

ALPOLIC®/fr ZCM
INNOVATION • STYLE • PERFORMANCE

Zinc Composite Material

 Mitsubishi Chemical Functional Products, Inc.

www.alpolic-northamerica.com

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ALPOLIC®/fr ZCM

Zinc Composite Material

ALPOLIC/fr ZCM is a zinc composite material composed of a chemically-weathered zinc sheet on the topside, a non-combustible mineral filled core and a zinc sheet or an aluminum sheet on the backside. ZCM is suited to the use of exterior applications such as soffit, awnings, parapets, rain screens, external claddings and roofs, especially when you feel insufficient with conventional building materials.

1. Features

(1) **Zinc alloy skin:** The topside skin is a real zinc alloy weathered with a chemical conversion process, which later develops to a distinctive gray appearance through natural weathering.

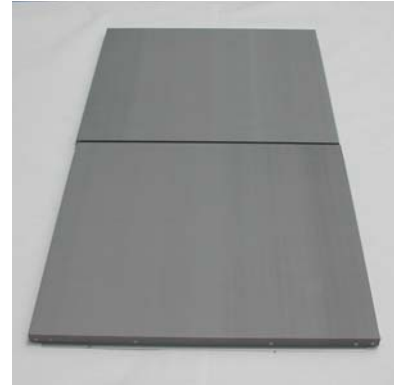
(2) **Long life:** Protected by the surface layers, zinc alloy has a long life. The annual erosion rate is normally 1 to 7 microns (3 microns in average), which indicates that 100 microns (0.1 mm) thick zinc lasts as long as 35 years to erode.

(3) **Bending strength:** ZCM has a high bending strength (rigidity), attributed from the rigid shape of the cross section. ZCM 4mm is equivalent to nearly 3mm thick solid zinc sheet in bending strength (rigidity). The panel weight is only 50% of the solid zinc sheet.

(4) **Flatness:** Generally speaking, composite materials have a better flatness than solid metals. ZCM is not an exception. The completed ZCM panels will be as flat as you have expected.

(5) **Workability:** The machining performance of zinc alloy is quite similar to that of aluminum. We can cut, groove, fold and bend ZCM panels with the same machines and tools that we have used for Aluminum Composite Materials (ACM). In assembling with accessories, we can use the same aluminum extrusions.

(6) **Installation:** Basically, the same fixing details as those for ACM are applicable to ZCM.

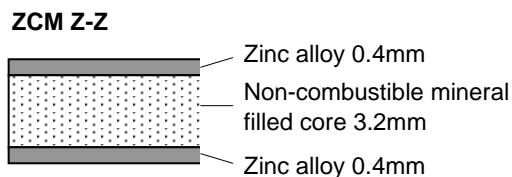


2. Material composition

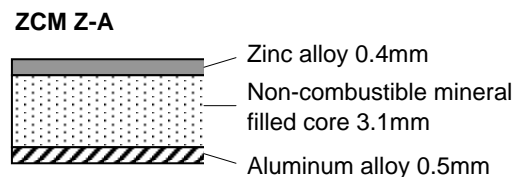
ZCM has two grades, namely Z-Z and Z-A below:

ZCM Z-Z is composed of two pieces of 0.4mm thick zinc alloy and non-combustible mineral filled core.

ZCM Z-A substitutes 0.5mm thick aluminum alloy for zinc alloy in the backside. The topside zinc and the core material remain the same.



Total thickness: 4mm



Total thickness: 4mm

We use the following materials for each component:

Zinc alloy: Zn-Cu-Ti alloy consisting of Zn \geq 99.5%, Cu=0.2%, Ti=0.1%.

Aluminum alloy: 3105-H14, coated with a wash coating in the backside.
 Core material: The non-combustible mineral filled core with the same contents as ALPOLIC/fr.

3. Surface finish

ZCM, Silver Light Gray

Initial finish: The topside zinc skin is initially finished with a chemical conversion layer formed in the production line. The color is Silver Light Gray.



