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Performance testing of a Fullgate lift shaft safety gate system.

Prepared for:
Mr Joe Woof
Fullgate Limited

28th October 2008

Test report number 248-108

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* See BRE test report 248-108 for full details of test methodology and results obtained.

2   Introduction

This report describes tests conducted on the Fullgate lift shaft safety gate system to BS EN 13374:2004[1]. This testing was conducted on behalf of Fullgate Limited and is based on BRE Proposal No. 123-276 dated 9th September 2008 which was sent to Mr Joe Woof of Fullgate, Fullmen Industrial Park, Kings Road, Canvey Island, Essex, SS8 0SF. It was accepted by Mr Woof in a fax dated 16th September 2008.

A series of four test specimens, as detailed in Section 3 of this report, were assembled at BRE's laboratories in Garston. The testing was carried out according to the test methods given in BS EN 13374:2004. This report describes the tests conducted and the results obtained.

The Client also requested BRE to conduct additional tests (outside the scope of BS EN 13374:2004) to determine the effect that the level of torque applied to the four fixing bolts during installation had upon the 'pull-out' performance of the safety gate system. The results of these tests are also reported in the current document, but are non relevant for the determination of compliance of the safety gate system with BS EN 13374:2004.

3 Details of the system

The product to be tested is a "Fullgate" lift shaft safety gate system which is designed for installation into lift shaft openings during construction and maintenance work. A range of four different types of Fullgate are available to suit various opening sizes. The system tested in the current work is of "Type A". This is a variable width unit which can be installed into openings measuring between 800mm and 1400mm. Further details of the system taken from the Clients web site (http://www.fullgate.co.uk) are reproduced in Annex A of this report for information.

The four samples tested were marked with reference numbers on their top rails as follows: A742, A622, A226 and A253. These specimens were randomly selected from current, used stock by the Client.

For the purposes of these tests, a custom test rig was assembled in the BRE laboratory comprising two stanchions which were securely fixed to the laboratory floor and also cross-braced at the top. The stanchions were fixed at a spacing of 1400mm and the Fullgate product installed between them. This width represents the maximum width of opening into which this type of Fullgate can be installed and is therefore the most onerous condition for the product in terms of loading and deflection. When the gate is installed into narrower width openings, it is likely that the performance of some aspects of the product will be better than the results reported herein as a result of the increased overlapping of the extendable horizontal members.

The four fixings bolts which fix the Fullgate system into the opening were tightened by hand using a standard spanner onto the two steel support stanchions. The steel work of the test rig is likely to provide less grip for the bolts compared to the brickwork or concrete as found in typical building constructions. However, it is also less susceptible to damage from the forces exerted by the bolts if over-tightened. The loadings and forces applied during the current series of tests tend to push the gate system into the opening (against the flanges down each side) and hence pull-out of the fixings was not an issue. It should however be noted that whilst the current tests permit determination of the structural performance of the Fullgate, care must still be taken during installation to ensure that the opening surround is appropriate to support the fixings.

The Fullgate lift shaft safety gate system has been tested to 'BS EN 13374:2004 Temporary edge protection systems - Product specification, test methods'. This Standard specifies "the requirements and test methods for temporary edge protection systems for use during construction or maintenance of buildings and other structures". It is not applicable to systems designed to protect against vehicular impact, sliding of bulk loose material, protection to the public from falling or side protection systems on scaffolds.

The Standard defines three classes of protection system as follows:
- Class A - for use where the angle of the working surface is less than 10°
- Class B - for use where the angle is less than 30° without limitation of the falling height, or 60° if the falling height is less than 2m.
- Class C - for use where the angle is between 30° and 45° without limitation of the falling height, or between 45° and 60° where the falling height is less than 5m.

The tests for Class A systems consider only static loading, whereas the tests for Classes B and C also include additional dynamic loading tests. Only Class A requirements are directly applicable to the lift shaft safety gate system since it is installed solely on flat surfaces. Classes B and C are not relevant for this product since the tests are designed to replicate the effects of a person rolling down a steeply inclined roof into the device.

The Client also requested BRE to conduct additional tests to determine the effect that the level of torque applied to the four fixing bolts during installation had upon the pull-out performance of the entire safety gate system from the opening. These are ad-hoc tests designed by BRE in order to provide the Client with the data required for specifying correct installation procedures. They therefore lie outside the scope of BS EN 13374:2004 but are reported in the current document for completeness. However, the results are not relevant for the determination of compliance of the safety gate system with BS EN 13374:2004.

Photographs of the lift shaft safety gate system are shown in Figures A1 and A2 in Annex A at the rear of this report.

4 Details of tests carried out

4.1 Static horizontal loads

4.1.1 General

Clause 6.3.1.1 of BS EN 13374:2004 specifies that each edge protection and each of its components (with the exception of toeboards) shall withstand a load of 0.3kN applied in a horizontal plane, perpendicular to the axis of the post, without excessive deflection or failure of any component.

Clause 6.3.1.3 specifies that toeboards shall withstand a horizontal load of 0.2kN applied at the most onerous location.

4.1.2 Deflection under load

Clause 5.2.1 of BS EN 13374:2004 gives additional requirements for Class A edge protection systems with regards to deflection. It specifies that the adjusted[1] elastic deflection should not exceed the value of 55mm, as given in Clause 6.3.5 of the Standard. Details of the test methodology are provided in Clause 7.4.2.

