		2	Figure 8, Zone A1 and A2	
La Rochère 1910 190 x 190 x 100	100	3	Figure 9, Zone B	-/90/-
La Rochère 3010 3010 x 3010 x 100				
La Rochère Type TF30 190 x 190 x 100	100	4		-/60/30
La Rochère Type TF60 190 x 190 x 150	150	5	Figure 10, Zone C	-/90/60
Fuchs Design FD1920 190 x 190 x 200	200	6		-/120/120
La Rochère 1910 190 x 190 x 100 50mm gap La Rochère 1910 190 x 190 x 100	250	7	Figure 8, Zone A2	-/120/-

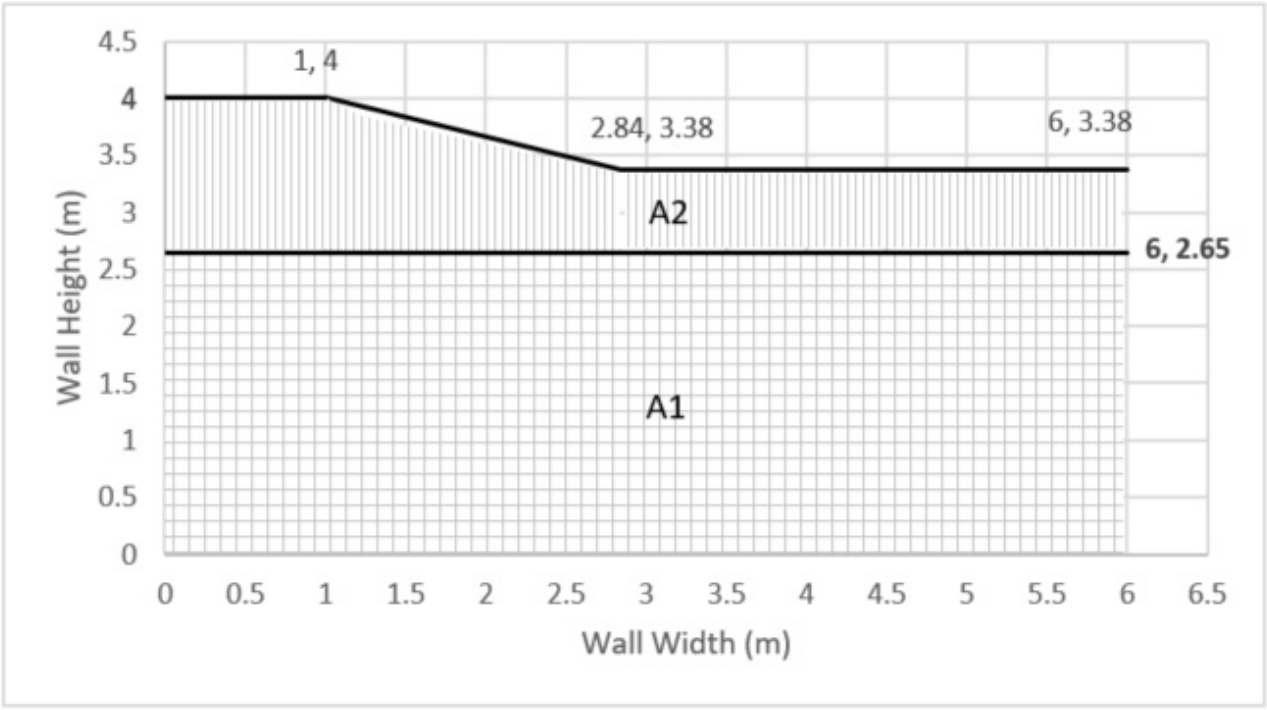


Figure 8 - Maximum wall dimensions for various blocks

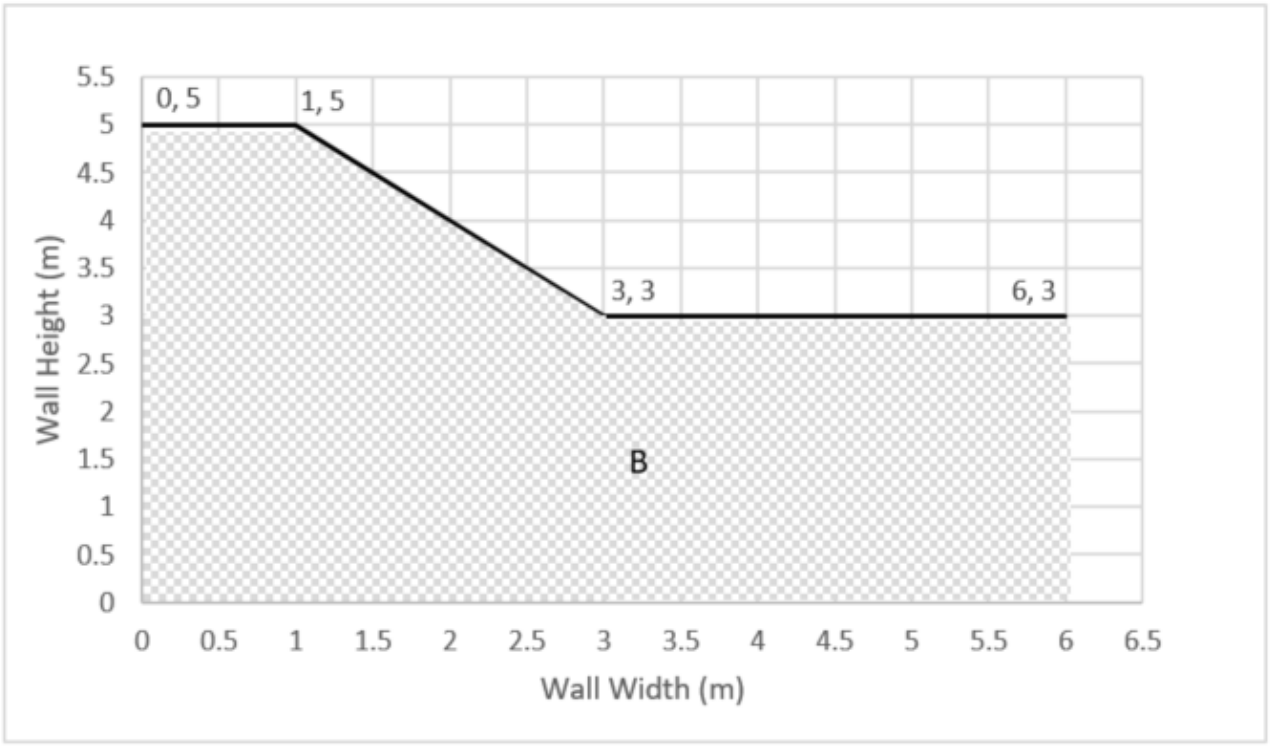


Figure 9 - Maximum wall dimensions for 100mm thick blocks

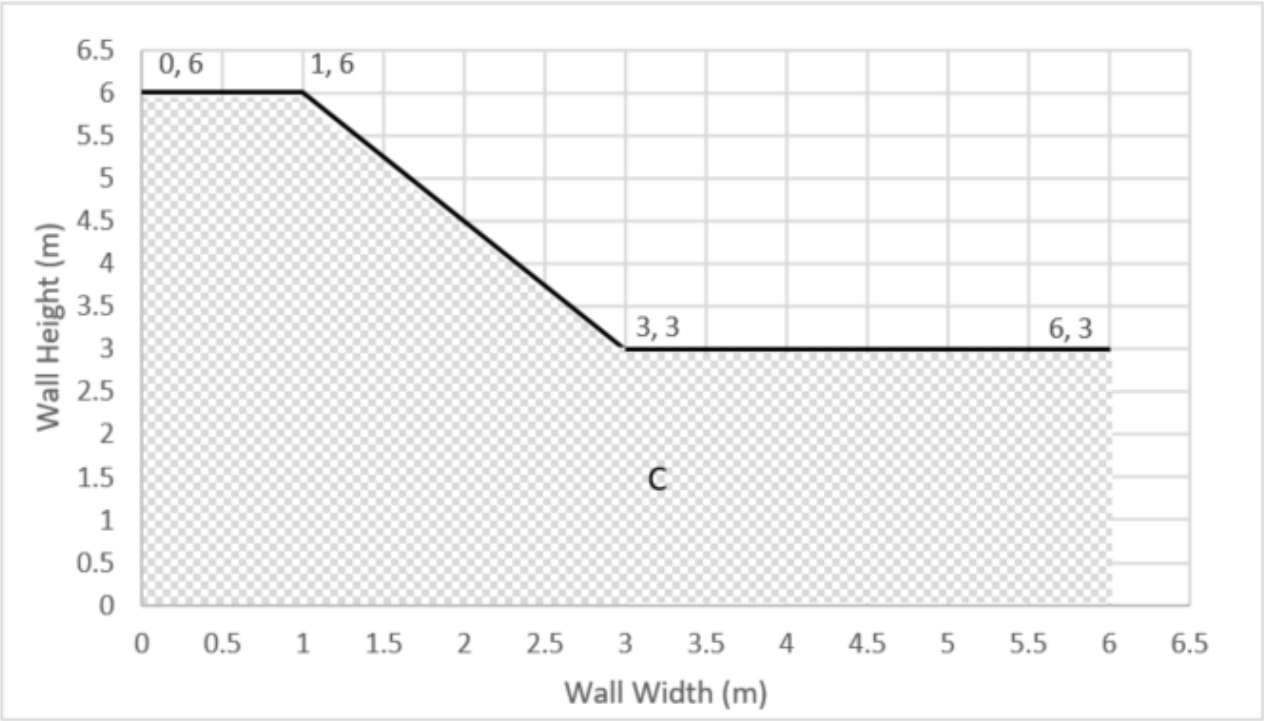


Figure 10 - Maximum wall dimensions for 150mm and 200mm thick blocks

6 Direct Field of Application of Results

The fire-resistance level of the glass block wall is applicable when it is exposed from either direction.

7 Requirements

It is required that the supporting construction is tested or assessed to achieve up to the required FRL, based on the assessed design in accordance with AS 1530.4. Fire rated sealant shall be supported by test or assessment demonstrating the sealant can achieve an FRL of -/120/120 as a wall or floor protecting a gap of 10-20mm wide and 10mm deep in accordance with AS 1530.4.

Control joint details are outside the scope of this assessment. It is required that control joint details be tested or assessed to achieve the required FRL in accordance with AS 1530.4.

Any variations with respect to size, constructional details, loads, stresses, edge or end conditions that are other than those identified in this report, may invalidate the conclusions drawn in this report.

8 Term of Validity

This assessment report will lapse on 31st July 2024. Should you wish us to re-examine this report with a view to the possible extension of its term of validity, would you please apply to us three to four months before the date of expiry. This Division reserves the right at any time to amend or withdraw this assessment in the light of new knowledge.

9 Limitations

The conclusions of this assessment report may be used to directly assess the fire resistance performance under such conditions, but it should be recognised that a single test method will not provide a full assessment of the fire hazard under all fire conditions.

