ALPOLIC®/fr ZCM

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Zinc Composite Material

Mitsubishi Chemical Functional Products, Inc.

URL http://www.alpolic.com

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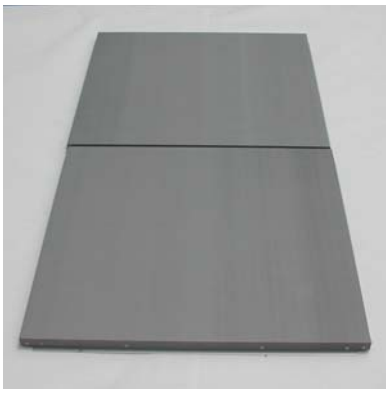
Zinc Composite Material

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 outdoor applications such as soffit, awnings, parapets, rain screens, external claddings and roofs, especially when you feel insufficient with conventional building materials.

1. Features



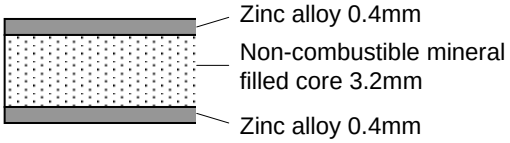
ZCM fabricated sample

(1) Zinc alloy skin: The topside skin is a real zinc alloy that is initially weathered with a chemical conversion process and 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), as one of attributes of composite materials. ZCM 4mm is equivalent to nearly 3mm thick solid zinc sheet in bending strength (rigidity), and the panel weight is only 50% the solid zinc sheet.
(4) Flatness: Generally, composite materials have a better flatness than solid metals. ZCM is not an exception, and 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 assembly, 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

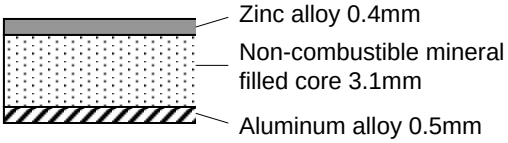
ZCM has two grades, namely Z-Z and Z-A below:
ZCM Z-Z is composed of two pieces of 0.4mm thick zinc alloy and non-combustible mineral filled core.
ZCM Z-A substitutes 0.5mm thick aluminum alloy for zinc alloy in the backside. The topside zinc and the core material remain the same.

ZCM Z-Z



Total thickness: 4mm

ZCM Z-A



Total thickness: 4mm

We use the following materials for each component:

Zinc alloy:	Zn-Cu-Ti alloy consisting of Zn>=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 weathering. This change takes place so slowly that the color change is almost imperceptible from its appearance. After natural weathering for several years, 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 necessary, the bow can be rectified by means of the methods shown in “6 Processing method” below.

5. Characteristics

(1) Physical properties

The following table shows principal properties of ZCM in comparison to 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: “Parallel and Traverse to the 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 property of zinc is analogous to aluminum, ZCM has the similar mechanical property to ALPOLIC/fr 4mm. However, according to our test, ZCM has a peculiar elastic behavior. Namely, a ZCM panel, loaded even within elastic limit, still has a residual deflection after the load is eliminated. This tendency is more apparent in ZCM Z-Z than Z-A. Therefore, in structural design, we have to apply a comparatively large safety factor to the permissible stress, in order to ensure the residual deflection being harmless. Refer to Appendix 5 Panel strength design for details.

	ASTM	Unit	ZCM Z-Z	ZCM Z-A	ALPOLIC/fr 4mm
Tensile strength	E8	MPa, N/mm^2	30	37	49
		Psi	4400	5400	7100
0.2% proof stress	E8	MPa, N/mm^2	27	35	44
		Psi	3900	5100	6400
Elongation	E8	%	20	6	5
Flexural elasticity (E)	C393	MPa, N/mm^2	33×10^3	34×10^3	40×10^3
		Psi	4.8×10^6	4.9×10^6	5.8×10^6
Flexural rigidity (E×I)	C393	$kN.mm^2/mm$	180	180	210
		$lb.inch^2/inch$	1.6×10^3	1.6×10^3	1.9×10^3
Punching shear resistance	D732	N/mm^2	28	28	32
		Psi	4.1×10^3	4.1×10^3	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 have analogous mechanical properties. However, in terms of the peculiar elastic behavior of ZCM, in structural design, we have to apply a comparatively large safety factor to the permissible stress, as mentioned above. Refer to Appendix 5 Panel strength design.

