Test Report No. 7191281147-MEC22/01-LCM
dated 28 Jul 2022

PSB Singapore

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SUBJECT:

Testing of fibre-cement board samples submitted by James Hardie Philippines Inc

TESTED FOR:

James Hardie Philippines Inc
Boracay San Isidro
Cabuyao City, Laguna
Philippines

Attn: Mr. Warren Paul Ensico

SAMPLE DESCRIPTION:

The following non-asbestos fiber cement board were received on 9 Mar 2022.

Sample	Nominal Size	Quantity
HardieFlex®	2438 mm x 1219 mm x 4.5 mm	9 pcs
	250 mm x 250 mm x 4.5 mm	72 pcs
	300 mm x 75 mm x 4.5 mm	10 pcs
	600 mm x 500 mm x 4.5 mm	8 pcs
	152 mm x 76 mm x 4.5 mm	6 pcs
	108 mm x 108 mm x 4.5 mm with 6 mm overhang	20 pcs

TEST METHOD:

The tests were conducted in accordance with ISO 8336 : 2017 “Fibre-Cement Flat Sheets - Product Specifications and Test Methods”

Section 5.5 Dimensions And Tolerances
Section 5.6.2 Modulus Of Rupture
Section 5.6.3 Apparent Density
Section 5.6.4 Moisture Movement
Section 5.6.5 Water Permeability
Section 5.6.10 Warm Water Performance
Section 5.6.11 Soak-Dry Performance
Section 5.6.13 Resistance To Nail Head Pull-Through cross-reference ASTM D1037 Standard Test Methods For Evaluating Properties Of Wood-Base Fibre And Particle Panel Materials Section 15 Nail Head Pull-Through
Section 5.6.14 Saturated Shear Bond Performance cross-reference ANSI A136.1 Section 5.2.1 Shear Strength, Conditioned, Dry

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TEST METHOD: (cont'd)

Dimensions And Geometrical Tests

1. Annex C

Test size	:	2438 mm x 1219 mm
No. of determinations	:	3
No. of measurements	:	3 per length and width 6 per thickness 4 per straightness of edges 4 per squareness of edges

Modulus Of Rupture

2. Annex D

Test size	:	250 mm x 250 mm
Test condition	:	23±2°C in water for 24 hours
Span length	:	200 mm
Crosshead speed	:	50 mm/min
No. of determinations	:	10 for first and second bending

Apparent Density

3. Annex E

Test size	:	250 mm x 250 mm
No. of determinations	:	3

Moisture Movement

4. Annex F

Test size	:	300 mm x 75 mm
Test condition	:	a. 23±2°C and 30% relative humidity for 24 hours b. 23±2°C and 90% relative humidity for 24 hours
No. of determinations	:	6 per direction

Water Permeability

5. Annex G

Test size	:	600 mm x 500 mm
Test condition	:	20 mm height of water for 24 hours
No. of determinations	:	3 for before and after heat and rain test

Warm Water After Modulus Of Rupture

6. Annex J

Test size	:	250 mm x 250 mm
Test condition	:	60±3°C in water for 56±2 days
Span length	:	200 mm
Crosshead speed	:	50 mm/min
No. of determinations	:	10 for first and second bending

TEST METHOD: (cont'd)

Soak-Dry After Modulus Of Rupture

7. Annex K

Test size	:	250 mm x 250 mm
Test condition	:	a. immersion in water at 23±2°C for 18 hours b. drying in oven at 60±3°C and less than 20% relative humidity for 6 hours c. repetition of steps a and b as 1 cycle to the specified no. of cycles
No. of cycles	:	25
Span length	:	200 mm
Crosshead speed	:	50 mm/min
No. of determinations	:	10 for first and second bending

Resistance To Nail Head Pull-Through

8. Section 5.6.13
ASTM D1037 : 2012 (Reapproved 2020) Standard Test Methods For Evaluating Properties Of Wood-Base Fibre And Particle Panel Materials
Section 15 : Nail-Head Pull-Through

Test size	:	152 mm x 76 mm
Test Sample	:	Test nail driven through sample at right angle
Crosshead speed	:	1.5 mm/min
No. of determinations	:	5

Saturated Shear Bond Performance

9. Section 5.6.14
ANSI A136.1 : 1999 American National Standard Specifications For Organic Adhesives For Installation Of Ceramic Tile

Test size	:	100 mm x 100 mm
Test Sample	:	Shear strength sample 108 mmx 108 mm with 6 mm overhang
Crosshead speed	:	13 mm/min
No. of determinations	:	5

CONDITIONING:

Unless otherwise specified, the test samples were tested at 23 ± 2°C and 50 ± 5% relative humidity.