Because of the nature of fire resistance testing, and the consequent difficulty in quantifying the uncertainty of measurement, it is not possible to provide a stated degree of accuracy. The inherent variability in test procedures, materials and methods of construction, and installation may lead to variations in performance between elements of similar construction.

This assessment report does not provide an endorsement by CSIRO of the actual products supplied to industry. The referenced assessment can therefore only relate only to the actual prototype test specimens, testing conditions and methodology described in the supporting data, and does not imply any performance abilities of constructions of subsequent manufacture.

This assessment is based on information and experience available at the time of preparation. The published procedures for the conduct of tests and the assessment of test results are the subject of constant review and improvement and it is recommended that this report is reviewed on or, before, the stated expiry date.

The information contained in this assessment report shall not be used for the assessment of variations other than those stated in the conclusions above. The assessment is valid provided no modifications are made to the systems detailed in this report. All details of construction should be consistent with the requirements stated in the relevant test reports and all referenced documents.

Appendix A Supporting Test Data

A.1. Efectis France report no. 08-V-064

On 28 February 2008 Efectis France conducted a full-scale fire-resistance test on a La Rochère “198 Bricks” glass brick wall incorporating 190-mm x 190-mm x 80-mm deep glass bricks. The bricks were laid up in La Rochère supplied bonding material and sand mortar.

The tested partition comprised three vertical panels placed side by side, with rigidity provided by a trellis made from reinforcing steel. The dimensions of the panels were 630-mm wide x 3380-mm high, 1590-mm wide x 3380-mm high, and 600-mm wide x 3380-mm high. The trellis was composed of horizontal reinforcement made up of one metal wires reinforcing each mortar joint between the glass bricks; vertical reinforcement made up of two metal wire reinforcing each mortar joint between the glass bricks, and peripheral reinforcement made up of two metal wires for the horizontal peripheral borders and vertical peripheral borders. The reinforcing metal wire was of 5 mm in diameter.

