Titanium Composite Material (TCM)

Stainless Steel Composite Material (SCM)

- Series of ALPOLIC® -

Characteristics

Mitsubishi Chemical Functional Products, Inc.

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March 2003

Summary of Specification Data
For Titanium Composite Materials (TCM)
- Series of ALPOLIC® -

Mitsubishi Chemical Functional Products, Inc

1. General

Titanium Composite Material (TCM) is used as the exterior cladding and roofing of new building and retrofit applications. TCM is manufactured by Mitsubishi Chemical Functional Products, Inc. and furnished by an approved dealer or distributor of the manufacturer.

2. Product composition

TCM is composed of non-combustible mineral filled core sandwiched between 0.3 mm (0.4 mm in custom order) thick titanium sheet on its surface and 0.3 mm (0.4 mm in custom order) thick stainless steel sheet on its back. The core consists of the same ingredients as that of ALPOLIC®/fr. Titanium sheet surface is protected with a self-adhesive peel off film. According to weathering tests under normal outdoor conditions, the protective film will withstand six months' exposure without losing its original peel-off characteristics or causing stains or other damages.

Composition:

Surface skin material:	0.3 mm (0.4 mm in custom order) thick titanium sheet (JIS Class 1)
Core material:	Non-combustible mineral filled core
Backside skin material:	0.3 mm (0.4 mm in custom order) thick stainless steel sheet (SUS430)

3. Available finishes

Dull finish

4. Product dimension and tolerance

(1) Panel thickness: 4 mm

(2) Panel size:
In case of 0.3 mm thick skin
Width: 1,000 mm
In case of 0.4 mm thick skin (custom order)
Width: 1,219 mm
Length: less than 7,200 mm

(3) Product tolerance

Width:	± 2.0 mm
Length:	± 4.0 mm
Thickness:	± 0.2 mm
Bow:	Maximum 0.5 % of the length and/or width
Squareness:	Maximum 5.0 mm

5. Principal properties

(1) Panel weight: 9.3 kg / m^2 (inn case of 0.3 mm thick skin)
10.2 kg / m^2 (in case of 0.4 mm thick skin)

(2) Thermal expansion: 0.52 mm / m / 50º

(3) Mechanical properties of TCM (In case of skin thickness 0.3 mm and total thickness 4 mm)

a. Tensile strength (ASTM E8): 7 kg /mm^2

b. Yield strength (ASTM E8): 6.1 kg / mm^2
c. Elongation (ASTM E8): 11.1 %

(4) Deflection temperature: 112 ºC

(5) Sound transmission loss: 25 STC

Sound transmission loss (STC) in accordance with ASTM E413

6. Mechanical properties of skin metals

	Titanium: Surface skin	Stainless steel: Back skin
(1) Yield strength (ASTM E8)	162 N/mm^2 (16.5 kg/mm^2)	205 N/mm^2 (20.9 kg/mm^2)
(2) Flexural elasticity (ASTM C393)	$1.06\times10^5 N/mm^2$ (10850kg/mm^2)	$2.00\times10^5 N/mm^2$ (20100kg/mm^2)

7. Fire performance of TCM

TCM has been tested with the following fire tests. In Japan, TCM is approved as a non-combustible material for external cladding, roof and interior. But other tests are only basic tests for general purpose..

TCM is virtually deemed as an eligible material, based on the fire performance of ALPOLIC®/fr, and approved in various countries. Refer to separate brochure for the details of ALPOLIC®/fr's fire performance.

(Specimen: TCM 4mm)

Country	Test standard	Result & classification
U.K.	BS476 Part 6 BS476 Part 7	Class 0 Class 1
U.S.A.	Tunnel test (ASTM E-84)	Class A/Class 1
Japan	Heat release test (ISO 5660-1) & gas toxicity test	No-combustible material. Certificate No. NM-0229

8. Prevention of galvanic corrosion

Titanium and stainless steel belong to "noble metals." If less noble metals like aluminum are used together, adequate protection is required on the less noble metal surface, to prevent possible galvanic corrosion.

9. Possible color variation among production lots

It is possible that the color of titanium slightly varies among production lots and inconsistent color is visible after installation. This is due to slight color difference among titanium coils. In order to prevent this problem, we recommend to place total requirement in one order or to control panels with adequate grouping arrangement.

