FAR 3555

Fire Resistance of Structural Steel Using Maxilite Calcium Silicate Board in Accordance with AS 4100 Section 12, Fire

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1. CLIENT

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2. INTRODUCTION

This report gives BRANZ's assessment of structural steel members using 20 mm to 60 mm thick Maxilite calcium silicate board in increments of 5 mm with a fire resistance of 60, 90, 120, 180 and 240 minutes depending on the size of the steel section and thickness of Maxilite board in accordance with AS 4100, Steel Structures, Section 12, Fire. It considers critical steel temperatures of 550°C for I-section beams and columns, RSJs, structural tees, angles and channels; CHS, SHS and RHS sections; and castellated sections.

This report has been prepared under the requirements of the Building Code of Australia, Specification A 2.3, Clause 2 (d) (i).

3. BACKGROUND

The client has stated that the product tested in the following reports has been renamed as Maxilite. The products tested and subject of this report are identical in all respects.

In General Building Research Corporation of Japan fire resistance test IIIA-99-18 a steel column protected with 20 mm thick Maxilite calcium silicate board was found to satisfy the criteria of ISO 834 for 114 minutes.

In Japan Testing Centre for Construction Materials fire resistance test 9H72550 a steel beam protected with 20 mm thick Maxilite calcium silicate board was found to satisfy the criteria of ISO 834 for 109 minutes.

Various reports have been received from Japanese fire testing laboratories on the performance of Maxilite board protecting a range of steel sections.

A Fire Performance Evaluation Report, issued by the Structural Fire Resistance Review Committee, to the Japanese Fireproofing Board Association, dated 24 June 1999, lists test results of short sections of I section columns, beams and hollow sections. Tests were carried out by the Building Research Institute (BRI), the General Building Research Corporation of Japan and the Japanese Testing Centre for Construction Materials.

The Japanese fire resistance test reports were prepared for Taika Hifukuban Kyokai, the Fire-Resistant Sheathing Board Association (Fireproofing Board Association). Written permission for Fire Containment (F&S Group Pty Ltd) to use this data has been received and retained by BRANZ.

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4. DISCUSSION

4.1 Test standards

The fire resistance tests referenced above were carried out in accordance with ISO 834. The similarities between this test method and that given in AS 1530.4-2005 are considered to be sufficient for the test data to be used to provide an assessment in accordance with AS 1530.4-2005.

4.2 Referenced tests

This analysis for the steel sections has been carried out using data from tests on two loaded I-Section columns, one loaded I-Section beam, eleven unloaded short hollow sections, 11 short columns, and 7 short beams. The loaded specimens were not used in the regression analysis.

The tests covered "exposed surface area to mass ratio" (ESA/m) section factors in the range from 7.4 to 41.6 m²/t, and fire resistance test times up to 255 minutes. The board thickness ranged from a minimum of 20 mm to a maximum of 50 mm.

4.3 Assessment procedure

The assessment process used is that specified in AS 4100, Steel Structures, Section 12, Fire. This requires a fit to an expression, based on calculations using least squares regression as :

$$t = k_0 + k_1.h_i + k_2.(h_i/k_{sm}) + k_3.T + k_4.h_i.T + k_5.(h_i.T/k_{sm}) + k_6.(T/k_{sm}) \qquad (4.1)$$

where:
t = time from the start of the test, in minutes
k_0 to k_6 = regression coefficients
h_i = thickness of fire protection material, in millimetres
T = steel temperature, in degrees Celsius, $T > 250$°C
k_{sm} = exposed surface area to mass ratio, in square metres/tonne (m²/tonne), or

k_{sm} may be expressed in m^{-1} or heated perimeter to surface area (Hp/A) and is used in this report.