4.1.3 Ultimate strength

Clause 5.2.1 of BS EN 13374:2004 also gives additional requirements for Class A edge protection systems with regards to their ultimate strength. It specifies that the adjusted[1] ultimate strength shall not be less than 1.2 times the maximum test load of 0.50kN calculated in Section 4.1.3 above. The ultimate strength of the lift shaft safety gate must therefore equal or exceed 0.60kN.

These tests were repeated at four separate locations of three test specimens. It was not possible to conduct these tests on the fourth test specimen since this was required for other tests and the ultimate strength tests involved loading to failure, thereby damaging the specimen.

4.1.4 Residual deflection

Additionally, the same clause also specifies that the residual defection of the lift shaft safety gate should not exceed 10% of the deflection under the maximum test load.

The maximum test load is calculated from the characteristic load provided in Clause 6.3.1 multiplied by the partial safety factors given in Clause 6.2.1 of the Standard. For the temporary edge protection system being tested, the partial safety factors are $\gamma_F = 1.5$ (for all permanent and variable loads) and $\gamma_M = 1.1$ (for ductile metallic materials). This gives maximum test loads of 0.30kN x 1.5 x 1.1 = 0.50kN for all components except toeboards for which it is 0.2kN x 1.5 x 1.1 = 0.33kN.

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[1] The measured values shall be adjusted using statistical methods in accordance with EN 12811-3 [2].

4.2   Loads parallel to the lift shaft safety gate

Clause 6.3.2 of BS EN 13374:2004 specifies that each edge protection shall be capable of withstanding a load of 0.20kN applied parallel to the lift shaft safety gate at the most onerous point.

4.3   Accidental loading

Clause 6.3.6 of BS EN 13374:2004 specifies that any guard-rail or toeboard shall be capable of resisting a downwards point load of 1.25kN.

For the purposes of testing, this load must be applied in the most unfavourable position and in a downwards direction at an angle no greater than 10° from the vertical.

For the lift shaft safety gate system being tested, the most unfavourable position has been identified as being at the latch side of the half-height safety gate. No other horizontal members of the lift shaft safety gate system are accessible once it is installed, and hence the only vertical load which could be applied would be to the top of the half-height gate.

4.4   Safety gate pull-out tests

The Client also requested BRE to conduct additional tests (beyond the scope of BS EN 13374:2004) to determine the force required to pull the safety gate system out of the opening. The safety gate is not usually loaded in this way since it is designed to prevent persons and material falling into (and not out of) the lift shaft. However, the Client asked BRE to determine the force required to pull the safety gate out of the opening with the fixing bolts tightened to a range of different torque settings.

5 Test results

5.1 Static horizontal loads

5.1.1 General

Horizontal static loads of 0.3kN were applied perpendicular to the specimen at various locations on the components of the lift shaft safety gate system, except at locations on the toeboard (or adjacent structural members) where a horizontal static load of 0.2kN was applied. The loading was achieved using a hand-held, calibrated force gauge by an operator standing at ground level adjacent to the specimen and pushing horizontally onto the specimen at the specified locations.

Horizontal static loads of 0.2kN were applied perpendicular to the lower portion (toeboard area) of the specimen at a total of seven locations. These locations were on the lowest sections of the side rails, infill panels and the full-height gate (locations 21 to 25 in Figure A3) and also on the toe-board of the half-height gate (locations 30 and 31 in Figure A4).

Locations at the mid-height of the various vertical rails were established as being the most onerous since these would provide the greatest leverage effect on the top and bottom rail fixings. Horizontal static loads of 0.3kN were therefore applied parallel to the specimen at this height at a total of thirteen locations. These locations are labelled numbers 11 to 20 in Figure A3, and numbers 26 to 28 on the top of the half-height gate in Figure A4. Horizontal static loads of 0.3kN were also applied at ten locations across the top of the specimen (locations 1 to 10 in Figure A3) and four locations on the half-height gate (locations 29, 32, 33 and 34 in Figure A4).

The total number of test locations was therefore thirty-four and the tests were repeated at these same locations on four separate test specimens.

The test results are presented in Table 1 on the following page. In all cases, the lift shaft safety gate system was able to withstand the static loads specified in the Standard without excess deflection or failure of any component. The system therefore complies with this clause of the test Standard

Test location	Description of test location	Number of repeats	Load applied	
			200N	300N
1	Top left corner of frame	4		✓
2	350mm across top of frame (1/4 way)	4		✓
3	700mm across top of frame (1/2 way)	4		✓
4	1050mm across top of frame (3/4 way)	4		✓
5	Top right corner of frame	4		✓
6	Top centre of small infill panel (75mm wide)	4		✓
7	Top centre of large infill panel (275mm wide)	4		✓
8	Top centre of medium infill panel (175mm wide)	4		✓
9	Top centre of main gate	4		✓
10	Top of right hand post of main frame	4		✓
11	Centre of small infill panel	4		✓
12	Centre of left post of large infill panel	4		✓
13	Centre of mesh of large infill panel	4		✓
14	Centre of right post of large infill panel	4		✓
15	Centre of left post of medium infill panel	4		✓
16	Centre of mesh of medium infill panel	4		✓
17	Centre of right post of medium infill panel	4		✓
18	Centre of left post of main gate	4		✓
19	Centre of mesh of main gate	4		✓
20	Centre of right post of main gate	4		✓
21	Bottom left corner of main frame	4	✓	
22	Small infill panel centre of kicker board	4	✓	
23	Large infill panel centre of kicker board	4	✓	
24	Medium infill panel centre of kicker board	4	✓	
25	Bottom centre of main gate	4	✓	
26	Top left corner of half gate	4		✓
27	Centre of half gate top rail	4		✓
28	Top of left post of half gate	4		✓
29	Centre of mesh of half gate	4		✓
30	Bottom left corner of half gate	4	✓	
31	Bottom right corner of half gate	4	✓	
32	Centre of door frame to half gate (leading edge)	4		✓
33	Centre of left post of half gate	4		✓
34	Centre of right post of half gate	4		✓