March, 2003

Cleaning Procedures of Titanium Composite Material (TCM)
– Series of ALPOLIC® –

Mitsubishi Chemical Functional Products, Inc

1. General

Titanium, the surface skin material of Titanium Composite Material (TCM), will not rust, as far as it is used for external cladding or roof wherever the building locates. Titanium will not rust even in such a corrosive area as coast. Furthermore, titanium will not rust with cohesion of floating particles of mild steel and other metals. Therefore, we do not have to think about maintenance due to rusting. But staining, caused by various factors, will take place on titanium surface. Suitable cleaning method for each staining factor will be described hereunder together with general notes for cleaning procedures.

2. Stain and suitable cleaning procedure

(1) Stain with finger mark and fat

Most of finger mark and fat can be removed with neutral detergent or soap. When the stain is too heavy to remove with them, use organic solvents such as alcohol or benzene with sponge or soft rug. The surface shall be washed with water rinse after cleaning.

(2) Stain with rain and dust

Wipe off with neutral detergent.

3. General notes to cleaning procedures

(1) Stain will be caused by various factors, and the staining condition will vary case by case. Hence, the cleaning method must fit to each staining condition. When cleaning chemical is applied, confirm the cleaning effect with pre-test prior to commencing overall cleaning operation.

(2) Use soft rug and sponge for cleaning. Do not use abrasive cleaners, sandpaper, steel wool and other cleaning tools made of metals. These might cause scratch on titanium surface.

(3) Clean not only staining portion but also the adjacent area to avoid uneven surface gloss.

(4) Thorough water rinse is necessary to remove the remaining chemicals, when cleaning chemicals are applied. Especially, when cleaning chemicals for ceramic tile, marble and other building materials are applied, the dispersed chemicals on titanium shall be thoroughly removed with water rinse.

(5) Do not mix different cleaners.

(6) Avoid cleaning under extreme temperature. Heat may accelerate chemical reaction and may evaporate water from solution. Cleaning under higher temperature may result in streaking. Extremely low temperature, on the contrary, may give poor cleaning effects. Ideally, cleaning should be done on the shaded side of the building under moderate temperature.

4. Precautions on installation and fabrication

(1) Generally speaking, if panel details are simplified, cleaning will be easier. Such projections as

cornice, soffit or sunshade shall be designed to avoid flow and rebound of soiled rain on building wall. The installation detail shall be designed to prevent accumulation of dust and regular lane of rain flow.

(2) If welding and/or grinding work is being held in the proximity of installed TCM and dispersion of sparks on titanium surface is possible, suitable protection is necessary on titanium surface. Spark derived from welding and/or grinding work will stick tightly on titanium surface, and it cannot be removed.

(3) The surface of TCM is protected with protective film. Do not peel off the protective film during fabrication and installation for prevention of scratch and soil. According to the test under normal weathering conditions, the protective film will withstand six months exposure without losing the original pee-off characteristics or causing stains or other damages. But peel off the protective film as early as possible after completion.

March 2003

Characteristics of Titanium as a Building Material

The following article is excerpt from Nippon Steel's Titanium Catalogue.

Characteristics of Titanium as a Building Material

Titanium offers superb properties as a building material that fits to applications in a highly corrosive environment.

1. Unparalleled Corrosion Resistance

At room temperature, titanium quickly forms a stable oxide film (passivated film) which gives it excellent corrosion resistance in various corrosive atmospheres.

(1) Seawater corrosion resistance is comparable to that of platinum. Titanium fits to application in coastal areas.

(2) Excellent corrosion resistance to corrosive gases (sulfurous acid gas, hydrogen sulfide gas, etc.). Titanium fits to application in large cities, industrial area, hot-spring resorts, etc.

(3) Titanium is free of stress, pitting, and crevice corrosion that are inherent in stainless steel.

(4) The corrosion potential of titanium is virtually equal to that of stainless steel. In terms of contact corrosion with different metals, titanium can be handled in the same manner as stainless steel. Consider prevention of dew-condensation or electric insulation of contact point, if contact corrosion is likely to occur.

Table 1. Comparison of weather-ability between various metals (Source: Japan Titanium Society)

	Titanium	Stainless steel SUS304	Copper
Sea salt particle resistance (pitting)	A	C	B
Ultraviolet ray resistance	A	A	A
Acid rain resistance (pitting)	A	C	C
Acid rain atmospheric resistance	A	C	D
Contact corrosion resistance*	A	D	C
Corrosion fluidity resistance	A	B	D
Thermal resistance	A	A	A
Erosion resistance	A	A	B

Rating: A: Excellent B: Good C: Fair D: Poor

*Contact corrosion: The phenomenon in which a metal itself corrodes due to foreign particles.