Natural color change: The initial layer is gradually replaced with a naturally produced layer (zinc carbonate) through natural weathering. This change takes place so slowly that the color change is almost imperceptible from its appearance. After several years of natural weathering, the zinc surface reaches a stable gray color.

4. Dimensions and product tolerance

Panel thickness: 4mm
 Standard panel size Width: 914mm (36")
 Length: Less than 5000mm (197")
 Product tolerance Width: +/-2.0mm
 Length: +/-4.0mm
 Thickness: +/-0.2mm
 Diagonal difference: Maximum 5.0mm
 Bow ^{Note:}

ZCM Z-Z; 0.5% (+/-5mm/m) of the length and/or width

ZCM Z-A; 0.8% (+/-8mm/m) of the length and/or width

Note: Due to the lamination of dissimilar metals, the bow tolerance of ZCM Z-A (0.8%) is slightly larger than that of ZCM Z-Z (0.5%). According to our test, this extent of bow will lessen after fabricated into a tray-panel, and will not harm the visual appearance virtually. However, if a flatter surface is necessary, rectify the bow by means of the methods shown in "6. Processing method."

5. Characteristics

(1) Physical properties

The following table shows principal properties of ZCM in comparison with ALPOLIC/fr 4mm composed of 0.5mm thick aluminum skins.

	ASTM	Unit	ZCM Z-Z	ZCM Z-A	ALPOLIC/fr
Thickness	-	mm	4	4	4
Specific gravity	-	-	2.7	2.3	1.9
Weight	-	kg/m ²	10.8	9.3	7.6
		psf	2.21	1.91	1.56
Thermal expansion / contraction	D696	mm/mm/°C	(P)28x10 ⁻⁶ , (T)20x10 ⁻⁶	(P)25x10 ⁻⁶ , (T)22x10 ⁻⁶	24x10 ⁻⁶
		in/in/°F	(P)15x10 ⁻⁶ , (T)11x10 ⁻⁶	(P)14x10 ⁻⁶ , (T)12x10 ⁻⁶	13x10 ⁻⁶
Thermal conductivity	D976	kcal/m.hr.°C	0.36	0.37	0.39
		W/m.°K	0.42	0.44	0.45
Thermal resistance	D976	m ² .hr.°C/kcal	0.40	0.31	0.19
		m ² .°K/W	0.34	0.27	0.16
Deflection temperature	D648	°C	115	115	116
		°F	239	239	241

Note: P and T indicate the measuring directions, namely “Parallel to rolling direction” and “Traverse to rolling direction” respectively. The thermal expansion/contraction of ZCM is slightly different between directions. This tendency is more apparent in ZCM Z-Z than Z-A.

(2) Mechanical properties

The following table shows the mechanical properties of ZCM. As the mechanical properties of zinc are analogous to aluminum, ZCM has similar mechanical properties to ALPOLIC/fr 4mm. However, according to our test, ZCM has a distinctive elastic behavior that a ZCM panel, loaded within an elastic limit, has a residual deflection after unloaded. This tendency is apparent in ZCM Z-Z. Therefore, in order to ensure the residual deflection within a harmless level, we have to apply a comparatively large safety factor for the permissible stress. Refer to Appendix for details.

	ASTM	Unit	ZCM Z-Z	ZCM Z-A	ALPOLIC/fr 4mm
Tensile strength	E8	MPa, N/mm ² psi	30 4400	37 5400	49 7100
0.2% proof stress	E8	MPa, N/mm ² psi	27 3900	35 5100	44 6400
Elongation	E8	%	20	6	5
Flexural elasticity (E)	C393	MPa, N/mm ² psi	33×10 ³ 4.8×10 ⁶	34×10 ³ 4.9×10 ⁶	40×10 ³ 5.8×10 ⁶
Flexural rigidity (E×I)	C393	kN.mm ² /mm lb.inch ² /inch	180 1.6×10 ³	180 1.6×10 ³	210 1.9×10 ³
Punching shear resistance	D732	N/mm ² psi	28 4.1×10 ³	28 4.1×10 ³	32 4.7×10 ³

(3) Dent (Impact) test by Du-pont method

Steel ball weight (kg)	Height (mm)	Dent depth (mm)	
		ZCM	ALPOLIC/fr 4mm
0.3	300	0.5	0.5
0.5	500	1.3	1.3
1.0	300	1.5	1.4
1.0	500	2.0	1.9

(4) Mechanical properties of skin metals

Zinc and aluminum skins have the following mechanical properties. However, in terms of the residual deflection, we will have to apply a large safety factor for the permissible stress, as mentioned above. Refer to Appendix.