TEST RESULTS:

Table 1 - Dimensional Measurements : Length, Width And Thickness

Test	Sample Reference: HardieFlex®									ISO 8336 : 2017 (E) Requirements
	1			2			3			
Length (mm)	2437	2437	2437	2437	2438	2437	2437	2437	2437	The manufacturer specified the nominal length to be 2438mm. The tolerances on nominal length shall be in accordance for the appropriate levels, Level I ±5mm, Level II ±8mm
Average (mm)	2437			2437			2437			
Width (mm)	1220	1220	1220	1220	1220	1220	1220	1220	1220	The manufacturer specified the nominal width to be 1219mm. The tolerances on nominal width shall be in accordance for the appropriate levels, Level I ±0.3% nominal width, Level II ±0.5% nominal width
Average (mm)	1220			1220			1220			
Thickness (mm)	4.53	4.57	4.54	4.55	4.53	4.55	4.51	4.51	4.54	The manufacturer specified the nominal thickness to be 4.5mm. The tolerances on nominal thickness shall be ±0.6mm.
	4.56	4.53	4.54	4.54	4.53	4.54	4.55	4.51	4.52	
Average (mm)	4.6			4.5			4.5			

TEST RESULTS: (cont'd)

Table 1 (cont'd) - Dimensional Measurements : Straightness And Squareness Of Edges

Test	Sample Reference: HardieFlex®						ISO 8336 : 2017 (E) Requirements
	1		2		3		
Straightness Of Edges (%)	0.006	0.004	0.006	0.004	0.006	0.004	The tolerances on the straightness of edges defined as a percentage of the length of the edge of the relevant dimension length or width shall be in accordance for the appropriate level I and II Level I ≤0.1%, Level II ≤0.3%
	0.006	0.004	0.006	0.004	0.006	0.004	
Average (%)	0.005		0.005		0.005		
Squareness Of Edges (%)	0.004	0.004	0.006	0.008	0.008	0.010	The tolerances on the squareness of edges of sheets measured shall be in accordance for the appropriate level I and II Level I ≤0.2%, Level II ≤0.4%
	0.004	0.004	0.006	0.008	0.008	0.010	
Average (%)	0.004		0.007		0.009		

TEST RESULTS: (cont'd)

Table 2 - Modulus Of Rupture : 1st Bending & 2nd Bending - Wet Conditioning 24 hours

Test	Sample Reference: HardieFlex®										ISO 8336 : 2017 (E) Requirements
	1st bending : Wet Conditioning										
	1	2	3	4	5	6	7	8	9	10	
Maximum Load (N)	193.70	174.67	173.40	178.48	195.06	178.73	197.77	211.30	192.10	183.05	-
Length of Span (mm)	200										
Bending Strength (Modulus Of Rupture) (MPa)	10.84	10.83	10.85	10.82	12.37	10.41	11.67	11.88	10.89	10.56	
Average Bending Strength (Modulus Of Rupture) (MPa)	11.1										

TEST RESULTS: (cont'd)

Table 2 (cont'd) - Modulus Of Rupture : 1st Bending & 2nd Bending - Wet Conditioning 24 hours

Test	Sample Reference HardieFlex®										ISO 8336 : 2017 (E) Requirements
	2nd bending : Wet Conditioning										
	1	2	3	4	5	6	7	8	9	10	
Maximum Load (N)	123.67	109.62	109.12	119.52	120.03	106.83	94.57	118.00	108.70	92.12	-
Length of Span (mm)	200										
Bending Strength (Modulus Of Rupture) (MPa)	6.92	6.79	6.83	7.24	7.61	6.22	5.58	6.63	6.16	5.32	
Average Bending Strength (Modulus Of Rupture) (MPa)	6.5										

TEST RESULTS: (cont'd)

Table 2 (cont'd) - Modulus Of Rupture : 1st Bending & 2nd Bending - Wet Conditioning 24 hours

Test	Sample Reference HardieFlex®	ISO 8336 : 2017 (E) Requirements
	1st & 2nd bending : Wet Conditioning	
Average Bending Strength (Modulus Of Rupture) (1st & 2nd bending) (MPa)	8.8	Minimum Modulus Of Rupture (Ambient Condition) Category C Class 1 – 4 MPa **Class 2 – 7 MPa** Class 3 – 10 MPa Class 4 – 16 MPa Class 5 – 22 MPa MOR in the weaker direction shall not less than 70% of the value specified above.