Table 1: Summary of static load test results

5.1.2 Deflection under load

A hydraulic loading cylinder and calibrated load cell were employed to provide the test load to the lift shaft safety gate. The lift shaft safety gate was loaded at four separate locations which were at heights equivalent to the handrail height of a typical temporary edge protection system. These locations were as follows:

1. At the centre of the top rail of the half-height safety gate
2. At the centre of the small infill panel
3. At the centre of the medium infill panel
4. At the centre of the large infill panel

A preload of 0.1kN was applied to the test specimen before each test and held for 1 minute to settle the guard-rail components. A test load of 0.3kN was then applied in equal increments and held for a further one minute before being removed. The deflection at maximum load and residual displacement after removal of the load were recorded using a calibrated displacement transducer. The results for these tests are presented in Table 2 to 5 below for the four different loading positions, and the mean deflections have also been calculated.

Load (kN)	Deflections (mm)				
	Test 1 (A226)	Test 2 (A622)	Test 3 (A742)	Test 4 (A253)	Mean
0.30	6.3	5.3	6.4	6.6	6.2
0 (Residual)	0.1	0.2	0.1	0.2	0.2

Table 2: Deflection under load results for centre of top rail of half-height gate

Load (kN)	Deflections (mm)				
	Test 1 (A226)	Test 2 (A622)	Test 3 (A742)	Test 4 (A253)	Mean
0.30	19.0	12.8	11.1	12.5	13.9
0 (Residual)	0.9	0.1	0.0	0.0	0.3

Table 3: Deflection under load results for centre of small infill panel

Load (kN)	Deflections (mm)				
	Test 1 (A226)	Test 2 (A622)	Test 3 (A742)	Test 4 (A253)	Mean
0.30	12.3	21.8	17.9	16.9	17.2
0 (Residual)	0.0	3.7	0.7	0.4	1.2

Table 4: Deflection under load results for centre of medium infill panel

Load (kN)	Deflections (mm)				
	Test 1 (A226)	Test 2 (A622)	Test 3 (A742)	Test 4 (A253)	Mean
0.30	12.1	13.4	16.7	17.2	14.9
0 (Residual)	0.1	0.2	0.0	0.1	0.1

Table 5: Deflection under load results for centre of large infill panel

To calculate the value of the characteristic deflection, the natural logarithm is first taken of the maximum deflections. The logarithmic characteristic value (y_c) of the deflection of the system is then calculated using the following equation:

$$y_c = \bar{y} - (S \times k_n)$$

where: $\bar{y}$ = mean log of deflection
S = standard deviation
and k_n is taken from Table 6 below (2.68 in the current case).

Number of test results	3	4	5	6
k_n	3.15	2.68	2.46	2.33

Table 6: Values of k_n

The logarithmic transformation is then reversed to obtain the characteristic value of the deflection. A partial factor of one has been assumed.

Therefore, the characteristic value for the deflection of the lift shaft safety gate are 4.7mm at the centre of the top rail of the half-height gate, and 7.2mm, 8.9mm and 9.3mm at the centres of the small, medium and large infill panels respectively. The system therefore complies with the requirements that the characteristic values of deflection must be less than 55mm.

5.1.3 Ultimate strength - loading at centre of top rail of half-height gate

For this test, the test specimen and equipment remained as described previously in Section 5.1.2. Loading was applied horizontally to the centre of the top rail of the half-height safety gate incrementally until failure occurred or the specimen was unable to withstand further loading. At each increment, the specimen was examined visually for signs of failure or deformation and the residual displacement was recorded upon removal of the load. The measured displacements are shown below in Table 7. This data is also plotted in Figures 1 and 2.

Load (kN)	Test 1 (A226)		Test 2 (A622)		Test 3 (A742)	
	Deflection (mm)	Residual (mm)	Deflection (mm)	Residual (mm)	Deflection (mm)	Residual (mm)
0.05	2.8	0	0.9	0.1	2.7	0
0.10	3.4	0	1.8	0.1	3	0
0.15	4	0	2.6	0.1	3.2	0
0.20	4.9	0	3.5	0.1	4.7	0
0.25	5.6	0	4	0.1	5.7	1.1
0.29	6.3	0.1	5.3	0.2	6.6	0.2
0.34	7.1	0.1	6.2	0.2	7.3	0.2
0.39	8.2	0.1	7.4	0.2	8.1	0.2
0.44	8.9	0.1	8.2	0.2	8.5	0.2
0.49	9.6	0.3	9	0.4	10	0.2
0.59	11.6	0.3	12.5	0.6	11.6	0.3
0.69	12.7	0.4	13.2	0.6	13.7	0.3
0.78	14.3	5.5	14	0.7	15.3	0.3
0.88	21.1	5.6	16.3	0.9	17.3	0.3
0.98	23.2	5.7	18	1.1	19	0.4
1.08	24.4	5.8	20.2	1.5	20.6	0.5
1.18	26.3	5.6	22.3	1.9	22.5	0.5
1.28	28.1	5.9	25.1	2.8	26.5	2.9
1.37	29.8	6.1	27.9	3.7	30.5	5.2
1.47	33.2	7.4	31.9	5.6	32.5	6.9
1.57	39	11.1	36.6	8	37.2	8.5
1.67	46.9	16.9	46.7	15.6	55.6	22.7
1.77	55.2	22.7	57.7	22.9	69.2	33.6
1.86	65.1	30	71.5	34	86.5	47.5
1.96	73.7	37.1	83.9	46.5	104.2	-
2.06	86.5	47	93.2	54	-	-
2.16	96.3	54.4	99.5	64.7	-	-
2.26	105.6	62.3	115.4	-	-	-