The panels were supported at the top of the partition by fixing lugs made from steel plate of dimensions 140-mm long x 25-mm wide x 4-mm thick associated with a 15-mm x 20-mm steel square whose side is welded on the steel plate. Each lug is fixed by two screws 5-mm diameter x 50-mm long and dowels 8-mm diameter x 50-mm long. The lugs fit into the supporting casings made from galvanised sheet steel of dimensions 150-mm long x 20-mm wide x 20-mm deep. The fixing devices are spaced at 600-mm centres. Lateral support was provided by M12 x 130-mm long galvanised steel pin inserted into the support construction using 16-mm diameter holes. The pins rest in casings made from galvanised sheet steel of dimensions 150-mm long x 20-mm wide x 20-mm deep. The fixing devices are spaced at 600 mm centres. At the base of the partition, support was provided by two galvanised steel corner irons with dimensions of 45-mm x 45-mm x 5-mm. The corner irons are fixed to the support construction using 5-mm diameter x 50-mm long screws at 600-mm centres.

The wall maintained integrity for 61 minutes while the wall was being subjected to the test conditions of NF EN 1363-1.

A.2. CTICM report no. 02-V-299

On 6 September 2002 CTICM Testing Station conducted a full-scale fire-resistance test on a La Rochère “HALTOFEU 30” type glass brick wall incorporating 190-mm x 190-mm x 100 mm deep glass bricks. The “HALTOFEU 30” bricks were made by assembling two La Rochère “195” type half bricks whose dimensions were 190-mm x 190-mm x 50 mm deep and assembled together by means of beads of Loctite “5375” silicon adhesive on their periphery. The bricks were laid up in Maxit supplied “Maxitherm 815” mortar comprising bonding material, sand, and fillers, and using 5-mm diameter steel reinforcing bars.

The tested partition comprised three horizontal panels placed one on top another, with rigidity provided by a trellis made from reinforcing steel.

The tested partition comprised three horizontal panels placed one on top another, with rigidity provided by a trellis made from reinforcing steel. The dimensions of the lower, middle and upper panels were 2980-mm wide x 1072.5-mm high, 2980-mm wide x 1010-mm high, and 2980-mm wide x 867.5-mm high respectively. The trellis was composed of horizontal reinforcement made up of three metal wires reinforcing each mortar joint between the glass bricks; vertical reinforcement made up of two metal wires reinforcing each mortar joint between the glass bricks; and peripheral reinforcement steel made up of six metal wires for the horizontal peripheral borders and four metal wires for the vertical peripheral borders. The reinforcing metal wire was of 5 mm in diameter.

The partition was held by a 125-mm x 60-mm rebate in the supporting masonry on the fire-exposed side, and 80-mm x 50-mm steel flats fixed to the masonry with FBN 16/10 (Fischer) steel studs on the

unexposed side. The bottom edge of the partition rested on 80-mm x 8-mm rubber supporting seal. On the periphery, expansion was allowed for by 94-mm x 10-mm foam seal positioned between the panels and the masonry. On the fire-exposed side, the rebate was fitted with mineral wool strips and sealed using fire-rated silicone sealant. On the non-fire side, 35-mm x 5-mm foam seal was placed between the panels and the steel flats.

The wall maintained insulation for 31 minutes and integrity for 84 minutes while the wall was being subjected to the test conditions of NF EN 1363-1.

A.3. CTICM report no. 05-V-136

On 3 May 2005 CTICM Testing Station conducted a full-scale fire-resistance test on a La Rochère "TF 60a" type glass brick wall incorporating 190-mm x 190-mm x 150 mm deep glass bricks. The "TF 60a" bricks were made by assembling three La Rochère "195T" type half bricks whose dimensions were 190-mm x 190-mm x 50 mm deep and assembled together by means of strips of Soudal "120251" silicon adhesive on their periphery and connecting strips of S.H.D. "8582" 35-mm wide adhesive cloth covered the assembly. The bricks were laid up in Maxit supplied "Maxitherm 815" mortar comprising bonding material, sand, and fillers, and using 5-mm diameter steel reinforcing bars.

The tested partition comprised four vertical panels placed side by side, with rigidity provided by a trellis made from reinforcing steel. The dimensions of the two end panels were 662.5-mm wide x 2980-mm high, and the dimensions of the two middle panels were 805-mm wide x 2980 mm high. The trellis was composed of horizontal reinforcement made up of two metal wires reinforcing each mortar joint between the glass bricks; vertical reinforcement made up of three metal wires reinforcing each mortar joint between the glass bricks; and peripheral reinforcement made up of four metal wires for the horizontal peripheral borders and six metal wires for the vertical peripheral borders. The reinforcing metal wire was of 5 mm in diameter.

The partition was held by a 180-mm x 60-mm rebate in the supporting masonry on the fire-exposed side, and 120-mm x 50-mm steel flats fixed to the masonry with 8-mm diameter steel dowels at 620-mm centres on the unexposed side. The bottom edge of the partition rested on 80-mm x 8-mm rubber supporting seal. On the periphery, expansion was allowed for by 74 mm x 10-mm foam seal positioned between the panels and the masonry. On the fire-exposed side, the rebate was fitted with a 30-mm diameter mineral wool flange and sealed using fire-rated silicone sealant. On the non-fire side, 35-mm x 5-mm foam seal was placed between the panels and the steel flats.

The wall maintained insulation for 62 minutes and integrity for 115 minutes while the wall was being subjected to the test conditions of NF EN 1363-1.

A.4. IBMB test report MPA 2101/419/16

On 12 October 2016, Institute of Building Materials Concrete –Construction and Fire Protection carried out a full-scale fire-resistance test on a Fuchs Design Gmbh "Typ Fuchs Glasstein" glass block wall 3000mm high and 3000mm wide, incorporating 190-mm x 190-mm x 200 mm deep glass bricks. The "Typ Fuchs Glasstein" glass bricks were made by sandwiching a 40mm fire protection inlay with two 80mm thick glass bricks, and assembled together by means of strips of silicon adhesive. The glass bricks were laid up in Quick-Mix mortar.

6mm diameter deformed reinforcement steel bars were placed in each horizontal and vertical joints; vertical joints had two reinforcement bars alternating in each joint while horizontal joints had 4 reinforcement bars in each joint. The peripheral reinforcement made up of four reinforcement bars for the horizontal peripheral and the vertical peripheral borders.

The glass brick wall was installed in a masonry opening. The glass brick wall was fixed to the masonry opening with a 50mm x 50mm x 5mm galvanised steel angles on each side of the wall. The angle was

fixed to the masonry wall with a 100mm long x 14-mm diameter masonry fasteners. Gaps between the glass brick wall and the test frame were filled with 25mm thick mineral wool.

The wall maintained insulation and integrity for 131 minutes duration of the test while the wall was being subjected to the test conditions of DIN EN 1363-1.

