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Putting Ideas into Action
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The Study On Durability Testing Of Heat-insulation Coating

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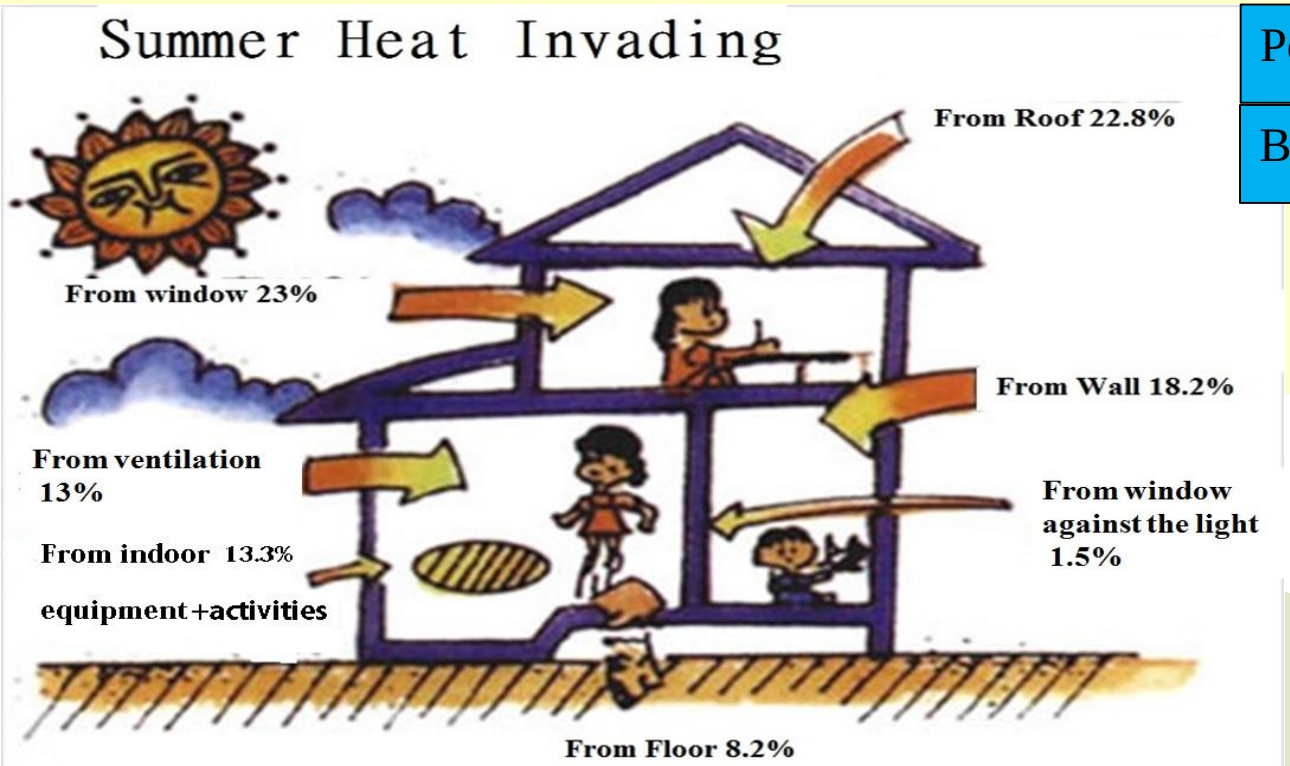
Research Center for Energy Technology and Strategy, National Cheng Kung University, Taiwan ROC

Introduction

Building energy consumption accounts for the proportion of total national energy consumption is quite large, such as the United States accounts for about 40% of total energy consumption, Taiwan for about 30%, and China for 25%.The current strategy to reduce the energy consumption of the building is not only to improve energy efficiency of equipment in buildings but also to develop heat insulation materials for building envelopes.



Heat source into houses in Taiwan during the summer.

