Superior Products
Attn: Ms. Juli Prichett
Japanese -> English
Transimpex Job #6861
Final copy delivered 12/12/05

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[*Logo*] Test Report

Test request no. 57463
Application date: July 13th, 1994

Requesting party: Cosmo Trade and Service Co., Ltd.
Head of the new materials business room Mr. Kazuo KOMATSU
6 Kojimachi 6-chome
Chiyoda-ku, Tokyo-to

Title of test: Simulation and calculation of temperature and heat penetration due to solar reflectivity and long wavelength emissivity of the reflective thermal coating "SUPERTHERM[1]"

The recorded test results are as presented in this document.
November 8th, 1994

Japan Testing Center for Construction Materials
[*Two different partially-legible stamps of the Japan Testing Center for Construction Materials*]
Yoichi SAWA, Administrative Director
1-3 Nihonbashi Kobunacho
Chuo-ku, Tokyo-to

[1] Best guess of what is probably a tradename.

(Test request no. 57463)

(Title of requested test)

Simulation and calculation of temperature and heat penetration due to solar reflectivity and long wavelength emissivity of the reflective thermal coating “SUPERTHERM[2]”

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[2] Best guess of what is probably a tradename.

1. Contents of the request

The following measurements and calculations were carried out with respect to the reflective thermal insulation coating “SUPERTHERM” from the Cosmo Trade and Service Co., Ltd.

(1) Measurement of solar reflectivity and long wavelength emissivity

(2) Calculation of heat penetration at the roof surface and roof surface temperature based on measurement results of (1) for the Tokyo region during summer (July - August) as well as the Okinawa region both during summer (July - August) and winter (January - February)

2. Measurement of solar reflectivity and long wavelength emissivity

2.1 Sample

The sample was a reflective coating which was applied as a coating to the roof surface, the exterior walls, etc. This sample was applied to an iron sheet (about 0.5 mm thick) to provide the test body.

The product name, dimensions, and quantities of the test body are indicated in Table 1.

2.2 Measurement methods

(1) Solar reflectivity

Testing was carried out according JIS A 5759 (film used on window glass) 5.3.4 (b).

(2) Long wavelength emissivity

Testing was carried out according to JIS A 5759 5.3.4 (c).

2.3 Measurement results

The measurement results for solar reflectivity and long wavelength emissivity are shown in Table 2.

Table 1. Test body

Product name	Measured item	Dimensions	Quantity
SUPERTHERM	solar reflectivity	50 x 50 mm	3
	long wavelength emissivity		1

Table 2. Measurement results

Test body no. / Test item	1	2	3	Average
solar reflectivity	92.1	92.4	92.0	92.2
long wavelength emissivity	99.5			

(Note) For normally utilized white paint, solar reflectivity of about 80%, and long wavelength emissivity is about 90% (source: Architecture (handbook), compiled by the Architectural Institute of Japan, 1980).

3. Calculation of simulation

3.1 Method and conditions of calculation

(1) Calculation method

The heat condition calculation applied an analysis method which described the subject of the calculation by appropriate partitioning and treatment of each partitioned area as a single mass point to express the thermal conduction system as a thermal network.

The thermal equilibrium equations of the various mass points may be generalized in the following form.

$$mc_j \frac{d\theta_j}{dt} = \sum_{i=1}^{n+n_0} C_{ij}(\theta_i - \theta_j) + H_j \qquad (1)$$

Wherein
- mcj = thermal capacity of mass point j, kcal/(m^3 x °C)
- èj = temperature of mass point j, °C
- èi = temperature of mass point i, °C
- t = time, hours
- Cij = thermal conductance from i to j, kcal/(m^2 x h x °C)
- Hj = direct heat input / output at mass point j, kcal/h
- n = number of unknown temperatures
- n_0 = number of mass points of known temperature

Equation (1) is expressed in finite difference form with respect to time to give the following.

$$mc_j \frac{\theta_{jk} - \theta_{jk-1}}{\Delta t} = \sum_{i=1}^{n+n_0} C_{ij}(\theta_{ik} - \theta_{jk}) + H_{jk} \qquad (2)$$

(2) Based Equation (2), the temperature (èj) at each mass point at the time interval k was determined based on solution of n coupled linear equations.