TEST RESULTS: (cont'd)

Table 3 - Apparent Density

Test	Sample Reference: HardieFlex®			ISO 8336 : 2017 (E) Requirements
	1	2	3	
Dry Mass (kg)	0.376	0.374	0.377	The manufacturer specified the density to be 1350kg/m^3 The apparent density shall not be less than the specified value.
Volume (m^3)	0.0002349			
Apparent Density (kg/m^3)	1601	1590	1605	
Average Apparent Density (kg/m^3)	1599			

TEST RESULTS: (cont'd)

Table 4 - Moisture Movement (Longitudinal Direction & Transverse Direction)

Test	Sample Reference: HardieFlex®			ISO 8336 : 2017 (E) Requirements
	Longitudinal Direction			
	1	2	3	
Length at 30% Relative Humidity (mm)	300.11	300.26	300.16	The manufacturer's literature shall state the percentage value of lineal sheet moisture movement measured when the sheet is exposed to a relative humidity change from 30% to 90%. The stated value shall be determined. For Category C sheets, this shall be ≤0.07%
Length at 90% Relative Humidity (mm)	300.26	300.34	300.40	
Length Change (%)	0.05	0.03	0.08	
Average Length Change (%)	0.05			

Test	Sample Reference: HardieFlex®			ISO 8336 : 2017 (E) Requirements
	Transverse Direction			
	1	2	3	
Length at 30% Relative Humidity (mm)	300.07	300.26	300.11	The manufacturer's literature shall state the percentage value of lineal sheet moisture movement measured when the sheet is exposed to a relative humidity change from 30% to 90%. The stated value shall be determined. For Category C sheets, this shall be ≤0.07%
Length at 90% Relative Humidity (mm)	300.29	300.55	300.21	
Length Change (%)	0.07	0.10	0.03	
Average Length Change (%)	0.07			

TEST RESULTS: (cont'd)

Table 5 : Water Impermeablity Before Heat And Rain Test & After Heat And Rain Test

Test	Sample Reference: HardieFlex® Before Heat And Rain Test			ISO 8336 : 2017 (E) Requirements
	1	2	3	
Water Impermeablity - Observation	No formation of drops of water on the underside	No formation of drops of water on the underside	No formation of drops of water on the underside	May exhibit traces of moisture on the underside of the sheet, but in no instance shall there be any formations of water drops

Test	Sample Reference: HardieFlex® After Heat And Rain Test			ISO 8336 : 2017 (E) Requirements
	1	2	3	
Water Impermeablity - Observation	No formation of drops of water on the underside	No formation of drops of water on the underside	No formation of drops of water on the underside	May exhibit traces of moisture on the underside of the sheet, but in no instance shall there be any formations of water drops

TEST RESULTS: (cont'd)

Table 6 - Modulus Of Rupture : 1st Bending & 2nd Bending - Warm Water 56 days

Test	Sample Reference: HardieFlex®										ISO 8336 : 2017 (E) Requirements
	1st Bending : Warm Water 56 days										
	1	2	3	4	5	6	7	8	9	10	
Maximum Load (N)	224.66	224.16	223.31	228.81	220.01	210.03	226.69	213.67	210.03	190.58	-
Length of Span (mm)	200										
Bending Strength (Modulus Of Rupture) (MPa)	13.14	12.66	13.23	12.92	12.87	11.96	12.74	11.91	12.12	11.05	
Average Bending Strength (Modulus Of Rupture) (MPa)	12.5										

TEST RESULTS: (cont'd)

Table 6 (cont'd) - Modulus Of Rupture : 1st Bending & 2nd Bending - Warm Water 56 days

Test	Sample Reference: HardieFlex®										ISO 8336 : 2017 (E) Requirements
	2nd Bending : Warm Water 56 days										
	1	2	3	4	5	6	7	8	9	10	
Maximum Load (N)	145.41	143.71	132.89	146.08	139.82	102.01	110.13	114.19	120.71	110.39	-
Length of Span (mm)	200										
Bending Strength (Modulus Of Rupture) (MPa)	8.50	8.11	7.87	8.25	8.18	5.81	6.19	6.36	6.97	6.40	
Average Bending Strength (Modulus Of Rupture) (MPa)	7.3										

TEST RESULTS: (cont'd)

Table 6 (cont'd) - Modulus Of Rupture : 1st Bending & 2nd Bending - Warm Water 56 days