A.5. Applicability of the above test data to AS 1530.4-2014

General

The fire resistance test reported in MPA 2101/419/16 was conducted in accordance with DIN EN 1363-1: 1999 – 10 which is identical to BS EN 1363-1: 1999.

The fire resistance tests reported in Efectis France report no. 08-V-064, CTICM report no. 02-V-299 and CTICM report no. 05-V-136 were conducted in accordance with NF EN 1363-1: 2000, which is identical to BS EN 1363-1: 1999.

BS EN 1363-1: 1999 differs from AS 1530.4 2014 and the significance of these differences is discussed below.

Temperature Regime

The furnace temperature regime for fire resistance tests conducted in accordance with AS 1530.4-2014 follows the same trend as BS EN 1363-1: 1999 – 10.

Furnace Thermocouples

The furnace thermocouples specified in AS 1530.4-2014 are type K, mineral insulated metal sheathed (MIMS) with a stainless steel sheath having a wire of a diameter of not less than 1.0mm and an overall diameter of 3mm. The measuring junction protrudes at least 25mm from the supporting heat resistant tube.

The furnace thermocouples specified in BS EN 1363.1: 1999 (plate thermometers) are made from folded steel plate that faces the furnace chamber. A thermocouple is fixed to the side of the plate facing the specimen with the thermocouple hot junction protected by a pad of insulating material. The plate part is to be constructed from 150 ±1 mm long by 100 ±1 mm wide by 0.7 ±0.1 mm thick nickel alloy sheet strips.

The measuring junction is to consist of nickel chromium/nickel aluminium (Type K) wire as defined in IEC584-1, contained within mineral insulation in a heat-resisting steel alloy sheath of nominal diameter 1 mm, the hot junctions being electrically insulated from the sheath.

The thermocouple hot junction is to be fixed to the geometric centre of the plate, by a small steel strip made from the same material as the plate. The steel strip can be welded to the plate or maybe screwed to it to facilitate the replacement of the thermocouple. The strip should be approximately 18 mm by 6 mm if it is spot-welded to the plate, and nominally 25 mm by 6 mm if it is to be screwed to the plate. The screw is to be 2 mm in diameter.

The assembly of plate and thermocouple should be fitted with a pad of inorganic insulation material 97 ±1 mm by 97 ±1 mm by 10 ±1 mm thick with a density of 280 ±30 kg/m^3.

The relative location of the furnace thermocouples for the exposed face of the specimen, for AS 1530.4-2014 and BS EN 1363.1: 1999, is 100mm ±10mm and 100mm ±50mm respectively.

The furnace control thermocouples required by BS EN 1363.1: 1999 are less responsive than those specified by AS 1530.4-2014. This variation in sensitivity an produce a potentially more onerous heating condition for specimens tested to BS EN 1363.1: 1999, particularly when the furnace temperature is changing quickly in the early stages of a test.

Furnace Pressure

It is a requirement of AS 1530.4-2014 and for BS EN 1363-1: 1999 that for vertical elements, a furnace gauge pressure of zero (0) Pa is established at a height 500mm above the notional floor level.

The parameters outlining the accuracy of control and location of zero gauge furnace pressure in AS 1530.4- 2014 and BS EN 1363-1: 1999 are not appreciably different.

Specimen thermocouple arrangements

The specimen thermocouple arrangements for the referenced tests are not appreciably different between BS EN 1364-1:1999 and AS 1530.4-2014 section 10 for non-load bearing walls.

Criteria for failure

The criteria for the referenced tests are not appreciably different between BS EN 1363-1: 1999 and AS 1530.4-2014.

Conclusion

Based on the above it is confirmed the referenced test data in accordance with the equivalent standard to BS EN 1363-1: 1999 can be used to assess performance in accordance with AS 1530.4-2014.

A.6. CSTB report no. 87.26109

On 12 April 1990 CSTB Scientific and Technical Centre for Building conducted a full-scale fire-resistance test on a La Rochère glass brick wall comprising: a bottom panel of 3010 LC (checked type) 300-mm x 300-mm x 100-mm deep glass bricks, 1020-mm high; a middle panel of 3010 T (transparent type) 300-mm x 300-mm x 100-mm deep glass bricks, 960-mm high; and a top panel of 3010 DC (cloud type) 300-mm x 300-mm x 100-mm deep glass bricks, 1020-mm high. The bricks were laid up in Ciments Francais supplied white cement and sand mortar using 6-mm diameter steel reinforcing bars.

The tested partition was mounted using 80-mm x 4-mm flat steel sheet attached on the periphery of the concrete frame every 250-mm x 40-mm on the non-exposed side using 8 mm diameter plastic dowels and 6-mm diameter x 40-mm long anchor bolts every 250 mm. The bottom and top of the test partition were placed in a 40-mm deep x 110-mm wide rebate, with interpolation at its base of a 74-mm x 10-mm polyethylene foam flexible compression joint at the bottom of the rebate, and 74-mm x 10-mm polyethylene foam joint between the top of the panel and the concrete. Lateral retention is provided by 80-mm x 4-mm flat steel sheet and placing 12-mm diameter Rockwool cord in the rebate. There were two 6mm diameter steel reinforcements in every horizontal and vertical joint.

The wall maintained integrity for 97 minutes while the wall was being subjected to the test conditions in accordance with the provisions of the order of 21 April 1983 from the French Ministry of the Interior Fire Resistance of a Building Element.

A.7. Applicability of the above test data to AS 1530.4-2014

General

The fire resistance test reported in CSTB report no. 87.26109 was conducted in accordance with the provisions of the order of 21 April 1983 from the French Ministry of the Interior Fire Resistance of a Building Element. It differs from AS 1530.4 2014 and the significance of these differences is discussed below.

Temperature Regime

The furnace temperature regime for fire resistance tests in each standard followings a similar trend.

Furnace Pressure

It is a requirement of AS 1530.4-2014 that for vertical elements, a furnace gauge pressure of zero (0) Pa is established at a height 500mm above the notional floor level. The average furnace pressure is 8Pa/m with an accuracy of ±3Pa after 10 minutes into the test.

The furnace pressure outlined in the provisions of the order of 21 April 1983 from the French Ministry of the Interior Fire Resistance of a Building Element is slightly lower than that of AS 1530.4-2014. Therefore any gap formation in the specimen must be examined to ensure it does not fail by leakage of more hot air at a higher pressure.

Specimen thermocouple arrangements

The specimen thermocouple arrangements for the referenced tests are not appreciably different between the two standards for non-load bearing walls.