Table 2. Comparison of chemical resistance between various metals (Source: Japan Titanium Society)

		Titanium	Stainless steel SUS304	Stainless steel SUS 316	Copper
Sea water	Room temperature	A	A*	A*	B
Hydrochloric acid	HCl 10% Room temperature	B	D	D	D
Sulfuric acid	$H_2SO_4$10% Room temperature	B	B	B	B
Nitric acid	$HNO_3$10% Room temperature	A	A	A	D
Caustic soda	NaOH 50%, Room temperature	A	A	A	A
Sodium chloride	NaCl 20%, Room temperature	A	B	B	A
Chlorine Gas	Cl_2 100% wet	A	D	D	D
Hydrogen sulfide gas	H_2S 100% wet	A	B	A	D
Sulfurous acid gas	SO_2 30-90°C	A	B	B	D

Rating: A:<0.05 B:0.05-0.5 C:0.55-1.27 D:>1.27 mm/year

*Pitting and crevice corrosion is likely to occur.

2. Great Strength

Titanium is almost as strong as steel, and it is the strongest of all metals in terms of strength per weight. As a building material, JIS Type 1 is mainly used. JIS Type 1 has good process-ability.

Table 3. Specifications for pure titanium for industrial use (JIS Products)

	Chemical composition					Mechanical properties (Thickness: 0.5-15mm.)			Bend test (Thickness: 0.5–5mm)	
	H	O	N	Fe	Ti	Tensile strength N/mm^2	Proof stress N/mm^2	Elongation %	Bend angle	Inside radius
JIS Type 1	<=0.013	<=0.15	<=0.05	<=0.20	Remain	270-410	>=165	>=27	180°	Thickness by 2
JIS Type 2	<=0.013	<=0.20	<=0.05	<=0.25	Remain	340-510	>=215	>=23	180°	Thickness by 2
JIS Type 3	<=0.013	<=0.30	<=0.07	<=0.30	Remain	480-620	>=345	>=18	180°	Thickness by 3

3. Light Weight

The specific gravity of titanium is 4.51 – 60% of steel, half of copper and 1.7 times of aluminum. Being a lightweight metal, titanium burdens less weight on a structure, and permits easy fabrication. In some applications, extra thickness for possible corrosion is not necessary, which enables further weight reduction.

4. Small Thermal Expansion

Titanium's thermal expansion coefficient is half of stainless steel and copper, and one third of aluminum. It is virtually equal to that of glass and concrete, making titanium compatible with these materials.

Being less expansive and contractive due to temperature change, titanium is suited for a long-length panel.

5. Excellent Aesthetic Qualities

The appearance of uncolored titanium is regarded as favorable one with sober and quiet color. In addition, titanium can be finished with brilliant colors by means of anodizing oxidation method.

6. Environmentally Sound

Titanium is a nontoxic metal.

In addition, metallic ion never dissolves from titanium, and there is no concern about environmental pollution.

7. Others

(1) Small Young's modulus (elastic modulus)
(2) Small thermal conductivity
(3) High melting point
(4) Non-magnetic
* Sliding property: Good result has been obtained in sliding tests made for snow on roof.

Table 4. Comparison of physical properties between titanium and other metals

Metallic materials	Titanium	Stainless steel SUS 304	Stainless steel SUS 316	Iron	Copper	Aluminum
Melting point, °C	1668	1398-1453	1370-1397	1530	1083	660
Specific Gravity	4.51	7.93	8.0	7.9	8.9	2.7
Thermal expansion coefficient $\times 10^{-6}$/°C (20-100°C)	8.4	17.3	16.0	12.0	17.0	23.0
Thermal conductivity cal/cm^2/sec/°C /cm	0.041	0.039	0.039	0.150	0.920	0.490
Electric resistance micro ohm-cm	47	72	74	9.7	1.7	2.7
Young's modulus kg/mm^2	10850	19300	19300	21000	11000	7050

Titanium is officially approved as a non-combustible material.
("Non-combustible No. 1019," by Minister of Construction)

Summary of Specification Data

For Stainless Steel Composite Materials (SCM)

- Series of ALPOLIC® -

Mitsubishi Chemical Functional Products, Inc

1. General

Stainless Steel Composite Material (SCM) is used as the exterior cladding and roofing of new building and retrofit applications. SCM is manufactured by Mitsubishi Chemical Functional Products, Inc. and furnished by an approved dealer or distributor of the manufacturer.