Test	Sample Reference: HardieFlex®										ISO 8336 : 2017 (E) Requirements
	1	2	3	4	5	6	7	8	9	10	
Average modulus of rupture, MOR_{fi} for warm water (1st & 2nd bending)	10.82	10.39	10.55	10.59	10.53	8.89	9.47	9.14	9.55	8.73	The ratio of the lower estimate mean values of the modulus of rupture for the exposed and unexposed specimens, determined at the 95% confidence levels R_L, shall not be less than 0.8
Average modulus of rupture, MOR_{fci} for wet conditioning (1st & 2nd bending)	8.88	8.81	8.84	9.03	9.99	8.32	8.63	9.26	8.53	7.94	
Individual Ratio $MOR_i = MOR_{fi} / MOR_{fci}$	1.22	1.18	1.19	1.17	1.05	1.07	1.10	0.99	1.12	1.10	
Average, *R*	1.22										
Standard Deviation, *s*	0.07										
Lower Estimation, $R_L = R - 0.58s$	1.18										

TEST RESULTS: (cont'd)

Table 7 - Modulus Of Rupture : 1st Bending & 2nd Bending - Soak-Dry 25 cycles

Test	Sample Reference: HardieFlex®										ISO 8336 : 2017 (E) Requirements
	1st Bending : Soak-Dry 25 cycles										
	1	2	3	4	5	6	7	8	9	10	
Maximum Load (N)	179.66	201.06	200.22	193.87	201.23	209.95	203.18	219.84	210.20	211.72	-
Length of Span (mm)	200										
Bending Strength (Modulus Of Rupture) (MPa)	10.46	11.86	11.55	11.39	11.31	11.85	11.62	12.58	12.08	12.38	
Average Bending Strength (Modulus Of Rupture) (MPa)	11.7										

TEST RESULTS: (cont'd)

Table 7 - Modulus Of Rupture : 1st Bending & 2nd Bending - Soak-Dry 25 cycles

Test	Sample Reference: HardieFlex®										ISO 8336 : 2017 (E) Requirements
	2nd Bending : Soak-Dry 25 cycles										
	1	2	3	4	5	6	7	8	9	10	
Maximum Load (N)	130.55	117.49	136.02	122.74	127.98	130.77	118.25	131.62	114.79	121.64	-
Length of Span (mm)	200										
Bending Strength (Modulus Of Rupture) (MPa)	7.59	6.93	7.85	7.21	7.20	7.38	6.76	7.53	6.60	7.11	
Average Bending Strength (Modulus Of Rupture) (MPa)	7.2										

TEST RESULTS: (cont'd)

Table 7 (cont'd) - Modulus Of Rupture : 1st Bending & 2nd Bending - Soak-Dry 25 cycles

Test	Sample Reference: HardieFlex®										ISO 8336 : 2017 (E) Requirements
	1	2	3	4	5	6	7	8	9	10	
Average modulus of rupture, MOR_{fi} for soak-dry 25 cycles (1st & 2nd bending)	9.03	9.40	9.70	9.30	9.26	9.03	9.40	9.70	9.30	9.26	The ratio of the lower estimate mean values of the modulus of rupture for the exposed and unexposed specimens, determined at the 95% confidence levels R_L, shall not be less than 0.8
Average modulus of rupture, MOR_{fci} for wet conditioning (1st & 2nd bending)	8.88	8.81	8.84	9.03	9.99	8.32	8.63	9.26	8.53	7.94	
Individual Ratio, $MOR_i = MOR_{fi} / MOR_{fci}$	1.02	1.07	1.10	1.03	0.93	1.09	1.09	1.05	1.09	1.17	
Average, *R*	1.06										
Standard Deviation, s	0.06										
Lower Estimation, $R_L = R - 0.58s$	1.03										

TEST RESULTS: (cont'd)

Table 8 : Nail Head Pull-Through

Test	Sample Reference: HardieFlex®					ISO 8336 : 2017 (E) Requirements
	1	2	3	4	5	
Maximum Load (N)	647.3	564.7	577.0	660.8	544.9	Shall have a minimum saturated nail head pull-through resistance of 400 N when tested in accordance with ASTM D1037
Average Maximum Load (N)	599					

TEST RESULTS: (cont'd)

Table 9 : Shear Bond Strength

Test	Sample Reference: HardieFlex®					ISO 8336 : 2017 (E) Requirements
	1	2	3	4	5	
Maximum Load (kN)	9.97	8.56	10.98	9.51	9.27	The minimum shear bond strength after 7 days of adhesive curing shall be 345 kPa
Teat Area (mm^2)	10000					
Shear Bond Strength (kPa)	997.5	855.7	1098.3	951.5	926.5	
Average Shear Bond Strength (kPa)	966					

REMARKS:

1. The tests and test standard were requested and specified by the client.
2. The nail head pull-through test samples were prepared by TUV SUD PSB Pte Ltd as agreed by the client.
3. The shear bond strength test samples were prepared by the client.

Eddie Suwand
Testing Officer

Lem Chee Meng
Product Manager
Real Estate & Infrastructure
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PSB Singapore

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Effective 26 January 2021