The regression analysis resulted in the following coefficients:

k_0	0.648
k_1	0.496
k_2	-8.07
k_3	-0.0808
k_4	0.0049
k_5	0.0781
k_6	1.38

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The main conditions of the analysis are as follows:

a) The regression equation is only to be used for interpolation. A window defining the limits of interpolation is determined by the range of tests carried out and used in the analysis. (Figures 1 shows the limits for each type of steel structure)

b) A regression equation obtained using prototypes with a four-sided fire exposure condition may be applied to a member with a three-sided fire exposure condition provided that stickability has been demonstrated for the three-sided case. (The full scale beam results demonstrated this.)

c) Where the analysis shows results below the window defining the limits, the lower limits of the window are used for that set of data.

d) All data has been used to give at least ten points on the graphs.

4.4 I- Sections and similar

The results of the analysis are given in Tables 1 and 2 and Figure 1.

The data in bold is within the window of applicability. The data in red is outside the window of applicability but is considered suitable as it gives the same thickness of protection for a lesser fire resistance level for the same steel section.

4.5 Castellated Sections

For castellated sections from 6.1 in the Association for Specialist Fire Protection (ASFP), *Fire Protection For Structural Steel In Buildings*, 4th Edition revised 6 August 2007, the following applies:

$$\text{modified thickness} = 1.20\ dp$$

Additional conditions are that:

1. Section factor Hp/A is calculated by:

$$Hp/A = 1400/t$$

where t = thickness (mm) of the lower steel web

2. the maximum thickness of protection should not exceed that of a tested section, in this case 50 mm.
3. The design temperature is the critical or limiting temperature as determined by the steel beam manufacturer or a competent structural or fire engineer.

The results of the analysis are given in Tables 3 and 4 and Figure 2.

The data in bold is within the window of applicability. The data in red is outside the window of applicability but is considered suitable as it gives the same thickness of protection for a lesser fire resistance level for the same steel section.

No distinction is made on whether the sections are columns or beams and the appropriate critical temperature must be chosen by the designer.

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5. CONCLUSION

It is considered that, in accordance with AS4100, Maxilite board would provide a fire resistance of I-section beams and columns, RSJs, structural tees, angles and channels; CHS, SHS and RHS sections; and castellated sections for various thicknesses and critical temperatures as shown in Tables 1 to 4 and Figures 1 and 2.

6. LIMITATION

This assessment report may only be quoted or reproduced in full and is subject to the accuracy and completeness of the information supplied.

For the purposes of this assessment it is assumed that the steel sections will be shot blasted and primed with a similar treatment in a similar manner and to a similar thickness to that used for the sections tested under the test references given in this report.

Should any data come to BRANZ's attention relating to the fire resistance of the items discussed herein, BRANZ reserve the right to amend this report.

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Table 1 Limits of Section Factor for Maxilite Thickness at the Specified FRL for 1, 2, 3 and 4 Sided Protection of I-Columns, Beams and Hollow Sections at 550°C for a Critical Temperature of 550°C or Greater

Maxilite thickness [mm]	Section Factor ESA/m [m²/t]	FRL	Maxilite thickness [mm]	Section Factor ESA/m [m²/t]	FRL
20	36.0	60/-/-	40	41.6	60/-/-
	20.7	90/-/-		41.6	90/-/-
	14.5	120/-/-		41.6	120/-/-
	9.0	180/-/-		22.2	180/-/-
	N/A	240/-/-		13.7	240/-/-
25	41.6	60/-/-	45	41.6	60/-/-
	29.8	90/-/-		41.6	90/-/-
	19.2	120/-/-		41.6	120/-/-
	11.2	180/-/-		28.6	180/-/-
	7.9	240/-/-		16.4	240/-/-
30	41.6	60/-/-	50	41.6	60/-/-
	41.6	90/-/-		41.6	90/-/-
	26.2	120/-/-		41.6	120/-/-
	14.0	180/-/-		N/A	180/-/-
	9.5	240/-/-		23.9*	240/-/-
35	41.6	60/-/-			
	41.6	90/-/-			
	37.4	120/-/-			
	17.5	180/-/-			
	11.4	240/-/-			

Note * For 50 mm thick Maxilite at 240/-/- the limit is given by an actual test result.