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

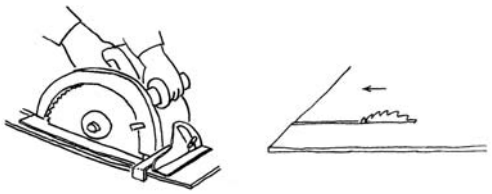
6. Processing method

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 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

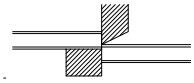
Saw cutting

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.



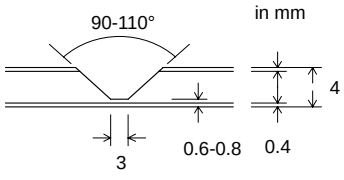
Shear cutting

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

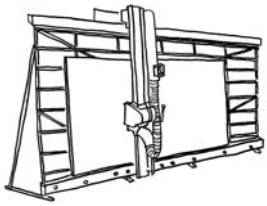


(2) U-Grooving

We can fold ZCM panels 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.



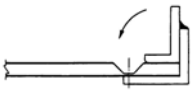
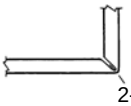
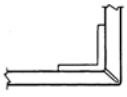
Panel saw and grooving cutter



Handy router and router bit

(3) Folding

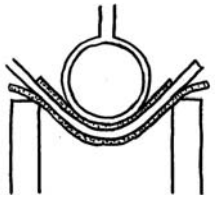
After U-grooving, we can fold ZCM with folding jig. The typical folding procedures are as follows:
To ensure a straight line of folded corners, fold panels on a flat worktable. To prevent zinc skin from cracking, hold folding work at 10°C (50°F) or higher temperature.

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

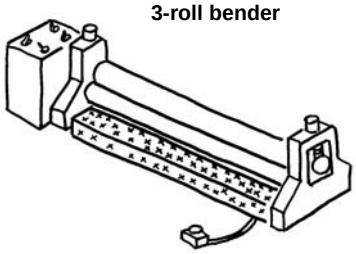
Bending with press brake



Bending direction	The smallest bendable radius (mm)		Exception
	ZCM 4mm	ALPOLIC/fr 4mm	ZCM Z-A Concave
Traverse	20	80	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 lies inner, aluminum skin lies outer).

3-roll bender



(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.

(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 required, the panel bow can be rectified by one of the following methods.

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

b) By stiffening the panel with aluminum profile.

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

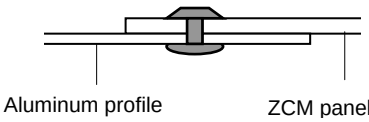
(7) Joining method

Accessory materials

In assembling ZCM panels, 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 outdoor conditions. However, when ZCM panels locate in moist and corrosive conditions, coat the aluminum profile with paints in order to ensure electric insulation between zinc and aluminum to prevent galvanic corrosion. Refer to “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 assembly of ZCM. The adhesives shall be suitable for and reliable in outdoor conditions. We have successfully used the following adhesives for fabrication and assembly work of ALPOLIC/fr, and these are suitable for ZCM as well. However, these adhesives are available only locally 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.

Sealing materials

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 outdoor environmental 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 method

ZCM is analogous to Aluminum Composite Materials (ACM) in most characteristics. 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 more apparent in ZCM Z-Z than Z-A. In order to keep the residual deflection within a harmless level, we have to apply a comparatively large safety factor to the permissible stress. Refer to Appendix 5 Panel strength design for details.

(3) Optical difference by direction

ZCM shows optical difference between directions as metallic-paint 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. 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 loosened with a suitable method. The thermal expansion difference between directions of ZCM is so small that we can ignore 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 outdoor atmospheric conditions. The topside zinc alloy is initially finished with a chemical conversion layer formed in the production line. Through weathering, a naturally produced layer emerges 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 environmental 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 it stands, and a naturally produced layer will gradually repair them over time. Do not apply touch-up paint, as it may cause a spot color change.