	ASTM	Unit	Zinc alloy	Aluminum alloy
0.2% proof stress	E8	MPa, N/mm ² psi	168 24×10 ³	152 22×10 ³
Flexural elasticity	C393	MPa, N/mm ² psi	87000 13×10 ⁶	70000 10×10 ⁶

(5) Fire performance

ZCM passes the following fire tests.

Country	Test Standard	Specimen	Result & Classification
U. K.	BS476, Part 6 BS476, Part 7	ZCM Z-Z & Z-A 4mm thick	Class 0 Class 1
U.S.A	ASTM E-84 (Tunnel Test)	ZCM Z-Z & Z-A 4mm thick	Class A Flame spread: 10-25 Smoke develop: 40-80

Note: We do not have extensive fire tests about ZCM so far. We estimate that ZCM will have a lower fire resistance than ALPOLIC/fr 4mm, because of the lower melting point of zinc alloy.

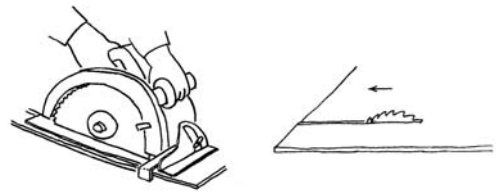
6. Processing method

As the machining performance of zinc is quite similar to that of aluminum, we can process ZCM with the same machines and tools that we have used for Aluminum Composite Materials (ACM). The working parameters are also the same, as long as the processing is in the extent of usual range. Namely, we can cut ZCM with circular saws, fold it after grooving with a router, bend it with a 3-roll bender and a press brake, and weld the core with hot-melt adhesives.

(1) Cutting

Saw cutting

Various types of circular saws including table saw, hand circular saw, and panel saw can cut ZCM. Suitable saw blade is carbide-tipped blades for aluminum or plastic use.



Shear cutting

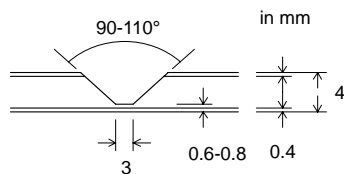
A square shear permits an efficient sizing work. Generally, the most suitable clearance is 0.1mm and rake angle is 1°30'. Either droop or burr appears on each edge.



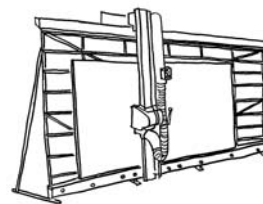
(2) U-Grooving

We can fold ZCM after U-grooving in the backside. Two types of machines are available for U-grooving. One is a circular cutter type and the other is a router type. The former includes hand grooving machines and panel saws, and the latter includes hand routers and CNC routers.

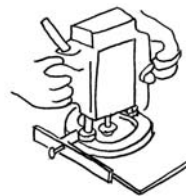
The diagram below is the typical U-groove shape. It is important to leave 0.2 to 0.4mm of core material: namely, the remaining thickness becomes 0.6 to 0.8mm including metal thickness.



Panel saw and grooving cutter



Handy router and router bit



(3) Folding

After U-grooving, we can fold ZCM with folding jig. The typical folding procedures are as follows:

To ensure a straight line of folded corners, fold panels on a flat worktable. To prevent zinc skin from cracking, hold folding work at 10°C (50°F) or higher temperature.

1. U-groove Leave 0.2-0.4 mm core.	2. Folding jig Folding jig is made of aluminum or steel angle.	3. Fold Use a jig nearly fits to the folding length.	4. Roundness Suitable roundness is 2-3 mm R.	5. Support Support with aluminum angle, if necessary.