2. Product composition

SCM is composed of non-combustible mineral filled core sandwiched between 0.3 mm thick stainless steel sheets. The core consists of the same ingredients as that of ALPOLIC®/fr. Stainless steel sheet of surface side is protected with a self-adhesive peel off film. According to weathering tests under normal outdoor conditions, the protective film will withstand six months' exposure without losing its original peel-off characteristics or causing stains or other damages.

Composition:

Surface skin material:	0.3 mm thick stainless steel sheet (YUS220M)
Core material:	Non-combustible mineral filled core
Backside skin material:	0.3 mm thick stainless steel sheet (SUS430)

3. Available finishes

Hairline finish
Dull finish

4. Product dimension and tolerance

(1) Panel thickness:	4 mm
(2) Panel size:	Width: 1,000 mm, 1219 mm
	Length: less than 7,200 mm
(3) Product tolerance	
Width:	± 2.0 mm
Length:	± 4.0 mm
Thickness:	± 0.2 mm
Bow:	Maximum 0.5 % of the length and/or width
Squareness:	Maximum 5.0 mm

5. Principal properties

(1) Panel weight:	10.2 kg / m^2
(2) Thermal expansion:	0.52 mm / m / 50º
(3) Mechanical properties of SCM	
a. Tensile strength (ASTM E8):	8.6 kg /mm^2
b. Yield strength (ASTM E8):	7.0 kg / mm^2
c. Elongation (ASTM E8):	12.6 %
(4) Deflection temperature:	117 ºC

(5) Sound transmission loss: 30 STC
Sound transmission loss (STC) in accordance with ASTM E413

6. Mechanical properties of skin metals

	YUS220M: Surface skin	SUS430: Back skin
(1) Yield strength (ASTM E8)	295 N/mm^2 (30.1 kg/mm^2)	205 N/m^2 (20.9 kg/mm^2)
(2) Flexural elasticity (ASTM C393)	$2.01\times10^5 N/mm^2$ ($20500 kg/mm^2$)	$2.00\times10^5 N/mm^2$ ($20100 kg/mm^2$)

7. Fire performance of SCM

SCM has been tested with the following fire tests. In Japan, SCM is approved as a non-combustible material for external cladding, roof and interior. But other tests are only basic tests for general purpose.

SCM is virtually deemed as an eligible material, based on the fire performance of ALPOLIC®/fr, and approved in various countries. Refer to separate brochure for the details of ALPOLIC®/fr's fire performance.

(Specimen: SCM 4mm)

Country	Test standard	Result & classification
U.K.	BS476 Part 6 BS476 Part 7	Class 0 Class 1
U.S.A.	Tunnel test (ASTM E-84)	Class A/Class 1
Japan	Heat release test (ISO 5660-1) & gas toxicity test	No-combustible material. Certificate No. NM-0229

8. Prevention of galvanic corrosion

Stainless steel belongs to "noble metals." If less noble metal like aluminum is used together, adequate protection is required on the less noble metal surface, to prevent possible galvanic corrosion.

9. Possible color variation among production lots

It is possible that the color of stainless steel slightly varies among production lots and inconsistent color is visible after installation. This is due to slight color difference among stainless steel coils. In order to prevent this problem, we recommend to place total requirement in one order or to control panels with adequate grouping arrangement.

March, 2003

Cleaning Procedures of Stainless Steel Composite Material (SCM)
- Series of ALPOLIC® -

Mitsubishi Chemical Functional Products, Inc.

1. General

Stainless steel YUS220M, the surface skin material of Stainless Steel Composite Material (SCM), hardly rusts. But it is not a rust-free metal. Under certain circumstances, rust and/or stain is possible to occur on the surface of stainless steel YUS220M.

The excellent corrosion resistance of stainless steel is derived from inactive, firm and fine oxide film formed on stainless steel surface as a result of chemical reaction between chromium in stainless steel and oxygen in atmosphere. This inactive film protects metal surface from various types of corrosion. When this film is damaged by certain causes and formation of inactive film is interrupted, stainless steel may start rusting. But, when the cause of corrosion is eliminated and the formation of inactive film is permitted again, the corrosion resistance will be restored to the original level.

Stain and rust of stainless steel YUS220M is caused by cohesion of various components. Floating mild steel particles, detrimental gas and salty component will cause stain and rust. When these components stick to stainless steel surface, they will harden with humidity and will hinder the restoration of inactive film as well as hurting the oxide film. Thus, rust will occur on stainless steel surface. Slight rust in early stage can be removed easily and the surface will be restored to the original condition. Even if rusting has taken place for long period, the surface will be restored to almost the original condition by means of proper cleaning method. Rust of stainless steel, unlike those of mild steel and aluminum, is not a corrosion of overall solid metal but a superficial corrosion.