Criteria for failure

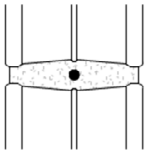
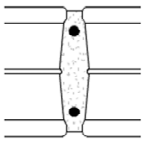
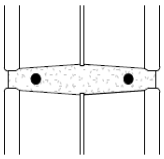
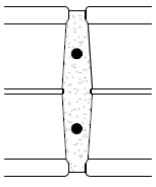
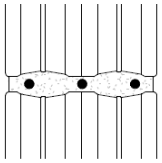
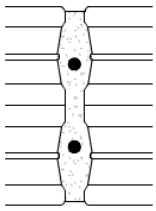
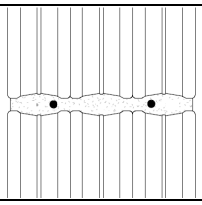
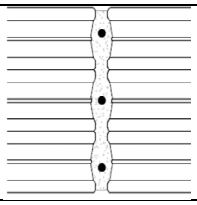
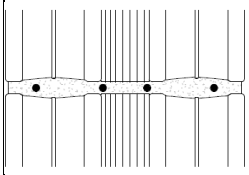
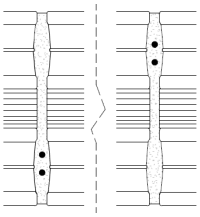
The integrity criteria outlined in the provisions of the order of 21 April 1983 from the French Ministry of the Interior Fire Resistance of a Building Element is the same as that of AS 1530.4-2014

Conclusion

Based on the above it is confirmed the referenced test can be used to assess performance in accordance with AS 1530.4-2014.

A.8. Summary of test results

Table A1: Summary of glass block walls with reinforcements as tested

Report No.	Block name and size (mm)	Wall thickness (mm)	Section view of each Horizontal joint	Section view of each vertical joint	Test wall size	FRL
Efectis France report no. 08-V-064	La Rochère 198 * 190 x 190 x 80	80			3.38m high x 2.84m wide	-/60/-
CSTB report no. 87.26109	La Rochère 3010 300 x 300 x 100	100			3m high x 3m wide	-/60/-
CTICM report no. 02-V-299	La Rochère Type TF30 190 x 190 x 100	100			3m high x 3m wide	-/60/30
CTICM report no. 05-V-136	La Rochère Type TF60 190 x 190 x 150	150			3m high x 3m wide	-/90/60
MPA 2101/419/16	Fuchs Design FD1920 190 x 190 x 200	F200			3m high x 3m wide	-/120/120

Appendix B Analysis of Variations

B.1 Variation to glass block wall perimeter detail

The proposed perimeter details as shown in Figures 1-7, show the fixing of an aluminium channel section containing glass blocks, fixed to the supporting structure using 200-mm long x 5-mm diameter stainless steel rods set into 50-mm deep x 6-mm diameter holes in the surrounding construction at 400mm centres both vertically and horizontally. The rods are embedded into the mortar. Kaowool installed between the mortar and the aluminium channel section to allow for the expansion of glass blocks on the top and sides. The aluminium channel is to be pushed onto a bead of fire rated sealant at the perimeter of the wall and the concrete or masonry supporting structure. The fire rated sealant is to have been tested or assessed to maintain the required FRL of a similar joint detail in concrete or masonry walls no thicker than 120mm.

In terms of the insulation criterion, thermocouples along the aluminium channel on the perimeter and head of the wall would have not raised their temperature by more than 180°C as the aluminium channel facing the furnace would melt away at between 10-15 minutes of testing. This would greatly reduce the exposed area to a thin strip similar to that of the steel perimeter angle as tested in MPA 2101/419/16 which maintained insulation for 131 minutes. The Kaowool in the aluminium channel's expansion gap would also protect the aluminium while the mortar around the perimeter would aid as a second source of the heat sink.

In terms of the integrity criterion, the proposed perimeter details as shown in figures 1-7, also provide similar lateral restraint to that of the tested specimen in MPA 2101/419/16 which maintained integrity for 131 minutes at the perimeter. It is expected that the steel reinforcement rods at the perimeter will restrain the wall such that it will not deflect at the perimeter so as to form gaps that warrant a cotton pad or allow the passage of flame. Also, the fire rated sealant would prevent the passage of hot gas at the perimeter of the wall.

Based on the above, it is considered that the proposed perimeter detail as shown in figures 1- 7 will not detrimentally affect the integrity and insulation performance of the glass block walls for up to 120 minutes when tested in accordance with AS 1530.4 -2014.

B.2 80mm thick La Rochère 198 blocks - Figure 8, Zone A1

The proposed wall construction comprises 80mm thick La Rochère 198 blocks with 1 vertical reinforcement and 2 horizontal reinforcements as shown in Figure 1 to a maximum height of 2.65m and width of 6m as shown in Figure 8, Zone A1.

With reference to Efectis France report no. 08-V-064 which comprised 3 vertical panels which made up a wall totalling 3380mm high and 2840mm wide, with 80mm thick La Rochère 198 blocks with 2 reinforcement per vertical joint and 1 reinforcement per horizontal joint. The wall was tested with a free edge. It failure integrity for 61 minutes due to gap formation at the vertical panel joint and failure insulation at 13 minutes. Its deflection at 60 minutes was 175mm.

With reference to MPA 2101/419/16 which comprised a 3000mm high and 3000mm wide wall with 200mm thick Fuchs Design FS1920 blocks with 2 reinforcements per vertical joint and 4 reinforcements per horizontal joint. The wall was tested with a free edge. The wall maintained insulation and integrity for 131 minutes duration of the test. Its deflection at 60 minutes was 57mm.

The main force driving the deflection of the glass block walls is the thermal expansion experienced by the reinforcements during the test, resulting in the wall deflecting towards the furnace. However, the reinforcements, when fixed on each end, are also acting restrain the movement of the wall. Therefore the more reinforcements are in a wall which is fixed on each end, the more ability the wall has to not collapse despite deflection.

The high deflection observed in Efectis France report no. 08-V-064 is therefore attributed to the three vertical wall panels not linked by continuous horizontal reinforcements. This test also shows that the 80mm block wall can deflect up to 175mm before it reaches integrity failure.

By comparing the deflection of the wall tested in Efectis France report no. 08-V-064 and MPA 2101/419/16, and taking into account the block thickness, it is expected that the proposed wall which has less vertical reinforcements straining the wall, can only handle 61.4% of bending capacity of the tested wall before it reaches the critical deflection of 175mm. Based on a further calculation, it is determined that when the proposed wall is a maximum of 2.65m in height it will reach the same deflection as that tested in Efectis France report no. 08-V-064.

With reference to AS 1530.4 -2014 clause 3.9, the test results of all specimen tested with one vertical edge unrestrained is applicable to the identical specimen with an increased length.