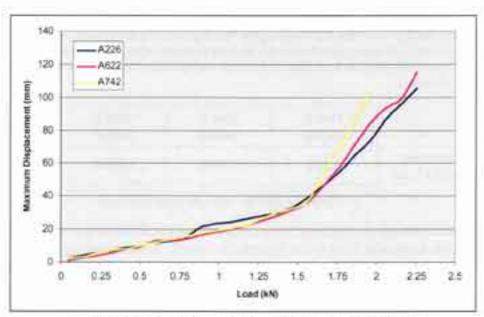Table 7: Results for centre of top rail of half-height gate

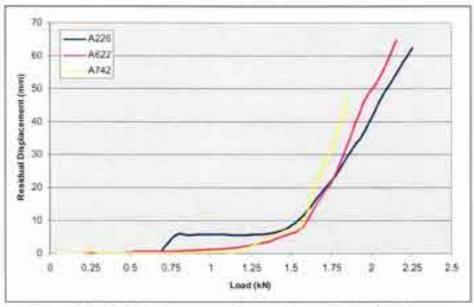Figure 1: Displacements of centre of top rail of half-height gate

Figure 2: Residual displacements of centre of top rail of half-height gate

The ultimate strength measurements (based upon the maximum loads which it was possible to apply to the three specimens) are summarised in Table 8 below and the average value has been calculated to be 2.16kN.

For loading onto the top rail of the half-height gate, the maximum load capacity was determined by the point at which the door stop tab was pushed past the vertical member of the safety gate frame. Once this critical load had been reached, the gate was pushed through the opening and therefore sprang open in the direction of the lift shaft.

	Test 1 (A226)	Test 2 (A622)	Test 3 (A742)	Average
Ultimate failure load	2.26N	2.26kN	1.96kN	2.16kN

Table 8: Ultimate strength tests summary

The characteristic ultimate strength may be calculated as per the characteristic deflection in Section 5.1.2 of this report (with k_n equal to 3.15) and is found to be 1.66kN. This exceeds the required maximum test load of 0.60kN and therefore the lift shaft safety gate system complies with this requirement of the Standard.

5.1.4 Ultimate strength - loading at the centre of the small infill panel

For this test, the test specimen and equipment remained as described previously in Section 5.1.2. Loading was applied horizontally to the centre of the top rail of the half-height safety gate incrementally until failure occurred or the specimen was unable to withstand further loading. At each increment, the specimen was examined visually for signs of failure or deformation and the residual displacement was recorded upon removal of the load. The measured displacements are shown below in Table 9. This data is also plotted in Figures 3 and 4.

Load (kN)	Test 1 (A226)		Test 2 (A622)		Test 3 (A742)	
	Deflection (mm)	Residual (mm)	Deflection (mm)	Residual (mm)	Deflection (mm)	Residual (mm)
0.05	1.8	0	1.9	0	2	0
0.10	4.6	0.2	5	0	4.5	0
0.15	6.5	0.1	6.7	0	6.4	0
0.20	8.4	0	9.1	0	8.8	0
0.25	10.4	0.1	10.9	0	10.7	0
0.29	12.3	0	12.8	0	12.5	0
0.34	13.4	0	15.9	0	14.7	0
0.39	16	0.1	18.6	0.4	17.1	0
0.44	17.5	0.1	20.5	0.5	19.8	0
0.49	18.7	0	23.4	0.5	21.5	0
0.59	25.5	9.2	29.1	0.6	25.9	0.1
0.69	27.2	9.2	33	0.6	29.4	0.2
0.78	31.7	9	38	1	35.7	0.8
0.88	36.1	8.9	42.5	1.3	40.1	1.1
0.98	42.8	10.5	47.9	2.6	43.8	1.4
1.08	72.4	19.2	56.8	6	49.5	3.2
1.18	-	-	73.4	15.4	61	7.2
1.28	-	-	-	-	91.9	25.7

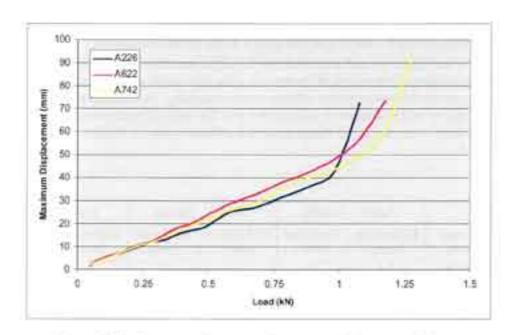Table 9: Results for the centre of the small infill panel

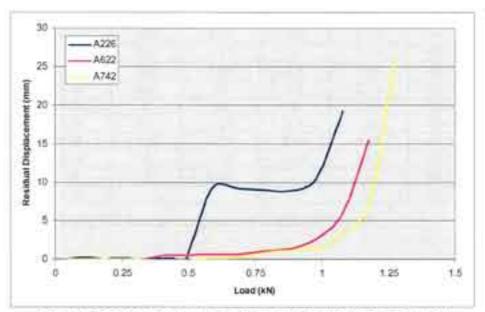Figure 3: Displacements of centre of the centre of the small infill panel

Figure 4: Residual displacements of the centre of the small infill panel

The ultimate strength measurements (based upon the maximum loads which it was possible to apply to the three specimens) are summarised in Table 10 below and the average value has been calculated to be 1.18kN.