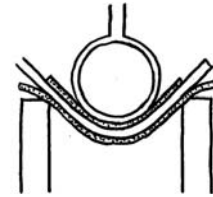
(4) Bending with press brake

We can bend ZCM panels with press brake. In bending with press brake, use a top die having almost the same radius as the final bending radius. The following table shows the smallest bendable radius in comparison to ALPOLIC/fr 4mm. The bendable limit of ZCM is smaller than ALPOLIC/fr 4mm.

Bending direction	The smallest bendable radius (mm)		Exception
	ZCM 4mm	ALPOLIC/fr 4mm	
Traverse	20	80	ZCM Z-A Concave 50
Parallel	30	100	70

Note: ZCM Z-A, as an exception, shows a larger bendable limit, when it is bent to concave (zinc skin inner).

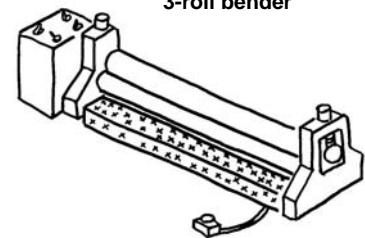
Bending with press brake



(5) Bending with 3-roll bender

We can use manual or electric-drive 3-roll bender for bending ZCM. The minimum bendable limit is normally 250mm in radius, but it depends on the length of the bender and the type of the machine.

3-roll bender



(6) How to rectify the panel bow

Compared with ZCM Z-Z and ALPOLIC/fr, ZCM Z-A has a slightly large bow (warping) tolerance, 0.8% or +/-8mm/m due to the lamination of dissimilar metals. According to our test, this extent of bow lessens to harmless level after folding into a tray-type panel, and the bow is virtually invisible in appearance. However, if the flatter surface is required, the panel bow can be rectified by one of the following methods.

By 3-roll bender: Let ZCM panels pass through 3-roll bender prior to grooving.

By stiffening the panel with aluminum profile.

Generally, the bow of ZCM Z-A is not a partial distortion, but a gradual entire warping.

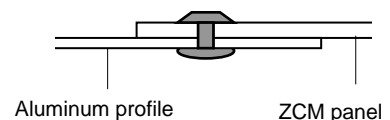
(7) Joining method

Accessory materials

In assembling ZCM panels with accessories, we can use the same aluminum profiles that we have used for Aluminum Composite Material (ACM). Aluminum profiles do not require special surface finishes in normal exterior conditions. However, when ZCM panels locate in moist or corrosive conditions, coat the aluminum profile with paints to ensure electric insulation between zinc and aluminum in order to prevent galvanic corrosion. See “9. General notes” below.

Rivet and bolt/nut

We can use rivets, bolt/nut and tapping screws for junction between ZCM and aluminum profiles. Use aluminum blind rivet. We can do riveting work from one direction. Use bolt/nut and tapping screw made of aluminum or stainless steel to prevent galvanic corrosion.



Adhesives

We can use commercial adhesives for joining and assembling of ZCM. The adhesives must be reliable in and suitable for exterior conditions. We have successfully used the following adhesives for fabrication and assembling work of ALPOLIC/fr, and these are suitable for ZCM as well. However, these adhesives are only locally available in Japan. If you are interested in these adhesives, please contact distributors or our office.

Brand name	Adhesive type	Manufacturer	Remarks
Diabond SG350	Acrylic	Nogawa Chemical	2-part, 5-15 min curing
Super X No.8008	Silyl-modified	Cemedine	1-part, 1-2 hrs curing

Double-sided tapes

Double-sided tape like 3M's VHB tape is effective in joining ZCM to other materials. Adhesion test held on 3M's VHB Y-4920 has shown good adhesion with both sides of ZCM Z-Z and Z-A.

Sealant

In order to ensure the waterproofing of joints between panels, normally a sealing material is used. The sealing material shall meet the performance required for the exterior atmospheric conditions. Silicone, modified silicone or polysulfide sealant are used. Adhesion tests show good adhesion between zinc and the following sealant.