The wall tested in Efectis France report no. 08-V-064 was tested with a free edge, therefore the test result is applicable to walls beyond the tested length of 2.84m.

Based on the above, the proposed construction with a maximum height of 2.65m and a width of 6m will be able to maintain integrity for up to 60 minutes when tested in accordance with AS 1530.4 -2014.

B.3 80mm thick La Rochure 198 blocks 2.65m to 4m High

The proposed wall construction comprises 80mm thick La Rochère 198 blocks with 2 vertical reinforcement and 1 horizontal reinforcement as shown in Figure 2 to a maximum height of 3.38m and width of 6m. When the proposed wall construction reduced to below 2.84m width, its maximum height is to be 4m.

With reference to Efectis France report no. 08-V-064 which comprised 3 vertical panels which made up a wall totalling 3380mm high and 2840mm wide, with 80mm thick La Rochère 198 blocks with 2 reinforcement per vertical joint and 1 reinforcement per horizontal joint. The wall was tested with a free edge. It failure integrity for 61 minutes due to gap formation at the vertical panel joint and failure insulation at 13 minutes.Its deflection at 60 minutes was 175mm.

With reference to AS 1530.4 -2014 clause 3.9, the test results of all specimen tested with one vertical edge unrestrained is applicable to the identical specimen with an increased length.

The wall tested in Efectis France report no. 08-V-064 was tested with a free edge, therefore the test result is applicable to walls beyond the tested width of 2.84m.

Based on the above, the proposed construction with a maximum height of 3.38m and a width of 6m will be able to maintain integrity for up to 60 minutes when tested in accordance with AS 1530.4 -2014.

When the proposed wall is a maximum of 2.84m wide and is fixed on all four sides, a 3.38m tall wall will deflect 95mm at 60 minutes based on plate theory. It is also expected that the horizontal reinforcement will act to support the wall structure at each mortar joint.

Where the wall aspect ratio becomes narrower than its height the horizontal reinforcement then becomes more effective at restraining the wall. This is explained by the fact that the deflection will tend to be driven by the maximum curvature allowed by the horizontal reinforcement it tries to keep the maximum curvature of the wall similar to that tested. This restraint has the effect of decreasing the lateral deflection and thereby reducing the instability created by the eccentricity of the weight of the wall.

Based on a calculation of a reduced lateral deflection as the wall becomes narrower, the maximum height of the proposed wall can be a maximum of 4m without increasing the compression on the face of the wall above that in the referenced tests.

Based on the above, the proposed construction with a maximum height of 3.38m and a width of 2.84m and 4m high and 1m wide will be able to maintain integrity for up to 60 minutes when tested in accordance with AS 1530.4 -2014 as shown in Figure 8, Zone A2.

B.4 100mm thick La Rochère 3010 blocks – 3m to 5m high

The proposed wall construction comprises 100mm thick La Rochère 3010 blocks with 2 vertical reinforcement and 2 horizontal reinforcements as shown in Figure 3 to a maximum height of 3m or 5m depending on width.

With reference to CSTB report no. 87.26109 which comprised a 3000mm high and 3000mm wide wall with 300mm high x 300mm wide x 100mm thick La Rochère 3010 blocks with 2 reinforcements per vertical joint and 2 reinforcements per horizontal joint. The wall was tested with a free edge. The wall failure integrity at 91 minutes and insulation at 21 minutes. Its deflection at 73 minutes was 50mm.

When the proposed wall is a maximum of 3m wide and is fixed on all four sides, a 3m tall wall will deflect 18.9mm at 50 minutes based on plate theory. It is also expected that the horizontal reinforcements will act to support the wall structure at each mortar joint.

Also as the wall width decreases from the tested width of 3m and increases in height, it will maintain the same amount of support from the surrounding structure while its axial deflection decreases.

Where the wall aspect ratio becomes narrower than its height the horizontal reinforcement then becomes more effective at restraining the wall. This is explained by the fact that the deflection will tend to be driven by the maximum curvature allowed by the horizontal reinforcement it tries to keep the maximum curvature of the wall similar to that tested. This restraint has the effect of decreasing the lateral deflection and thereby reducing the instability created by the eccentricity of the weight of the wall.

Based on a calculation of a reduced lateral deflection as the wall becomes narrower, the maximum height of the proposed wall can be a maximum of 5m without increasing the compression on the face of the wall above that in the referenced tests.

Based on the above, the proposed construction with a maximum height of 3m and width of 3m and 5m high and 1m wide will be able to maintain integrity for up to 90 minutes when tested in accordance with AS 1530.4 -2014 as shown in Figure 9 Zone B.

B.5 100mm thick La Rochère 3010 blocks - 3m high and 6 wide

The proposed wall construction comprises 100mm thick La Rochère 3010 blocks with 2 vertical reinforcement and 2 or 3 horizontal reinforcements as shown in Figure 3 to a maximum height of 3m and width of 6m.

With reference to CSTB report no. 87.26109 which comprised a 3000mm high and 3000mm wide wall with 300mm high x 300mm wide x 100mm thick La Rochère 3010 blocks with 2 reinforcements per vertical joint and 2 reinforcements per horizontal joint. The wall was tested with a free edge. The wall failure integrity at 91 minutes and insulation at 21 minutes. Its deflection at 73 minutes was 50mm.

With reference to AS 1530.4 -2014 clause 3.9, the test results of all specimen tested with one vertical edge unrestrained is applicable to the identical specimen with an increased length.

The wall in CSTB report no. 87.26109 was tested with a free edge, therefore the test result is applicable to the proposed wall beyond the tested width of 3m.

Based on the above, the proposed construction with a maximum height of 3m and width of 6m will be able to maintain integrity for up to 90 minutes when tested in accordance with AS 1530.4 -2014 as shown in Figure 9 Zone B.

B.6 100mm thick La Rochère TF30 – 3m to 5m high

The proposed wall construction comprises 100mm thick La Rochère TF30 blocks with 2 vertical reinforcement and 3 horizontal reinforcements as shown in Figure 3 to a maximum height of 5m and width of 3m.

With reference to CTICM report no. 02-V-299 which comprised a 3000mm high and 3000mm wide wall with 100mm thick La Rochère TF30 blocks with 2 reinforcements per vertical joint and 3 reinforcements per horizontal joint. The wall was tested with a free edge. The wall failure integrity at 84 minutes and insulation at 31 minutes. Its deflection at 60 minutes was 68mm and at 84min was 140mm.

When the proposed wall is a maximum of 3m wide and is fixed on all four sides, a 3m tall wall will deflect 27.5mm at 60 minutes based on plate theory. It is also expected that the horizontal reinforcements will act to support the wall structure at each mortar joint.