The heat entering the room interior (called the “heat gain”) and the released heat (called the “heat loss”) were calculated from the surface temperature within the room based on the following equation.

$$Qd = \sum_{1}^{24} \alpha_i (\theta_{si} - \theta_i) A \qquad (3)$$

Wherein
- Qd = heat loss or gain integrated over 1 day, kcal/d
- ái = thermal conductivity of the room-side surface, kcal/(m^2 x h x °C)
- èsi = temperature of ALC room interior-side surface, °C
- èi = room internal temperature, °C
- A = surface area of the roof, m^2

Moreover, the heat penetration from the roof during the time interval can be determined by integration of Qd. In this case, the heat penetration to the room interior from the roof becomes positive, and release of heat from the room interior to the roof is expressed by a negative value.

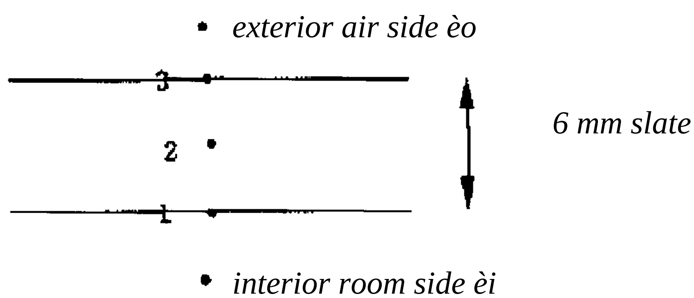
(2) Conditions of the calculation

Standard meteorological data were used as the input data for the external air, and the room interior temperature was assumed to be constant. The calculation time interval was assumed to be 1 hour, which was consistent with the standard meteorological data.

The various conditions of the calculation are listed below.

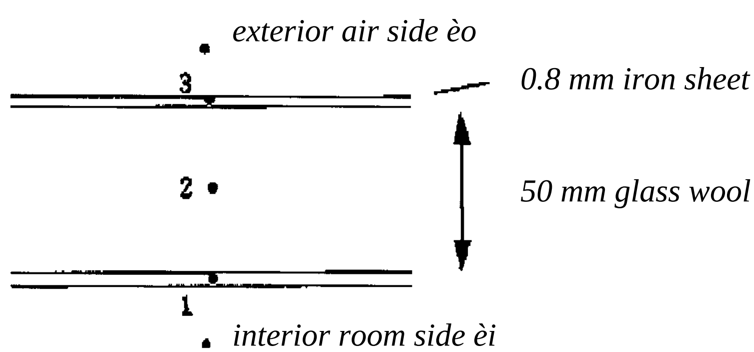
□ Standard meteorological data	MICRO HASP (Nihon Kuchoeisei Kogakukai[3])	
	regions, Tokyo and Naha	
	time period, July 1 - August 31	
□ Type of roof	(1) slate roof	
	(2) corrugated metal roof	
□ Roof pitch	horizontal	
□ Exterior air temperature conditions	(1) solar insolation absorptivity	SUPERTHERM surface, 0.08
		slate surface, 0.70
		green-colored zinc-iron sheet, 0.40
	(2) long wavelength emissivity	SUPERTHERM surface, 0.94
		slate surface, 0.90
		green-colored zinc-iron sheet, 0.90
	(3) surface heat conductivity	takes into account exterior air velocity (v)
	(4) exterior air temperature	standard meteorological data
	(5) solar insolation	standard meteorological data
	(6) night time radiant quantity	standard meteorological data
□ Room interior-side conditions	(1) surface thermal conductivity	8 kcal/(m^2 x □h x □°C)
	(2) room temperature	air conditioning time period, 28°C
		space heating time period, 28°C
□ Material properties	Material properties used for the calculation and the map of partitioning used for calculation are shown in Figure 1.	