(4) Chemical corrosion

Chemical substances, adhering and accumulating on zinc surface, may 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 wearing gloves 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 screws and rivets made of stainless steel and aluminum 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 placing 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 gradually replaced with a naturally produced protective layer through weathering.

(3) Excellent durability

Zinc alloy forms a corrosion-resistant layer (zinc carbonate) on its surface under natural environmental 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 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 weathering.

2. Comparison of properties of metals

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

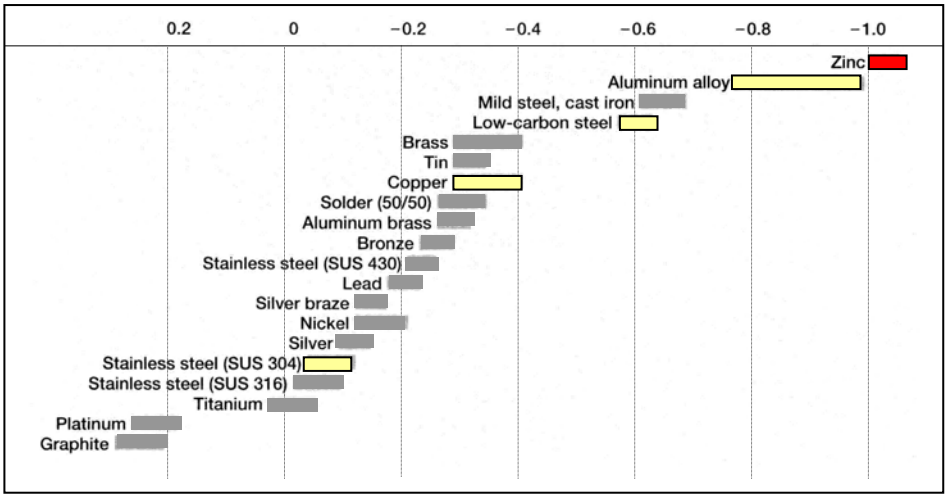
	Unit	Zinc alloy	Aluminum	Galvanized steel	Stainless steel 304	Copper
Specific gravity		7.1	2.7	7.9	7.9	8.9
Melting point	°C °F	420 790	650 1200	1530 2790	1400 2550	1080 1980
Thermal expansion/ contraction ratio	10^{-6} mm/mm/°C	(P) 22-24x10^{-6} (T) 18-19x10^{-6}	24	12	17	17
	10^{-6} in/in/°F	(P) 12-13x10^{-6} (T) 10-11x10^{-6}	13	6.7	9.5	9.5
Thermal conductivity	m^2.hr.°C/kcal m^2.°K/W	97 113	180 210	46 54	14 16	331 385
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 and Traverse to the 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. Stainless steel form inactive layers on the surface and will not cause such an accelerated corrosion of zinc.

Corrosion potential in seawater (flowing water)



4. Thermal expansion/contraction

The expansion/contraction coefficient of ZCM is almost the same as that of aluminum and nearly twice that 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 10^{-6}/in/in/°F	17 9.5	17 9.5	12 6.7	9 5.0	70 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 and Traverse to the rolling direction” respectively.

5. 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 depends on the load or the maximum deflection under loading, and is supposedly derived from the elastic behavior of zinc alloy. Therefore, when we handle a structural design of ZCM, in most projects, we have to apply a comparatively large safety factor to 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, the use or disuse of stiffener and its interval can be calculated 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	Use or disuse of stiffener	Stiffener interval, mm
ZCM Z-Z	1.0 (102)	600	No use	-
		750	No use	-
		900		2700
	2.0 (204)	600	No use	-
		750		1250
		900		1060
	3.0 (306)	600		1050
		750		860
		900		770
ZCM Z-A	1.0 (102)	600	No use	-
		750	No use	-
		900	No use	-
	2.0 (204)	600	No use	-
		750		2250
		900		1410
	3.0 (306)	600	No use	-
		750		1120
		900		1000

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