Sealant type	Brand name	Manufacturer	Result
Silicone	SilPruf SCS2000	GE	Good adhesion without primer
Silicone, Less Stain	SilPruf SCS9000	GE	Ditto
Modified Silicone, 2-parts	Hamatite Super II	Yokohama Rubber	Good adhesion with primer
Polysulfide, 2-parts	Hamatite SC-M500	Yokohama Rubber	Ditto

7. Installation method

(1) Fixing detail

ZCM is analogous to Aluminum Composite Materials (ACM) in most properties. Therefore, essentially, the same fixing details as ACM are applicable to ZCM.

(2) Strength design

The mechanical properties of ZCM are analogous to ALPOLIC/fr 4mm. However, according to our test, ZCM shows a distinctive elastic behavior that a ZCM panel, loaded within elastic limit, has a residual deflection after unloaded. This tendency is apparent in ZCM Z-Z. In order to keep the residual deflection within a harmless level, we have to apply a comparatively large safety factor for permissible stress. Refer to Appendix for details.

(3) Optical difference by direction

ZCM shows optical difference between directions as metallic-colors do. Therefore, it is important to arrange ZCM panels in the same direction to avoid the optical (color) difference.

(4) Thermal expansion/contraction

The thermal expansion ratio of ZCM is almost the same as aluminum metal. Therefore, temperature change will not cause a movement between ZCM and aluminum extrusions. However, the thermal expansion of steel and concrete is almost one half, and some movement will occur. This movement must be relieved with a suitable method. The thermal expansion difference between directions of ZCM is so small that we can neglect it in most cases.

(5) Accumulation of water

Accumulating water may cause a serious corrosion of zinc alloy. Therefore, the design shall permit a proper drainage of moisture to avoid accumulation. Especially stagnant water in backside of ZCM panels must be drained through drain holes.

8. Maintenance method

(1) Natural weathering

Generally, we do not need special cleaning of ZCM panels as far as panels locate in normal external atmospheric

conditions. The topside zinc alloy is initially finished with a chemical conversion layer formed in the production line, and a naturally produced layer emerges through natural weathering and replaces the initial layer. These layers protect zinc metal for long time without cleaning.

(2) Color of natural layer

The naturally produced layer contains very small content of different zinc compounds and may show slightly different colors depending on the atmospheric conditions. Typically, the color tends to be blue-gray in rural area, light to dark gray in urban area and white-gray in coastal area. All these colors are natural and normal reactions.

(3) Self-repairing

Zinc surface is self-repairing. Leave small scratches as they are, and a naturally produced layer will gradually repair them over time. Do not apply touch-up paints that may cause spot color changes.

(4) Chemical corrosion

Chemical substances, adhering and accumulating on zinc alloy, might cause white or black stains. These stains often occur with acid cleaners for ceramic tiles, chemical components from hot spring, and salty components in coastal area. In these cases, we have to remove the chemical substances with water rinse to avoid accumulation.

(5) Fingerprint

It is very difficult to remove fingerprints on zinc alloy. Therefore, do the fabrication work using glove in order not to leave fingerprints on zinc surface.

9. General notes

(1) Galvanic corrosion

Contact between dissimilar metals will cause an electrochemical reaction under moist conditions. As zinc has a lower corrosion potential than copper and iron, galvanic corrosion will accelerate the corrosion of zinc alloy by a contact with these metals. Use stainless steel and aluminum for screws and rivets for assembling ZCM panels.

(2) Color difference between production lots

It is possible that the color of initial finish shows an obvious difference between production lots. We recommend ordering the full quantity for the project in one order. Even in one production lot, although it is produced in a continuous chemical process, slight color difference may exist in the initial finish.

(3) Handling

When you handle a long ZCM panel, hold the middle of the panel in addition to both ends, because ZCM is heavier than ALPOLIC/fr 4mm and tends to have a large warping with its dead load.

(4) Storing and transportation

Store the panels in a less humid and ventilated indoor places. Avoid contact with wet surface and keep dry during transportation and at construction site.