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Table 2: Maxilite Thickness (mm).
I-Columns, Beams and Hollow Sections at 550°C

Section Factor		Fire Resistance				
ESA/m	**Hp/A**	**60**	**90**	**120**	**180**	**240***
1.3	10	20	20	20	20	25
2.5	20	20	20	20	20	25
3.8	30	20	20	20	20	25
5.1	40	20	20	20	20	25
6.4	50	20	20	20	20	25
7.6	60	20	20	20	20	25
8.9	70	20	20	20	20	30
10.2	80	20	20	20	25	*40*
11.5	90	20	20	20	30	*40*
12.7	100	20	20	20	30	*40*
14.0	110	20	20	20	30	*40*
15.3	120	20	20	25	35	*40*
16.6	130	20	20	25	35	*50*
17.8	140	20	20	25	40	*50*
19.1	150	20	20	25	40	*50*
20.4	160	20	20	30	40	*50*
21.7	170	20	25	30	40	*50*
22.9	180	20	25	30	45	*50*
24.2	190	20	25	30	45	
25.5	200	20	25	30	45	
26.8	210	20	25	35	45	
28.0	220	20	25	35	45	
29.3	230	20	25	35	50	
30.6	240	20	30	35	50	
31.8	250	20	30	35	50	
33.1	260	20	30	35	50	
34.4	270	20	30	35	50	
35.7	280	20	30	35	50	
36.9	290	25	30	35	50	
38.2	300	25	30	40	50	
39.5	310	25	30	40	55	
40.8	320	25	30	40	55	

Note*: Values at 240 minutes in italics are the direct application of test results

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Figure 1 I - Beams and columns at 550 C