For loading onto the centre of the small infill panel, the maximum load capacity was determined by the point at which the two pins which locate the panel into the bottom rail of the outer frame became disengaged. Loading of the infill panel causes it to bow along its vertical axis, and hence to the lower pins being pulled from their location holes (the top pins are held in place with nuts and so did not pull through). Once these lower pins are released from the bottom rail, the infill panel springs open at its bottom and hence no further loading can be sustained.

	Test 1 (A226)	Test 2 (A622)	Test 3 (A742)	Average
Ultimate failure load	1.08kN	1.18kN	1.28kN	1.18kN

Table 10: Ultimate strength tests summary

The characteristic ultimate strength may be calculated as per the characteristic deflection in Section 5.1.2 of this report (with k_n equal to 3.15) and is found to be 0.90kN. This exceeds the required maximum test load of 0.60kN and therefore complies with this requirement of the Standard.

5.1.5 Ultimate strength - loading at the centre of the medium infill panel

For this test, the test specimen and equipment remained as described previously in Section 5.1.2. Loading was applied horizontally to the centre of the top rail of the half-height safety gate incrementally until failure occurred or the specimen was unable to withstand further loading. At each increment, the specimen was examined visually for signs of failure or deformation and the residual displacement was recorded upon removal of the load. The measured displacements are shown below in Table 11. This data is also plotted in Figures 5 and 6.

Load (kN)	Test 1 (A226)		Test 2 (A622)		Test 3 (A742)	
	Deflection (mm)	Residual (mm)	Deflection (mm)	Residual (mm)	Deflection (mm)	Residual (mm)
0.05	3.9	0	4.1	0	3.5	0
0.10	8.3	0.1	6.5	0.2	5.6	0
0.15	10.8	0.3	9.3	0	8.2	0
0.20	13.3	0.8	13	0.2	11.1	0
0.25	16.1	0.7	15.8		13.9	0
0.29	19.0	0.9	18.4	0.3	16.9	0.4
0.34	22.1	1.2	21	0.4	20.6	0.7
0.39	24.6	1.3	24.1	0.6	22.6	0.7
0.44	27.4	1.6	27.1	0.7	25.6	0.8
0.49	30.1	1.7	29.2	0.8	28.7	0.9
0.59	36.1	2.4	35.2	1.1	33.5	1
0.69	42.6	2.7	40.5	1.5	39.1	0.9
0.78	47.2	3	46.9	1.9	44.9	1.6
0.88	53.6	3.4	53.3	2.1	51.1	2.3
0.98	60.4	4.4	60.6	3.9	62	4.7
1.08	68.2	5.8	68.1	6.5	72.8	9.1
1.18	-	-	82.6	12.9	86.4	16.8

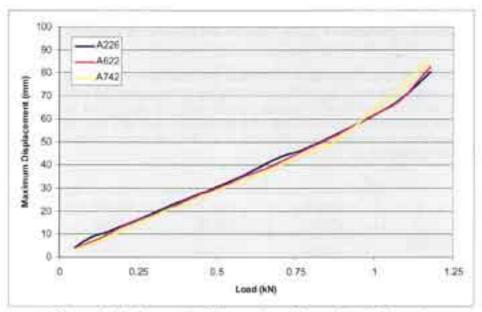Table 11: Results for the centre of the medium infill panel

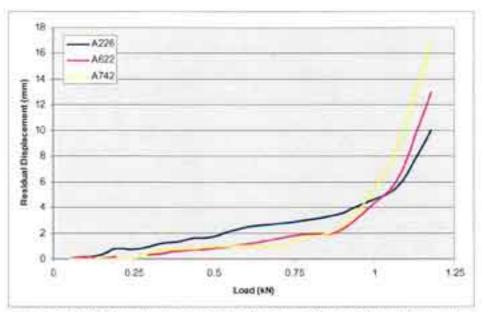Figure 5: Displacements of the centre of the medium infill panel

Figure 6: Residual displacements of the centre of the medium infill panel

The ultimate strength measurements (based upon the maximum loads which it was possible to apply to the three specimens) are summarised in Table 12 below and the average value has been calculated to be 1.18kN.

For loading onto the centre of the medium infill panel, the maximum load capacity was determined by the point at which the two pins which locate the panel into the bottom rail of the outer frame became disengaged. Loading of the infill panel causes it to bow along its vertical axis, and hence to the lower pins being pulled from their location holes (the top pins are held in place with nuts and so did not pull through). Once these lower pins are released from the bottom rail, the infill panel springs open at its bottom and hence no further loading can be sustained.

	Test 1 (A226)	Test 2 (A622)	Test 3 (A742)	Average
Ultimate failure load	1.08kN	1.18kN	1.18kN	1.15kN

Table 12: Ultimate strength tests summary

The characteristic ultimate strength may be calculated as per the characteristic deflection in Section 5.1.2 of this report (with k_n equal to 3.15) and is found to be 0.98kN. This exceeds the required maximum test load of 0.60kN and therefore complies with this requirement of the Standard.