Where the wall aspect ratio becomes narrower than its height the horizontal reinforcement then becomes more effective at restraining the wall. This is explained by the fact that the deflection will tend to be driven by the maximum curvature allowed by the horizontal reinforcement it tries to keep the maximum curvature of the wall similar to that tested. This restraint has the effect of decreasing the lateral deflection and thereby reducing the instability created by the eccentricity of the weight of the wall.

Based on a calculation of a reduced lateral deflection as the wall becomes narrower, the maximum height of the proposed wall can be a maximum of 5m without increasing the compression on the face of the wall above that in the referenced tests.

The insulation performance of the wall will not be detrimentally affected until gaps are formed in the glass wall. Therefore, it is considered the taller walls will maintain insulation as tested.

Based on the above, the proposed construction with a maximum height of 3m and width of 3m and 5m high and 1m wide will be able to maintain integrity for up to 60 minutes when tested in accordance with AS 1530.4 -2014 and shown in Figure 9 Zone B

B.7 100mm thick La Rochère TF30 - 3m high x 6m wide

The proposed wall construction comprises 100mm thick La Rochère TF30 blocks with 2 vertical reinforcement and 3 horizontal reinforcements as shown in Figure 4 to a maximum height of 3m and width of 6m as shown in Figure 9 Zone B.

With reference to CTICM report no. 02-V-299 which comprised a 3000mm high and 3000mm wide wall with 100mm thick La Rochère TF30 blocks with 2 reinforcements per vertical joint and 3 reinforcements per horizontal joint. The wall was tested with a free edge. The wall failure integrity at 84 minutes and insulation at 31 minutes. Its deflection at 60 minutes was 68mm and at 84min was 140mm.

With reference to AS 1530.4 -2014 clause 3.9, the test results of all specimen tested with one vertical edge unrestrained is applicable to the identical specimen with an increased length.

The wall in CTICM report no. 02-V-299 were tested with a free edge, therefore the test result is applicable to the proposed wall beyond the tested width of 3m.

The removal of horizontal reinforcement is not expected to detrimentally affect the lateral deflection of the wall since the horizontal reinforcements are not fixed on both sides due to the specimen having one free edge.

Based on the above, the proposed construction with a maximum height of 3m and width of 6m will be able to maintain integrity for up to 60 minutes and insulation for up to 30 minutes when tested in accordance with AS 1530.4 -2014.

B.8 150mm thick La Rochère TF60 blocks – 3m to 6m high

The proposed wall construction comprises 150mm thick La Rochère TF60 blocks with 2 vertical reinforcement and 2 horizontal reinforcements as shown in Figure 5 to a maximum height of 6m and width of 3m.

With reference to CTICM report no. 05-V-136 which comprised a 3000mm high and 3000mm wide wall with 150mm thick La Rochère TF60 blocks with 3 reinforcements per vertical joint and 2 reinforcements per horizontal joint. The wall was tested with a free edge. The wall failure integrity at 115 minutes and insulation at 62 minutes. Its deflection at 60 minutes was 36mm.

When the proposed wall is a maximum of 3m wide and is fixed on all four sides, a 3m tall wall will deflect 31.8mm at 97 minutes based on plate theory. It is also expected that the horizontal reinforcements will act to support the wall structure at each mortar joint.

Also, as the wall width decreases from the tested width of 3m and increases in height, it will maintain the same amount of support from the surrounding structure while its axial deflection decreases.

The low deflection of the wall at 97 minutes and the 25 minutes of margin in integrity performance give further confidence of the ability of the taller wall to maintain integrity when fixed on all four sides for up to 90 minutes.

Where the wall aspect ratio becomes narrower than its height the horizontal reinforcement then becomes more effective at restraining the wall. This is explained by the fact that the deflection will tend to be driven by the maximum curvature allowed by the horizontal reinforcement it tries to keep the maximum curvature of the wall similar to that tested. This restraint has the effect of decreasing the lateral deflection and thereby reducing the instability created by the eccentricity of the weight of the wall.

Based on a calculation of a reduced lateral deflection as the wall becomes narrower, the maximum height of the proposed wall can be a maximum of 6m without increasing the compression on the face of the wall above that in the referenced tests.

The insulation performance of the wall will not be detrimentally affected until gaps are formed in the glass wall. Therefore it is considered the taller walls will maintain insulation or up to 60 minutes.

Based on the above, the proposed construction with a maximum height of 3m and width of 3m and 6m high and 1m wide will be able to maintain integrity for 90 minutes and insulation for 60 minutes when tested in accordance with AS 1530.4 -2014 and shown in Figure 10, Zone C

B.9 150mm thick La Rochère TF60 blocks - 3m high x 6m wide

The proposed wall construction comprises 150mm thick La Rochère TF60 blocks with 2 vertical reinforcement and 2 horizontal reinforcements as shown in Figure 5 to a maximum height of 3m and width of 6m.

With reference to CTICM report no. 05-V-136 which comprised a 3000mm high and 3000mm wide wall with 150mm thick La Rochère TF60 blocks with 3 reinforcements per vertical joint and 2 reinforcements per horizontal joint. The wall was tested with a free edge. The wall failure integrity at 115 minutes and insulation at 62 minutes. Its deflection at 97 minutes was 84mm.

The proposed construction has the middle vertical reinforcement removed from which will result in the wall be able to handle a bending capacity that's 17% less than the tested wall before it reaches the critical deflection limit that induced cracking of the brick in the lower section of the tested wall. However, the tested wall had a 27% margin in integrity. Therefore it is considered that the proposed wall will be able to maintain integrity for up to 90 minutes at 3m height.

With reference to AS 1530.4 -2014 clause 3.9, the test results of all specimen tested with one vertical edge unrestrained is applicable to the identical specimen with an increased length.

The wall tested in CTICM report no. 05-V-136 was tested with a free edge, therefore the test result is applicable to the proposed wall beyond the tested width of 3m.

Based on the above, the proposed construction with a maximum height of 3m and width of 6m will be able to maintain integrity for up to 90 minutes and insulation for up to 60 minutes when tested in accordance with AS 1530.4 -2014 and shown in Figure 10, Zone C.

B.10 200mm Fuchs Design F120 blocks - 6m high x 3m wide

The proposed wall construction comprises 200mm thick Fuchs Design F120 blocks with 2 vertical reinforcement and 4 horizontal reinforcements as shown in figure 6 to a maximum height of 6m and width of 3m as shown in Figure 10 Zone C.