(5) Protective film

The ZCM surface is covered with a peeling-off film to protect from scratch during fabrication and installation. Remove the film soon after the installation is completed. Leaving the film long after installation may cause an extreme difficulty in removing the film.

Appendix

1. Surface characteristics of zinc alloy

(1) Composition of zinc alloy

Zinc: 99.5% or more, copper: 0.2%, titanium: 0.1%

(2) Surface finish

Zinc alloy is initially finished with a chemical conversion layer of Silver Light Gray, formed in the production line. This initial layer will be replaced with a naturally produced protective layer through the natural weathering.

(3) Excellent durability

Zinc alloy forms a corrosion-resistant layer (zinc carbonate) on its surface under natural atmospheric conditions. Protected with the layer, zinc's erosion rate is only 1-7 microns per year (3 microns in average), which indicates that 100 microns (0.1mm) thick zinc lasts as long as 35 years to erode.

(4) Color change through weathering

The zinc surface reaches a stable natural layer through natural weathering for several years. The natural layer's main component is zinc carbonate, but small contents of other zinc compounds may coexist, and hence the color can take different tints depending on the environmental conditions. This transition takes place so slowly that the color change is almost imperceptible from its appearance.

(5) Self-repairing of scratch

As the naturally produced layer can heal scratches, surface scratches become invisible through the natural weathering.

2. Comparison of properties of metals

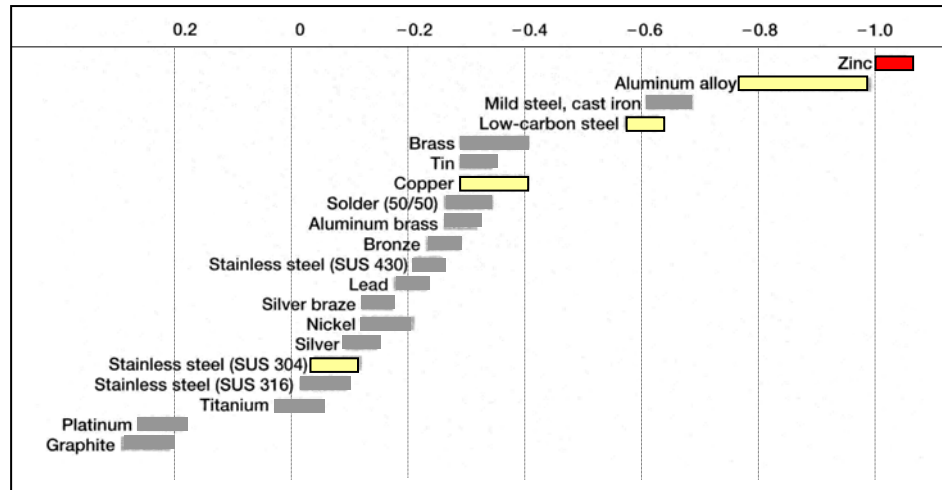
The following table shows typical values of principal properties of zinc metal in comparison with other metals.

	Unit	Zinc alloy	Aluminum	Galvanized steel	Stainless steel 304	Copper
Specific gravity		7.1	2.7	7.9	7.9	8.9
Melting point	°C	420	650	1530	1400	1080
	°F	790	1200	2790	2550	1980
Thermal expansion/ contraction ratio	10 ⁻⁶ mm/mm/°C	(P) 22-24x10 ⁻⁶ (T) 18-19x10 ⁻⁶	24	12	17	17
	10 ⁻⁶ in/in/°F	(P) 12-13x10 ⁻⁶ (T) 10-11x10 ⁻⁶	13	6.7	9.5	9.5
Thermal conductivity	m ² .hr.°C/kcal	97	180	46	14	331
	m ² .°K/W	113	210	54	16	385
Tensile strength	MPa, N/mm ²	(P) 240 (T) 170	152	340	580	245
	10 ³ psi	(P) 35 (T) 25	22	49	84	36
Modulus of elasticity	10 ³ MPa,N/mm ²	(P) 110 (T) 87	70	210	200	120
	10 ⁶ psi	(P) 16 (T) 13	10	30	29	17
Hardness	Hv	40-60	75	100	150	75

Note: The thermal expansion/contraction and mechanical properties of zinc is different between directions. In the table, P and T indicate "Parallel to Rolling Direction" and "Traverse to Rolling Direction" respectively.