5.1.6 Ultimate strength - loading at the centre of the large infill panel

For this test, the test specimen and equipment remained as described previously in Section 5.1.2. Loading was applied horizontally to the centre of the top rail of the half-height safety gate incrementally until failure occurred or the specimen was unable to withstand further loading. At each increment, the specimen was examined visually for signs of failure or deformation and the residual displacement was recorded upon removal of the load. The measured displacements are shown below in Table 13. This data is also plotted in Figures 7 and 8.

Load (kN)	Test 1 (A226) Deflection (mm)	Residual (mm)	Test 2 (A622) Deflection (mm)	Residual (mm)	Test 3 (A742) Deflection (mm)	Residual (mm)
0.05	2.8	0	0.9	0.1	2.7	0
0.10	3.4	0	1.8	0.1	3	0
0.15	4	0	2.6	0.1	3.2	0
0.20	4.9	0	3.5	0.1	4.7	0
0.25	5.6	0	4	0.1	5.7	1.1
0.29	6.3	0.1	5.3	0.2	6.6	0.2
0.34	7.1	0.1	6.2	0.2	7.3	0.2
0.39	8.2	0.1	7.4	0.2	8.1	0.2
0.44	8.9	0.1	8.2	0.2	8.5	0.2
0.49	9.6	0.3	9	0.4	10	0.2
0.59	11.6	0.3	12.5	0.6	11.6	0.3
0.69	12.7	0.4	13.2	0.6	13.7	0.3
0.78	14.3	5.5	14	0.7	15.3	0.3
0.88	21.1	5.6	16.3	0.9	17.3	0.3
0.98	23.2	5.7	18	1.1	19	0.4
1.08	24.4	5.8	20.2	1.5	20.6	0.5
1.18	26.3	5.6	22.3	1.9	22.5	0.5
1.28	28.1	5.9	25.1	2.8	26.5	2.9
1.37	29.8	6.1	27.9	3.7	30.5	5.2
1.47	33.2	7.4	31.9	5.6	32.5	6.9
1.57	39	11.1	36.6	8	37.2	8.5
1.67	46.9	16.9	46.7	15.6	55.6	22.7
1.77	55.2	22.7	57.7	22.9	69.2	33.6
1.86	65.1	30	71.5	34	86.5	47.5
1.96	73.7	37.1	83.9	46.5	104.2	-
2.06	86.5	47	93.2	54	-	-
2.16	96.3	54.4	99.5	64.7	-	-
2.26	105.6	62.3	115.4	-	-	-

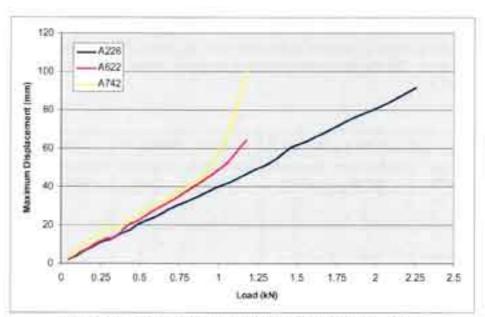Table 13: Results for the centre of the large infill panel

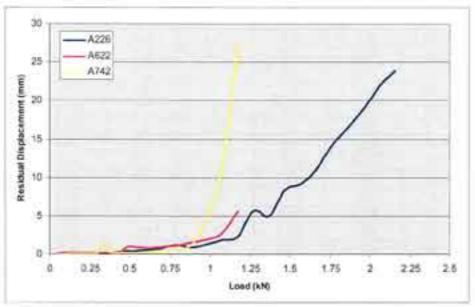Figure 7: Displacements of the centre of the large infill panel

Figure 8: Residual displacements of the centre of the large infill panel

The ultimate strength measurements (based upon the maximum loads which it was possible to apply to the three specimens) are summarised in Table 14 below and the average value has been calculated to be 1.57kN.

For loading onto the centre of the large infill panel, the maximum load capacity was determined by the point at which the two pins which locate the panel into the bottom rail of the outer frame became disengaged. Loading of the infill panel causes it to bow along its vertical axis, and hence to the lower pins being pulled from their location holes (the top pins are held in place with nuts and so did not pull through). Once these lower pins are released from the bottom rail, the infill panel springs open at its bottom and hence no further loading can be sustained.

	Test 1 (A226)	Test 2 (A622)	Test 3 (A742)	Average
Ultimate failure load	2.30	1.20	1.20	1.57

Table 14: Ultimate strength tests summary

It is clear from these results that the first infill panel tested performed very differently to the other two test specimens; the load at which if failed was almost double. On closer inspection of the specimens after the test, it was noticed that the two locating pins at the bottom of the first specimen were spaced at 250mm centres as opposed to 200mm centres for the other two specimens. Being more widely spaced means that the pins are closer to the side (vertical) rails of the infill panel and hence this section of the bottom rail may be less susceptible to twisting under load. It is suggested that this could be the reason for the variation in performance although this cannot be verified since the movement and position of the bottom pins was not observed during the test. Further tests could be performed if required to further quantify the effect of the two types of large infill panel.

The characteristic ultimate strength may be calculated as per the characteristic deflection in Section 5.1.2 of this report (with k_n equal to 3.15) and is found to be 0.48kN. The nature of this calculation is such that any variation in the results from the mean (be it either above or below) increases the standard deviation of the data and hence reduces the characteristic ultimate strength. The significantly higher failure load of the first specimen thereby actually reduces the characteristic strength to below the required 0.60kN and therefore does not technically comply with this requirement of the Standard.