With reference to MPA 2101/419/16 which comprised a 3000mm high and 3000mm wide wall with 200mm thick Fuchs Design FS1920 blocks with 2 reinforcements per vertical joint and 4 reinforcements per horizontal joint. The wall was tested with a free edge. The wall maintained insulation and integrity for 131 minutes duration of the test. Its deflection at 60 minutes was 57mm.

When the proposed wall is a maximum of 3m wide and is fixed on all four sides, a 3m tall wall will deflect 21.6mm at 60 minutes based on plate theory. It is also expected that the horizontal reinforcements will act to support the wall structure at each mortar joint.

Also as the wall width decreases from the tested width of 3m and increases in height, it will maintain the same amount of support from the surrounding structure while its axial deflection decreases.

Where the wall aspect ratio becomes narrower than its height the horizontal reinforcement then becomes more effective at restraining the wall. This is explained by the fact that the deflection will tend to be driven by the maximum curvature allowed by the horizontal reinforcement it tries to keep the maximum curvature of the wall similar to that tested. This restraint has the effect of decreasing the lateral deflection and thereby reducing the instability created by the eccentricity of the weight of the wall.

Based on a calculation of a reduced lateral deflection as the wall becomes narrower, the maximum height of the proposed wall can be a maximum of 6m without increasing the compression on the face of the wall above that in the referenced tests.

The low deflection of the wall at 60 minutes and the 11 minutes of margin in integrity performance give further confidence of the ability of the taller wall to maintain integrity when fixed on all four sides for up to 120 minutes.

The insulation performance of the wall will not be detrimentally affected until gaps are formed in the glass wall. Therefore it is considered the taller walls will maintain insulation or up to 120 minutes.

Based on the above, the proposed construction with a maximum height of 3m and width of 3m and 6m high and 1m wide will be able to maintain integrity for 120 minutes and insulation for 120 minutes when tested in accordance with AS 1530.4 -2014 and shown in Figure 10, Zone C

B.11 200mm Fuchs Design F120 blocks - 3m high x 6m wide

The proposed wall construction comprises 200mm thick Fuchs Design F120 blocks with 2 vertical reinforcement and 4 horizontal reinforcements as shown in figure 6, to a maximum height of 3m and width of 6m.

With reference to MPA 2101/419/16 which comprised a 3000mm high and 3000mm wide wall with 200mm thick Fuchs Design FS1920 blocks with 2 reinforcements per vertical joint and 4 reinforcements per horizontal joint. The wall was tested with a free edge. The wall maintained insulation and integrity for 131 minutes duration of the test. Its deflection at 60 minutes was 57mm.

With reference to AS 1530.4 -2014 clause 3.9, the test results of all specimen tested with one vertical edge unrestrained is applicable to the identical specimen with an increased length.

The wall tested in MPA 2101/419/16 was tested with a free edge, therefore the test result is applicable to the proposed wall beyond the tested width of 3m.

Based on the above, the proposed construction with a maximum height of 3m and width of 6m will be able to maintain integrity for up to 120 minutes and insulation for up to 120 minutes when tested in accordance with AS 1530.4 -2014.

B.12 La Rochère 1910 blocks up to 3m- 5m high

The proposed construction comprises glass block walls made from 190mm x 190mm x 100mm La Rochère 1910 blocks.

With reference to test report CSTB report no. 87.26109, which comprised of 300mm x 300mm x 100mm La Rochère 3010 blocks forming a glass brick wall. The specimen maintained integrity for the 97-minute duration of the test. The glass block cracked on the exposed and unexposed face throughout the duration of the test and melted on the exposed face near the end of the test.

The possible modes of integrity failure for a glass block wall as constructed in CSTB report no. 87.26109 are the cracking and dislodgement of sections of glass block which would allow either hot gas fluing through the crack or for a gap gauge to go through it into the furnace. This would most likely occur at the thin front wall section of the glass block and less likely to occur at the thick all-around fillet section of the glass block.

The reduction in the height and width of the glass block will introduce more glass blocks per meter square of the wall into the wall system, and thus increase the amount of all-around fillet section of glass blocks. This would result in an increase in the area of strength at the all-around fillet section and a reduction in the area of weakness at the front wall section. Also, provided that the front wall section thickness is maintained as the tested block in CSTB report no. 87.26109, the integrity of the glass block would not be detrimentally affected.

Where the wall aspect ratio becomes narrower than its height the horizontal reinforcement then becomes more effective at restraining the wall. This is explained by the fact that the deflection will tend to be driven by the maximum curvature allowed by the horizontal reinforcement it tries to keep the maximum curvature of the wall similar to that tested. This restraint has the effect of decreasing the lateral deflection and thereby reducing the instability created by the eccentricity of the weight of the wall.

Based on a calculation of a reduced lateral deflection as the wall becomes narrower, the maximum height of the proposed wall can be a maximum of 5m without increasing the compression on the face of the wall above that in the referenced tests.

The insulation performance of the wall will not be detrimentally affected until gaps are formed in the glass wall. Therefore, it is considered the taller walls will maintain insulation as tested.

Based on the above, the proposed modified block construction with a maximum height of 3m and width of 3m and 5m high and 1m wide will be able to maintain integrity for up to 90 minutes when tested in accordance with AS 1530.4 -2014 and shown in Figure 9 Zone B

Double-wall made from La Rochère 1910 blocks

The proposed wall construction comprised a twin wall made from 100mm thick La Rochère 1910 blocks separated by a cavity of 50mm as shown in figure 7.

Based on the discussion above a single leaf of 100mm thick La Rochère 1910 blocks is considered to maintain integrity for at least 97 minutes after deflecting toward the heating. When tested the glass block cracked on the exposed and unexposed face throughout the duration of the test and melted on the exposed face near the end of the test.

The proposed duplication of the glass block wall though doubling the construction and adding a separating cavity will not double the performance as the cavity between the walls will accumulate heat and this heat will be transferred to the second wall leaf albeit at a slower rate.

This assessment is based on a conservative approach in that it will take some time for the second leaf to increase in temperature once the first wall started to significantly degrade at 97 minutes. It is considered on balance the beneficial effect of the cavity separating the walls, the integrity of each leaf to maintain 97 minutes integrity in isolation is sufficient to provide for an additional 23 minutes integrity performance when the leaves are built together and tested in accordance with AS 1530.4-2014.

Based on the above, it is considered proposed construction will achieve an integrity of 90 minutes when tested in accordance with AS 1530.4-2014 from either direction.

Similarly for single layer walls and the discussion above it is considered the proposed modified block construction with a maximum height of 3m and width of 3m and 5m high and 1m wide will be able to maintain integrity for up to 90 minutes when tested in accordance with AS 1530.4 -2014 and shown in Figure 9 Zone B.

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