2. Cleaning procedures

There are several types of rust and stain. The cleaning method must be selected depending on the type. Refer to Table 1 for details of cleaning procedures.

3. General notes

(1) When cleaning chemicals are applied, hold a pre-test prior to commencing overall cleaning operation. During handling cleaning chemicals, put on rubber gloves for protection. Thorough water rinse is necessary to remove remaining cleaning chemicals. The remaining chemicals may cause rust.
(2) Clean not only the stain and the rust, but also their neighboring area to avoid uneven surface gloss.
(3) When sponge, brush or rug is used, rub the surface along the polishing direction. Rubbing with circular movement is not efficient and disturbs glossy line of the surface. Cleaning tools made of steel, abrasive cleanser and sandpaper should not be used, unless the stain and rust is very heavy. These might cause scratches on the surface and further rusting due to remaining iron particles.
(4) When stainless steel surface is soiled with cleaning chemicals for granite, remove it quickly with water rinse. Such foreign materials as mortar, soil, iron particles and abrasive particles stuck on stainless steel surface shall be thoroughly removed.

4. Fabrication and installation in terms of cleaning

(1) Generally speaking, if panel details can be simplified, cleaning operation will be easy.
(2) Avoid rebound of soiled rain on building wall especially from such projections as cornice, soffit or sunshade.
(3) Permit rain and condensed dew to drain out from horizontal surface, gap, slit or gutter.
(4) Avoid capillary action through junction points, to prevent from accumulation of stain.
(5) Use screw and rivets made of stainless steel for junction, to prevent galvanic corrosion. Apply rust-preventive paint or other surface treatment on sub-structure, metal fixtures, fasteners, and stiffeners behind panel.
(6) If welding and/or grinding work is being held in the proximity of installed SCM and dispersion of sparks on SCM surface is possible, suitable protection is necessary on the protective film of SCM.
(7) The surface of SCM is protected with protective film. Do not peel off the protective film during fabrication and installation for prevention of scratch and soil. According to the test under normal weathering conditions, the protective film will withstand six months exposure without losing the original peel-off characteristics or causing stains or other damages. But peel off the protective film as early as possible after completion.

Table 1. Suitable Cleaning Methods for Each Type of Rusts and Stains

Rusts and stains	Suitable cleaning method
1. Floating metal particles	Rusts caused by cohesion of floating metal particles, if the rust is still slight, can be removed easily with mild detergent or soap with sponge or rug. After cleaning, remove detergent or soap with water rinse. If the rust has been left unclean for long time, the rust shows distinct brown color. In this stage, mixture of iron hydroxide, iron oxide and iron sulfide has been formed on the surface. To remove this stubborn rust, commercial cleaning chemicals for stainless steel, 15% nitric acid or other suitable chemical agents will be required. When the rust is too stubborn to remove with these chemical agents, the surface must be polished with sandpaper or stainless steel brush. After polishing, apply cleaning chemicals on the surface. In this case, the surface will have scratch due to polishing.
2. Exhaust gas	In heavily industrial area and urban area where traffic is very busy, stain tends to occur easily and worsen quickly. In these cases, fine spot rusting sometimes can be observed. This is mostly caused by detrimental component in exhaust gas from vehicles, air-conditioner and factory. Also in this type of rust, apply the same cleaning method as above. Slight stain in early stage can be removed easily, but heavy stain will require cleaning chemicals and sometimes polishing. Under these circumstances, periodical cleaning will be required: at least once a year or 2-3 times in a year, if possible.
3. Salty component in coastal area	Salt spray resistance of YUS220M is one of the best among stainless steel alloys, but the surface will rust in coastal area more quickly than in normal area. The cleaning method is the same as the above. In the coastal area where panels are exposed directly to salty wind, periodical cleaning is required: 3-4 times in a year, if possible.
4. Cleaning chemicals	Cleaning chemicals will also cause rust. Therefore, completely remove cleaning chemicals with water rinse after cleaning.
5. Finger mark and fat	Finger mark and fat which cannot be removed with mild detergent or soap will require solvents such as alcohol or benzene with sponge or rug. If stain is too heavy, apply cleaning chemicals for stainless steel. The surface shall be washed with water after cleaning.

YUS 220M

High Rust-Resistant Ferric Stainless Steel

22Cr-1.5Mo-Nb, Ti / Similar grade: SUS 445J2

The following article is excerpt from Nippon Steel's YUS Series Catalogue.