[3] This organization does not seem to have a WWW site, so this name is phonetic rather than an official English name.



Slate physical property values:
thermal conductivity ë = 1.1 kcal/(m^2 x h x °C)
specific heat c = 0.18 kcal/(kg x °C)
density ñ = 2240 kg/m^3

Slate roof



Glass wool physical property values:
thermal conductivity ë = 0.0377 kcal/(m^2 x h x °C)
specific heat c = 0.2 kcal/(kg x °C)
density ñ = 20 kg/m^3
volumetric specific heat = 821 kcal/(m^3 x °C)

(Note) Although weight based on heat capacity[4] [*sic*] was considered for the iron sheet, the temperature distribution within the interior was ignored.

Corrugated metal roof

Figure 1. Partitioning and physical properties of the roof

[4] This looks like an error in the source text. Surely this should be opposite: “heat capacity based on weight”.

3.2 Results of calculation

(1) Tokyo region

Results of the simulation calculations for the surface temperatures of the slate roof and the corrugated metal roof are shown in Figures 2 and 3. The surface temperatures for both of these roofs when coated with SUPERTHERM were found to be clearly lower than when uncoated. However, the difference naturally disappeared on a rainy day (August 7th) when there was little solar insolation. That is to say, it was found that SUPERTHERM was effective as a solar radiation reflection material.

Table 3 shows results of integration of the heat penetration into the room from the roof surface, according to conditions, based on the simulation calculation results for temperature. In order to examine the method of calculation, the integration of heat penetration at the time of air conditioning was done this time without integration of heat release to the exterior air. That is to say, the total heat release was taken to be 0 in order not to become negative during air conditioning. When restriction of this method to mid-summer (July and August) was attempted, the coating with SUPERTHERM appeared to have an effect on heat penetration.

(2) Okinawa region

Results of the simulation calculations for the surface temperatures of the slate roof and the corrugated metal roof are shown in Figures 4 and for summertime. The surface temperatures for both of these roofs when coated with SUPERTHERM were found to be lower than when uncoated, and these results are similar to those for the Tokyo region.

Moreover, results of the simulation calculations for the surface temperatures of the slate roof and the corrugated metal roof are shown in Figures 6 and 7 for wintertime.

Table 3 shows results of integration of heat penetration into the room from the roof surface according to conditions based on the simulation calculation results for temperature. In summer, solar insolation at Naha was high in comparison to Tokyo, and as a result, a marked difference arose in heat penetration results for SUPERTHERM. In this case, total heat release was taken to be 0 in the same manner as for the Tokyo region.

In winter, heat penetration becomes negative, and it was found that heat release from the room interior to the roof occurs. That is to say, in winter and when there is a coating of SUPERTHERM, there was a space heating load for maintenance of the room interior at 28 °C. However, there are few instances when room temperature is actually maintained at 28 °C. In other words, temperature can be said to become somewhat lower in comparison to the non-coated case.

Table 3. Heat penetration from the roof surface (results of simulation calculation), units = Mcal/m^2

Region	Time period of calculation	Type of roofing	SUPERTHERM Coating	Uncoated
Tokyo	July 1 - August 31	slate roof	3.8	36.9
		double corrugated roof	0.4	2.4
Naha	July 1 - August 31	slate roof	9.5	52.7
		double corrugated roof	1.1	3.7
Naha	January 1 - February 28	slate roof	-8.7	13.1
		double corrugated roof	-4.1	0.4

5[5]. Testing period, persons in charge, and location

Time period:	from September 16, 1994 until October 4, 1994	
Persons in charge:	Section chief of physical testing:	Masayoshi[6] UESO
	Test operators:	Katsuichi KUROKI Tetsuo FUJIMOTO Hiroaki SAITO
Location:	Central test site	

[5] These numbers are not consecutive, probably because several pages are missing.
[6] Japanese given names are sometimes given irregular pronunciations, so these are all best guesses.

[*Partial seal of the Japan Testing Center for Construction Materials.*]