However, given that the variation in the measured maximum strengths is as a result of differences in the panel designs, this calculation is not necessarily appropriate. It is not possible to simply discount the first result and use only the other two since a minimum of three tests are required (there is no k_n value specified for only two tests, see Table 6). It is therefore suggested that a lower failure load is taken for the first test specimen; a value of 1.20kN would seem appropriate given that this is the load at which both of the other panels failed. The characteristic ultimate strength thereby obtained for the large infill panel is 1.20kN which is greater than the value of 0.6kN required by the Standard, and therefore this result constitutes a pass.

5.1.7 Residual deflection

For these tests, the test specimens and equipment remained as described previously in Section 5.1.6. The lift shaft safety gate was loaded to 0.50kN at the four locations described previously, and this load was sustained for one minute. The deflection at this maximum test load was recorded and the load removed. The residual deflection of the lift shaft safety gate was then measured.

The results for this test are presented below in Tables 15 to 18 for the four loading locations.

	Deflections (mm)			
	Test 1 (A226)	Test 2 (A622)	Test 3 (A742)	Mean
Maximum	9.6	9.0	9.7	9.4
Residual	0.3	0.4	0.2	0.3
$\dfrac{Residual}{Maximum} \times 100$	3.1	4.4	2.1	3.2

Table 15: Residual deflection measurement results for centre of top rail of half-height gate

	Deflections (mm)			
	Test 1 (A226)	Test 2 (A622)	Test 3 (A742)	Mean
Maximum	16.7	23.4	21.2	21.1
Residual	0.0	0.5	0.1	0.2
$\dfrac{Residual}{Maximum} \times 100$	0.0	2.1	0.5	0.9

Table 16: Residual deflection measurement results for centre of small infill panel

	Deflections (mm)			
	Test 1 (A226)	Test 2 (A622)	Test 3 (A742)	Mean
Maximum	30.1	29.2	27.9	29.1
Residual	1.7	0.8	0.9	1.1
$\dfrac{Residual}{Maximum} \times 100$	5.6	2.7	3.2	3.9

Table 17: Residual deflection measurement results for centre of medium infill panel

	Deflections (mm)			
	Test 1 (A226)	Test 2 (A622)	Test 3 (A742)	Mean
Maximum	20.2	22.0	24.5	22.2
Residual	0.4	1.0	0.2	0.5
$\dfrac{Residual}{Maximum} \times 100$	2.0	4.5	0.8	2.4

Table 18: Residual deflection measurement results for centre of large infill panel

In all tests, the measured residual displacement was below 10% of the deflection under the 0.50kN test load. The maximum residual displacement measured was 5.6% of the deflection under maximum load. The system therefore complies with this clause of the test Standard.

5.2 Loads parallel to the lift shaft safety gate

A horizontal load of 0.2kN was applied longitudinally to the various accessible vertical members, parallel with the lift shaft safety gate using a handheld calibrated force gauge by an operator standing at floor level next to the specimen. The tests were repeated at five locations on four separate test specimens.

Three of the test locations (locations 1 to 3 in Figure A5) were on the side members of the three sizes of infill panel at their mid-height. One location was on the full-height safety gate at its mid-height (location 4) and loading was also applied onto the half-door close tab (location 5) to establish if this would cause the gate to disengage and thereby open.

A summary of the test results is given below in Table 19. In each case, there was no failure or observable deformation of the posts or guard-rails. The guard-rail system therefore complies with this requirement of the test Standard.

Test location	Description of test location	Number of repeats	Load applied	
			200N	300N
1	Side member of small infill panel at mid-height	4	✓	
2	Side member of large infill panel at mid-height	4	✓	
3	Side member of medium infill panel at mid-height	4	✓	
4	Side member of main gate at mid-height	4	✓	
5	Top stop tab of half gate	4	✓	

Table 19: Parallel loading

5.3   Accidental loading

The required vertical load of 1.25kN was applied to the top of the half-height gate of the lift shaft safety system using a series of dead weights. The test was repeated at total of four times on the supplied test specimens.

In each case, the half-height lift shaft safety gate was opened and closed prior to test to verify its smooth operation. During the tests, the loaded gate was seen to deflect downwards slightly but no damage was apparent. After the vertical test load was removed, there was no significant residual deformation on any of the four gates tested, and each of these continued to open and close smoothly. The lift shaft safety gate system remained serviceable after the test and its operation and the locking of the two gates were unaffected.

The tested specimens therefore comply with this clause of the Standard.

6   Pull-out tests

For these tests, the lift shaft safety gate system remained setup as described for the previous tests. The four fixing bolts which hold the outer frame of the safety gate in place within the opening were tightened using a torque wrench to the specified settings.

A force was applied perpendicular to the safety gate system which therefore acted to pull the specimen out of the opening between the two stanchions (i.e. away from the lift shaft in practice). The load was applied using a hydraulic loading cylinder acting through a calibrated load cell which featured a maximum hold function to allow the peak load required to pull the specimen out of the test rig to be recorded. The applied load was gradually increased until the safety gate system pulled free of the test rig.

Four different torque settings of the fixing bolts were tested: 2Nm, 4Nm, 10Nm and 15Nm. The forces required to pull the specimen from the test rig at each of these settings are listed below in Table 21.