Features and Applications

1. The rust resistance of YUS 220M is superior to that of YUS 220due to a higher addition of Mo and combined addition of Nb and Ti.
2. Its rust resistance is superior to that of SUS 316.
3. It has a lower thermal expansion coefficient than ordinary steel, and therefore, is suitable for such applications as roofs and exterior walls in which thermal expansion and contraction are problematic.
4. YUS 220M has a slightly higher hardness than SUS 304 due to its high chromium content.

Applications: Roofs, walls

Chemical Composition (%)

	C	Si	Mn	P	S	Cr	Mo	N	(Ti+Nb)/(C+N)
Specified values	<=0.020	<=1.00	<=1.00	<=0.040	<=0.007	22.00-23.00	1.50-2.50	<=0.020	>=16
Typical values	0.006	0.10	0.13	0.026	0.002	22.29	1.63	0.01	28.92

Performance Characteristics

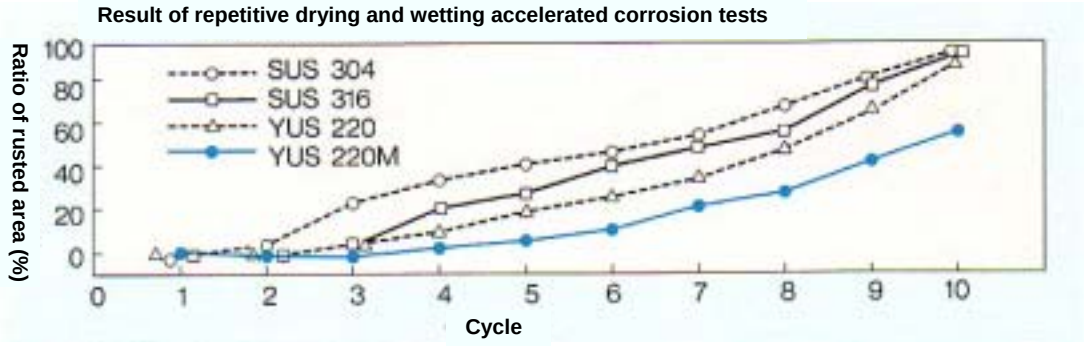
Mechanical Properties

	0.2% Yield strength, N/mm^2	Tensile strength, N/mm^2	Elongation %	Hardness HV	Bending (180°)
Specified values	>=295	>=470	>=22	<=200	1.0t
Typical values	370	516	30	175	No cracking

Physical Properties

Item	Specific gravity	Average thermal expansion coefficient
Values	7.73	$10.4X10^{-6}$/°C (30-100°C)

Corrosion Resistance



Test Method: 10-cycle repetition: Seawater spraying (room temperature) to Drying (60°C×15minutes) to Wetting (50°C, 100% RH×30minutes).

Comparison of Physical Properties

Mitsubishi Chemical Functional Products, Inc.

1. Specific gravity and weight

(1) Composite materials

Composite materials	Specific gravity	Weight, kg/m^2
TCM 4mm	2.3	9.3
SCM 4mm	2.5	10.2
ALPOLIC®/fr 4mm	1.9	7.6

(2) Metals

Metals	Specific gravity	Metals	Specific gravity
Aluminum	2.71	Stainless steel SUS304	7.93
Titanium	4.51	Stainless steel SUS316	8.0
Stainless steel YUS220M	7.73	Iron	7.9
Stainless steel SUS430	7.70		

2. Thermal expansion ratio

(1) Composite materials

Composite Materials	Expansion ratio 1/°C	Expansion per 1m×50°C
TCM 4mm	10.4×10^{-6}	0.5 mm
SCM 4mm	10.4×10^{-6}	0.5
ALPOLIC®/fr 4mm	24×10^{-6}	1.2

(2) Metals

Metals	Expansion ratio 1/°C	Expansion per 1m×50°C
Aluminum	24×10^{-6}	1.2 mm
Titanium	8.4×10^{-6}	0.4
Stainless steel YUS220M	10.4×10^{-6}	0.5
Stainless steel SUS430	10.4×10^{-6}	0.5
Stainless steel SUS304	17.3×10^{-6}	0.9
Stainless steel SUS316	16.0×10^{-6}	0.8
Iron	12×10^{-6}	0.6

3. Thermal conductivity

Materials	Thermal conductivity kcal/m·hr·°C	Materials	Thermal conductivity kcal/m·hr·°C
TCM	0.34	Iron	54
SCM	0.34	Glass	0.86
ALPOLIC®/fr 4mm	0.39	Concrete	1.4
Aluminum	180	Brick	0.24
Titanium	14	Gypsum board	0.11
Stainless steel SUS304	15	Rock wool / Glass wool	0.035

Rigidity and Panel Strength

Mitsubishi Chemical Functional Products, Inc.