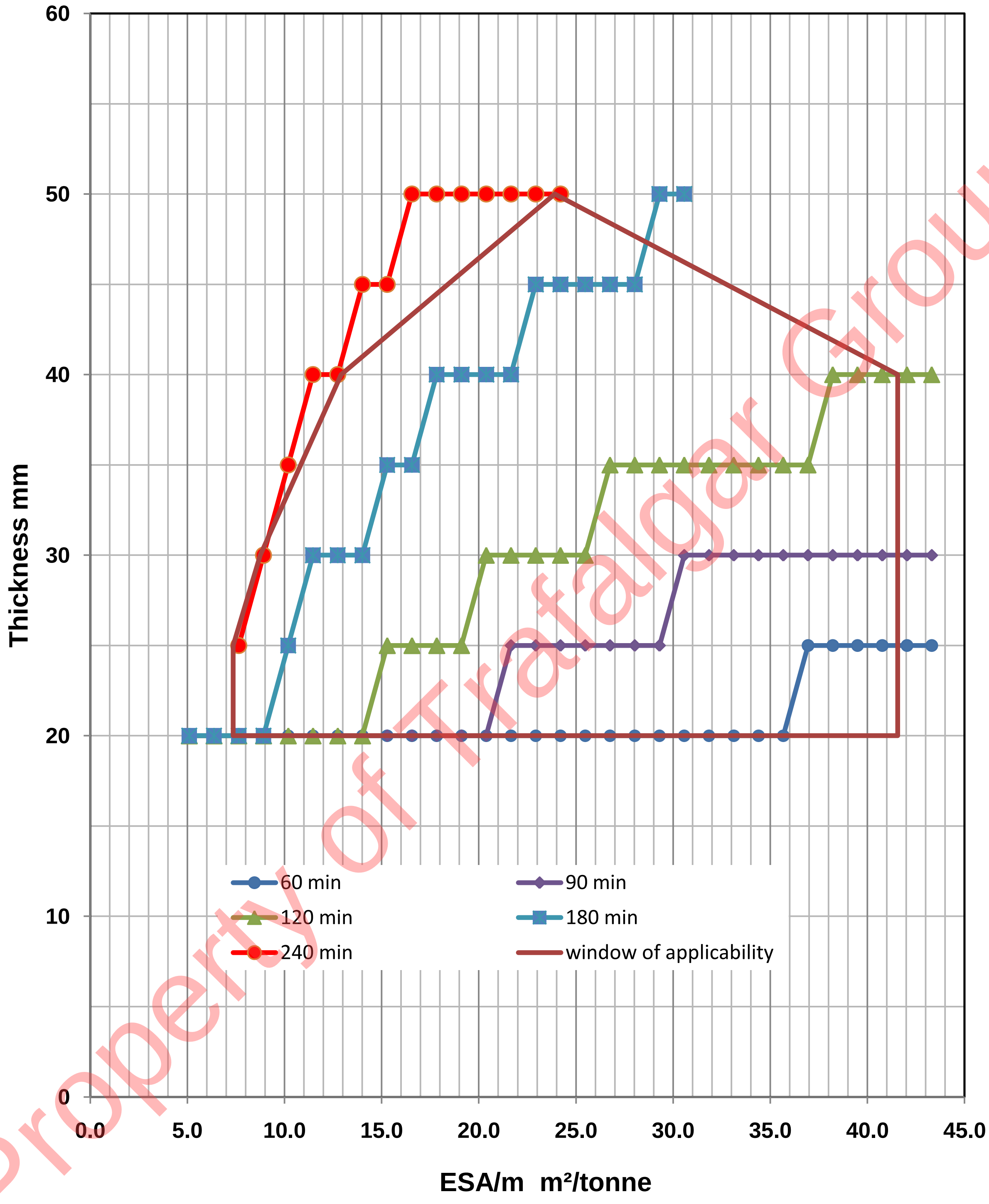

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Table 3 Limits of Section Factor for Maxilite Thickness at the Specified FRL for Castellated Steel Sections for a Critical Temperature of 550°C or Greater

Maxilite thickness [mm]	Section Factor ESA/m [m²/t]	FRL	Maxilite thickness [mm]	Section Factor ESA/m [m²/t]	FRL
20	26.3	60/-/-	40	41.6	60/-/-
	16.5	90/-/-		41.6	90/-/-
	12.0	120/-/-		33.0	120/-/-
	7.8	180/-/-		16.2	180/-/-
25	39.3	60/-/-	45	41.6	60/-/-
	21.9	90/-/-		41.6	90/-/-
	15.2	120/-/-		41.5	120/-/-
	9.4	180/-/-		19.6	180/-/-
30	41.6	60/-/-	50	41.6	60/-/-
	29.8	90/-/-		41.6	90/-/-
	19.2	120/-/-		41.6	120/-/-
	11.2	180/-/-		24.1	180/-/-
35	41.6	60/-/-			
	41.6	90/-/-			
	24.8	120/-/-			
	13.5	180/-/-			

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Table 4: Maxilite Thickness (mm).
Castellated Sections at 550°C

Section Factor		Fire Resistance			
ESA/m	Hp/A	60	90	120	180
1.3	10	20	20	20	20
2.5	20	20	20	20	20
3.8	30	20	20	20	20
5.1	40	20	20	20	20
6.4	50	20	20	20	20
7.6	60	20	20	20	20
8.9	70	20	20	20	25
10.2	80	20	20	20	30
11.5	90	20	20	20	35
12.7	100	20	20	25	35
14.0	110	20	20	25	40
15.3	120	20	20	30	40
16.6	130	20	20	30	45
17.8	140	20	25	30	45
19.1	150	20	25	30	45
20.4	160	20	25	35	
21.7	170	20	25	35	
22.9	180	20	30	35	
24.2	190	20	30	35	
25.5	200	20	30	40	
26.8	210	25	30	40	
28.0	220	25	30	40	
29.3	230	25	30	40	
30.6	240	25	35	40	
31.8	250	25	35	40	
33.1	260	25	35	45	
34.4	270	25	35		
35.7	280	25	35		
36.9	290	25	35		
38.2	300	25	35		
39.5	310	30	35		
40.8	320	30	35		