Torque setting on four fixing bolts	Force required to pull safety gate out of opening
2Nm	0.29kN
4Nm	0.42kN
10Nm	1.38kN
15Nm	1.94kN

Table 21: Safety gate system pull-out test results

This test is beyond the scope of the BS EN 13374:2004 and there are therefore no pass/fail criteria for the results obtained. It is likely that the results presented here are onerous since the steel stanchions of the test rig will provide less friction for the fixings than, for example, may be obtained against a brickwork wall or timber batten in practice. The actual force required to pull the safety gate system out of the opening in a given situation will depend upon a range of factors including the surrounding material and the tightness of the fixing bolts. The results presented above may therefore be used as guidance in the installation process, but it remains essential that each installation is individually checked for security of fitment upon completion.

7 Video recording of testing

Testing of the Fullgate lift shaft safety gate system was recorded by BRE onto a series of five DVD's. The chapters contained on each of this discs are described in Tables 22 and 23 below.

Disc	Chapter	Specimen	Description
1	1	A742	Horizontal loading. Left hand post of main frame.
	2		Horizontal loading. Large infill panel centre of mesh.
	3		Horizontal loading. Main gate centre of left hand post.
	4		Horizontal loading. Main gate centre of mesh.
	5		Horizontal loading. Large infill panel centre of kicker board.
	6		Horizontal loading. Main gate centre of kicker board.
	7		Horizontal loading. Half gate centre of top rail.
	8		Horizontal loading. Half gate centre of mesh.
	9		Parallel loading. Large infill panel centre of right hand post.
	10		Parallel loading. Medium infill panel centre of right hand post.
	11		Parallel loading. Half gate door frame centre of left hand post.
	12		Parallel loading. Main gate centre of left hand post.
	13		Parallel loading. Half gate top stop tab.
	14		Accidental loading. Leading edge of half gate.
	15		Accidental loading. Centre of half gate.
	16		Displacement. Centre of small infill panel.
	17		Displacement. Centre of large infill panel.
	18		Displacement. Centre of medium infill panel.
	19		Displacement. Half gate centre of top rail.
	20		Strength. Centre of small infill panel.
	21		Strength. Centre of large infill panel.
	22		Strength. Centre of medium infill panel.
	23		Not used (disk ran out).
2	1	A742	Strength. Half gate centre of top rail.
	2		Strength. Half gate centre of top rail.
	3		Strength. Half gate centre of top rail.
3	1	A622	Accidental loading. Centre of half gate.
	2		Accidental loading. Leading edge of half gate.
	3		Displacement and strength. Centre of small infill panel.
	4		Displacement and strength. Centre of large infill panel.
	5		Displacement and strength. Centre of medium infill panel.
	6		Displacement and strength. Half gate centre of top rail.

Table 22: Contents list for DVD numbers one to three

Disc	Chapter	Specimen	Description
4	1	A226	Accidental loading. Centre of half gate.
	2		Accidental loading. Leading edge of half gate.
	3		Displacement and strength. Centre of small infill panel and large infill panel.
	4		Displacement and strength. Centre of medium infill panel.
	5		Displacement and strength. Half gate centre of top rail.
	6		Displacement and strength. Half gate centre of top rail.
5	1-10	A226	Additional tests not applicable to current system
	11		Frame pull out test. Top and bottom bolts tightened to 2N.m
	12		Frame pull out test. Top and bottom bolts tightened to 4N.m
	13		Frame pull out test. Top and bottom bolts tightened to 10N.m
	14		Frame pull out test. Top and bottom bolts tightened to 15N.m

Table 23: Contents list for DVD numbers four and five

8   References

[1]   BS EN 13374:2004 Temporary edge protection systems – Product specification, test methods. BSI, November 2004.

[2]   EN 596 Timber structures – test methods – Soft body impact test of timber framed walls. BSI, March 1995.

Annex A - Photographs of the test specimen

Figure A1: Fullgate lift shaft safety gate system installed in BRE test rig

Figure A2: Fullgate lift shaft safety gate system with main door ajar

Figure A3: Horizontal static load test locations with main door open

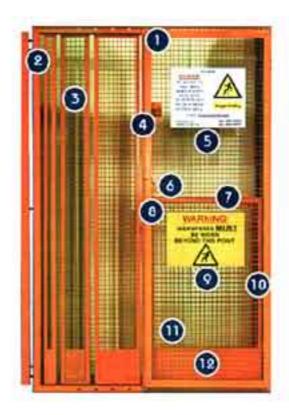Figure A4: Horizontal static load test locations with main door open

Figure A5: Parallel static load test locations

Figure A6: Safety gate pull-out test loading location

Annex B - Information provided by Client

Key:

1. Fixing holes at 25mm increments to suit opening ranges (M8 adjustable bolts).
2. Clamp rail with 25mm adjustment.
3. Three infill panels used singly or in combination to suit opening width (275mm, 175mm and 75mm). Unused panels stored behind door panel.
4. Door lock with double guarding to prevent opening from outside of lift shaft.
5. Outer gate A3 size safety warning notice.
6. Outer gate IP65 slam lock (lift door release key) with internal release.
7. One metre high inner Gate opening "Out" on Rising Butt hinges for self closing assisted by heavy duty return spring (see 10).
8. Inner gate slam lock
9. Inner gate A3 size safety warning notice
10. Heavy duty return spring to assist closing inner gate
11. Infill of 25mm x 12G steel mesh
12. 16 SWG kicking plate

==============REPORT ENDS==============

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