1. Rigidity (bending strength) and panel weight

As an attribute of composite panel, TCM and SCM have high rigidity with a light weight. Titanium is well known as a rigid and lightweight metal, but TCM is more rigid than titanium metal per the same weight. Table 1 and 2 show rigidity of TCM and SCM in comparison with other metals of the equivalent rigidity.

Table 1. Rigidity of TCM in comparison to aluminum, stainless steel and titanium metals

	TCM	Metal thickness with equivalent rigidity		
		Aluminum	Stainless steel	Titanium
Thickness	4 mm	3.6 mm	2.5 mm	3.1 mm
Modulus of elasticity (E, N/mm^2)	4.90×10^4	68.6×10^4	20.0×10^4	10.6×10^4
Flexural rigidity (E×I, Nmm^2/mm)	2.61×10^5	2.66×10^5	2.60×10^5	2.63×10^5
Panel weight (%, TCM = 100)	9.3 kg/m^2 (100%)	9.8 kg/m^2 (105%)	19.4 kg/m^2 (209%)	13.9 kg/m^2 (149%)

Table 2. Rigidity of SCM in comparison to aluminum, stainless steel and titanium metals

	SCM	Metal thickness with equivalent rigidity		
		Aluminum	Stainless steel	Titanium
Thickness	4 mm	4.2 mm	2.9 mm	3.6 mm
Modulus of elasticity (E, N/mm^2)	7.72×10^4	68.6×10^4	20.0×10^4	10.6×10^4
Flexural rigidity (E×I, Nmm^2/mm)	4.12×10^5	4.23×10^5	4.06×10^5	4.12×10^5
Panel weight (%, SCM = 100)	10.2 kg/m^2 (100%)	11.4 kg/m^2 (112%)	22.3 kg/m^2 (219%)	16.2 kg/m^2 (159%)

2. Panel strength

When TCM and SCM are used outdoors, the panel and sub-structure must withstand the wind load. When wind blows toward the panel, uniformly distributed load works on the panel. On the contrary, in the opposite side of the building, negative load (suction) works on the panel. As a result of loading, the panel deflects and stress will arise inside the panel. As far as the deflection and stress is small enough (within elastic range), the panel will be restored to the original conditions after the wind load is eliminated. The panel strength can be evaluated as shown below.

(1) Flexural strength design

To design the flexural strength of TCM and SCM, we assume that skins of titanium or stainless steel are burdened with all of wind load. If the stress arisen in skins is smaller than the permissible value (yield stress or 0.2% proof stress, refer to Table 3), the skins lie in elastic range and the panel

is restored to the original conditions, if the load is eliminated. Therefore, we check whether or not the skins lie in the elastic range. The stress that arises in skins can be calculated with the following equation. If the calculated stress value is lower than the yield stress (0.2% proof stress), the panel lies in elastic range under the calculated conditions. Actually, the calculated result is multiplied with safety factor.

Stress in skins = $B \cdot w \cdot b^2 / t^2$

Where, B: Coefficient dependent on a/b ratio (panel width/panel height, the shorter is denominator) and supporting condition, as shown in Table 5.
w: Wind load (10^{-6}×N/m^2, 10^{-3}×kPa or 10^{-6}×kg/m^2)
b: Panel width or height, whichever shorter one (mm)
t^2: Square of apparent thickness of TCM and SCM, given in Table 3 (mm^2).

(2) Calculation of deflection

The expected deflection of TCM and SCM panels can be calculated with the following equation.

Deflection = $A \cdot w \cdot b^4 / (E \cdot t^3)$

Where, A: Coefficient dependent on a/b ratio (panel width/panel height, the shorter is denominator) and supporting condition, as shown in Table 6.
w: Wind load (10^{-6}×N/m^2, 10^{-3}×kPa or 10^{-6}×kg/m^2)
b: Panel width or height, whichever shorter one (mm)
$E \cdot t^3$: Elastic modulus multiplied by panel thickness, as shown in Table 4 (kg·mm).