3. Galvanic potential

Zinc’s corrosion potential is lower than other metals. Contact with steel and copper, of which corrosion potential is higher, may cause an accelerated corrosion of zinc under moist conditions. Aluminum and stainless steel form inactive layers on the surface and will not cause such an accelerated corrosion of zinc.



4. Thermal expansion/contraction

The expansion/contraction coefficient of ZCM is almost the same as that of aluminum metal and nearly twice those of steel and concrete. The following table shows the expansion/contraction of various building materials.

	Unit	ZCM Z-Z	ZCM Z-A	ALPOLIC/fr	Aluminum	Steel
Thermal expansion / contraction coefficient	10 ⁻⁶ mm/mm/°C	(P) 28 (T) 20	(P) 25 (T) 22	24	24	12
	10 ⁻⁶ in/in/°F	(P) 15 (T) 11	(P) 14 (T) 12	13	13	6.7
Expansion per 1 meter with 50°C change	mm	(P) 1.4 (T) 1.0	(P) 1.3 (T) 1.1	1.2	1.2	0.6
Expansion per 3 ft with 90°F change	inch	(P) 0.049” (T) 0.036”	(P) 0.042” (T) 0.036”	0.042”	0.042”	0.022”

(Continued)

	Unit	Stainless steel 304	Copper	Concrete	Glass	Acrylic sheet
Thermal expansion / contraction coefficient	10 ⁻⁶ mm/mm/°C	17	17	12	9	70
	10 ⁻⁶ in/in/°F	9.5	9.5	6.7	5.0	39
Expansion per 1 meter with 50°C change	mm	0.9	0.9	0.6	0.5	3.5
Expansion per 3 ft with 90°F change	inch	0.031”	0.031”	0.022”	0.016”	0.13”

Note: In the table, P and T indicate “parallel to rolling direction” and “traverse to rolling direction” respectively.

3. Panel strength design

(1) General

When wind load works on ZCM panels, a certain intensity of stress will arise in metal skins to withstand the bending force. At the same time, the panel will show a certain deflection. If the intensity of stress is larger than

the permissible limit, ZCM panel will lose its elasticity and the deflection will not be restored. We can check this possibility with the same calculations as we have used on Aluminum Composite Materials (ACM).

However, according to our test, ZCM panels still keep a static deflection after being unloaded, even though the loading is below the elastic limit. This residual deflection is supposedly derived from the elastic behavior of zinc alloy and depends on the load or the maximum deflection under loading. Therefore, when we have a structural design of ZCM, in most projects, we have to apply a comparatively large safety factor for the permissible stress in order to keep the residual deflection within a harmless value. This tendency is more apparent in ZCM Z-Z than in Z-A.

(2) Permissible stress in terms of harmless residual deflection

The measured 0.2% proof stress of zinc alloy is 168 MPa. However, according to our test result, we recommend the following permissible stress for the strength calculation to ensure the harmless residual deflection.

Grade	Recommended permissible stress
ZCM Z-Z	77 MPa
ZCM Z-A	105 MPa

(3) Recommended stiffener interval

Based on the above permissible stress, we recommend the use of the stiffener and its interval as follows. If you need an exact calculation, please contact local distributors or our office.

Grade	Wind load kPa (kg/m ²)	Panel width mm	Stiffener interval, mm
ZCM Z-Z	1.0 (102)	600	-
		750	-
		900	2700
	2.0 (204)	600	-
		750	1250
		900	1060
	3.0 (306)	600	1050
		750	860
		900	770
ZCM Z-A	1.0 (102)	600	-
		750	-
		900	-
	2.0 (204)	600	-
		750	2250
		900	1410
	3.0 (306)	600	-
		750	1120
		900	1000

Note: “-” shows that stiffener is not necessary in this condition.