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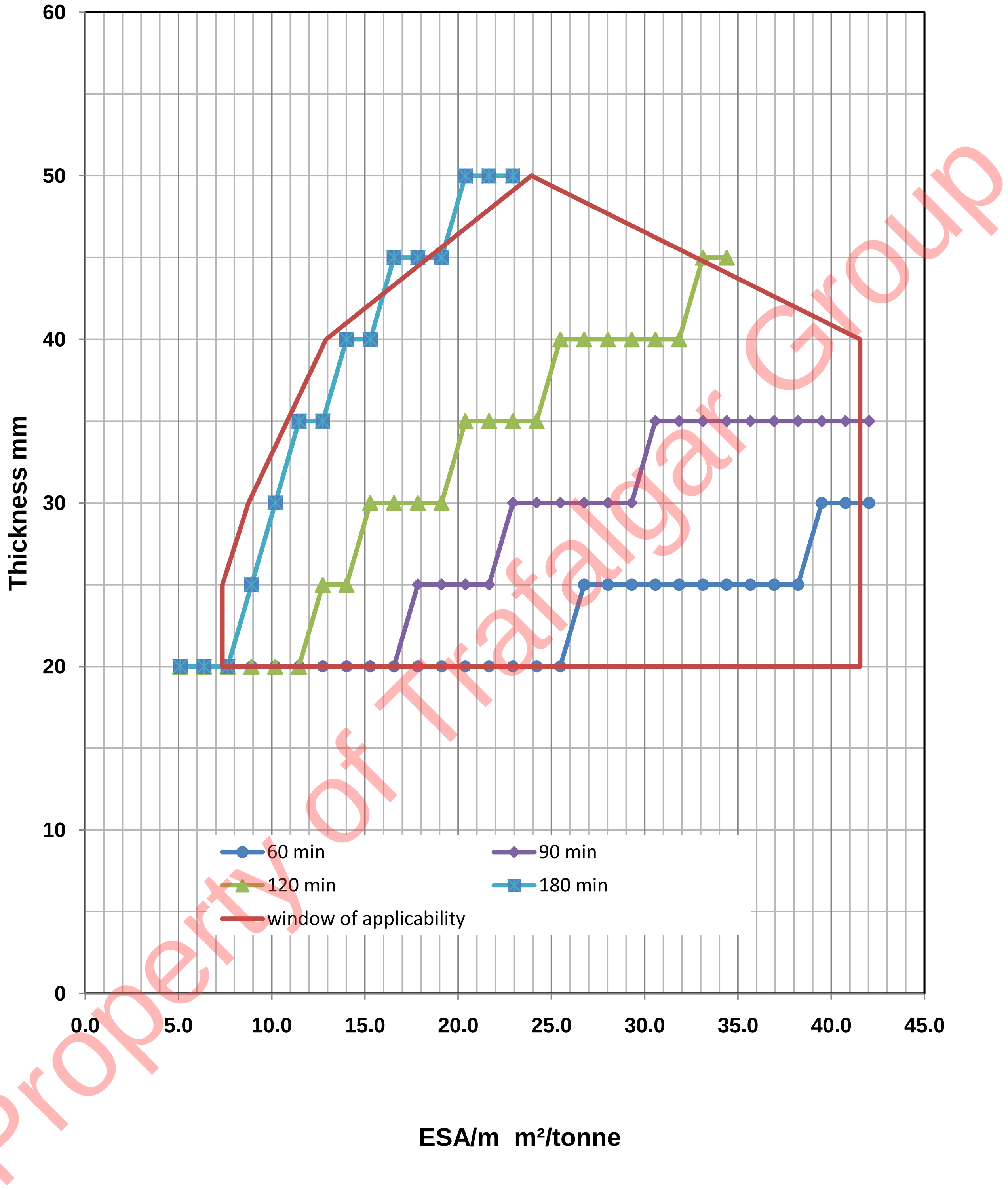
Figure 2 Castellated Sections at 550 C



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