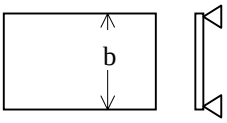
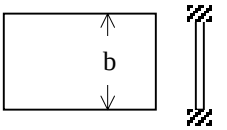
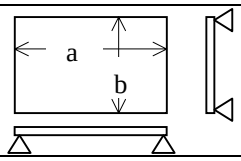
Table 3, t^2 and yield stress (0.2% proof stress)

	t^2 (mm^2)	0.2% proof stress
TCM 4 mm	6.17	16.5 kg/mm^2 (162 N/mm^2)
SCM 4 mm	6.17	20.9 kg/mm^2 (205 N/mm^2)

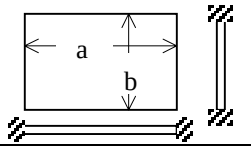
Table 4, Elastic modulus (E) and $E \cdot t^3$

	Elastic modulus (E)	$E \cdot t^3$
TCM 4 mm	5.00×10^3 kg/mm^2 (4.90×10^4 N/mm^2)	320×10^3 kg·mm (314×10^4 N·mm)
SCM 4 mm	7.88×10^3 kg/mm^2 (7.72×10^4 N/mm^2)	504×10^3 kg·mm (494×10^4 N·mm)

Table 5, Coefficient "B" and equation to calculate stress

Supporting condition		Coefficient "B" and equation
2-side simply supported, 2-side free		Stress in skins = $0.75 \cdot w \cdot b^2 / t^2$
2-side fixed, 2-side free		Stress in skins = $0.5 \cdot w \cdot b^2 / t^2$
4-side simply supported		Stress in skins = $B \cdot w \cdot b^2 / t^2$

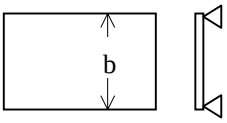
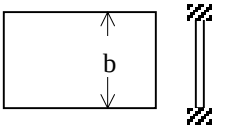
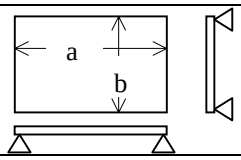
a/b	1	1.2	1.4	1.6	1.8	2.0	3.0
B	0.2874	0.3762	0.4530	0.5172	0.5688	0.6102	0.7134

4-side fixed		Stress in skins = $B \cdot w \cdot b^2 / t^2$

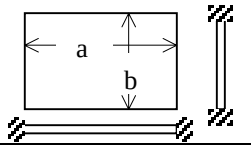
a/b	1	1.2	1.4	1.6	1.8	2.0	>2.0
B	0.3078	0.3834	0.4356	0.4680	0.4872	0.4974	0.5000

Note: The above table is excerpt from White Binder (technical brochure) P. 10. Refer to White Binder for detail.

Table 6, Coefficient "A" and equation to calculate deflection

Supporting condition		Coefficient "A" and equation
2-side simply supported, 2-side free		Deflection = $0.156 \cdot w \cdot b^4 / (E \cdot t^3)$
2-side fixed, 2-side free		Deflection = $0.0313 \cdot w \cdot b^4 / (E \cdot t^3)$
4-side simply supported		Deflection = $A \cdot w \cdot b^4 / (E \cdot t^3)$

a/b	1	1.2	1.4	1.6	1.8	2.0	3.0	>3.0
A	0.044	0.062	0.077	0.0906	0.1017	0.1110	0.1335	0.1422

4-side fixed		Deflection = $A \cdot w \cdot b^4 / (E \cdot t^3)$

a/b	1	1.2	1.4	1.6	1.8	2.0	>2.0
A	0.0138	0.0188	0.0226	0.0251	0.0267	0.0277	0.0284

Note: The above table is excerpt from White Binder (technical brochure) P. 12. Refer to White Binder for detail.

Prevention of Galvanic Corrosion

Mitsubishi Chemical Functional Products, Inc.

When other metals like aluminum are used together as accessories for assembling TCM and SCM panels, it is necessary to design the panel detail to prevent accelerated corrosion of the metal with galvanic corrosion. Titanium and stainless steel belongs noble metals in corrosion potential, and aluminum is less noble metal. If such metal is connected with TCM or SCM and if moisture exists, it is possible that the corrosion of the less noble metal is accelerated with galvanic corrosion. Refer to the chart below.

Especially, embody the following points to avoid possible galvanic corrosion:

1. Avoid such panel details that permit accumulation of water and condensed dew behind TCM and SCM panels.
2. Use stainless steel rivet, tapping screw and bolt/nut, instead of those made of aluminum. Also, use stainless steel angle and flange, as far as the shape is not complicated for processing stainless steel sheet.
3. If less noble metal like aluminum is used as accessories for assembling TCM or SCM panel, insulate electrically the metal surface with suitable method. In case of aluminum, finish the surface with anodizing or powder coating, or insulate with shim. Perfect insulation is necessary in every method.

Corrosion Potential in Seawater (Flowing water)