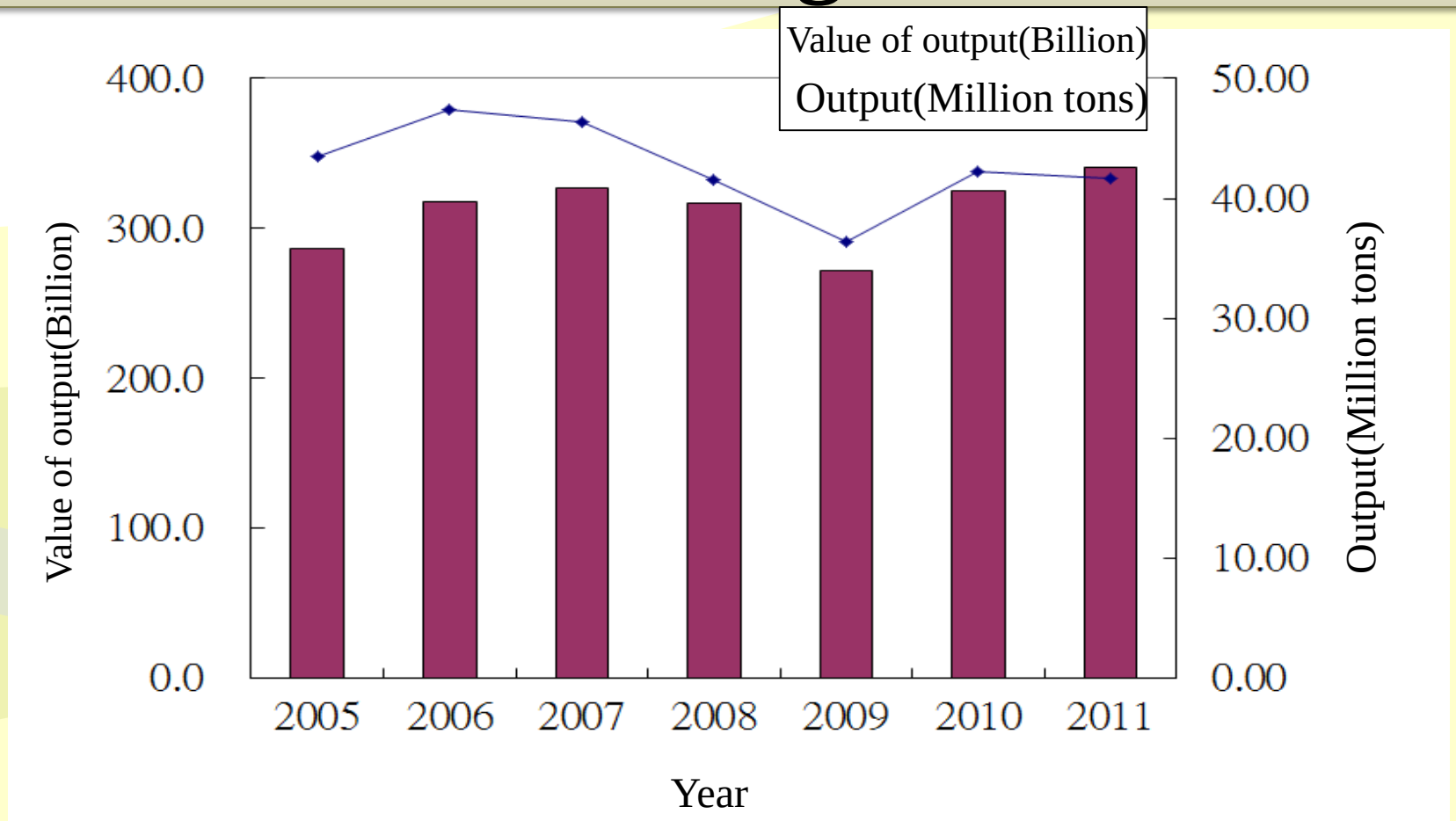
Polar Ice decreasing

Building Coatings

reflects solar radiation

Heat-insulation building material
&
Carbon emission

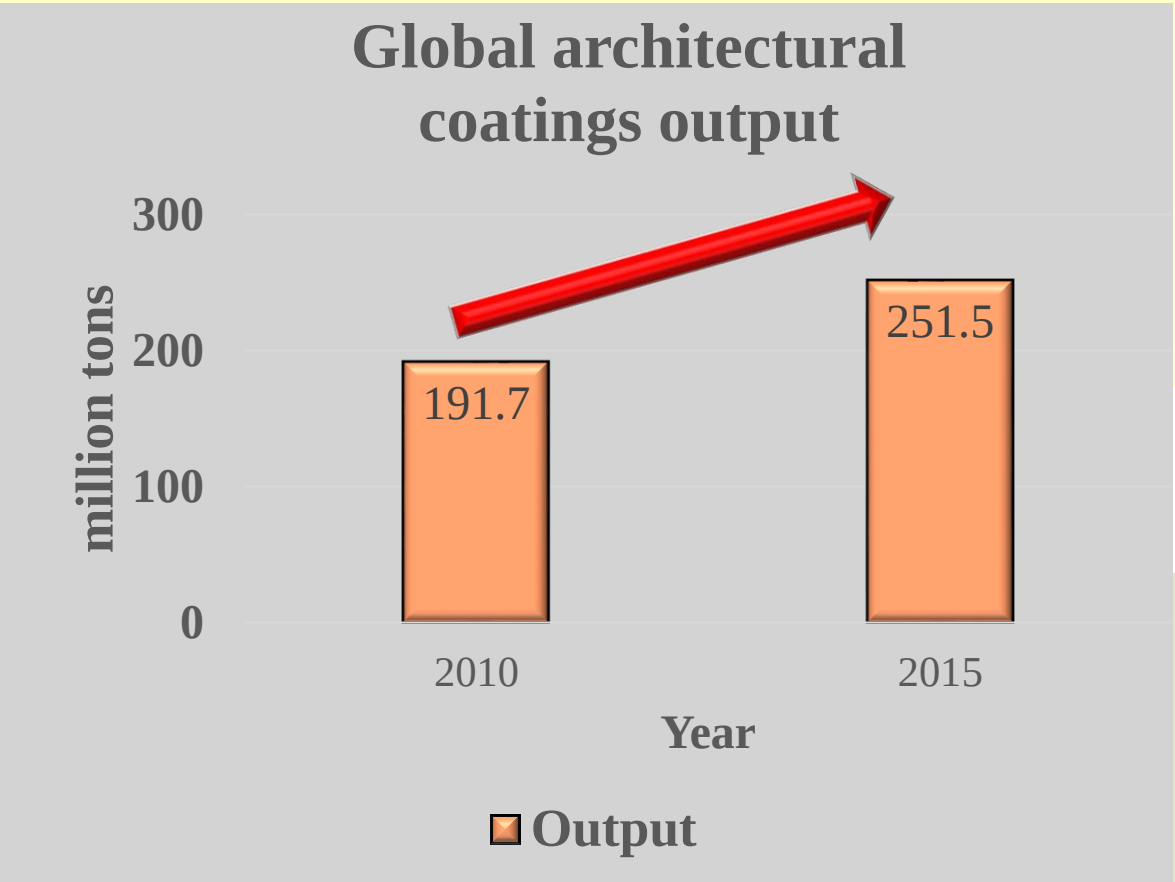
Taiwan coatings market

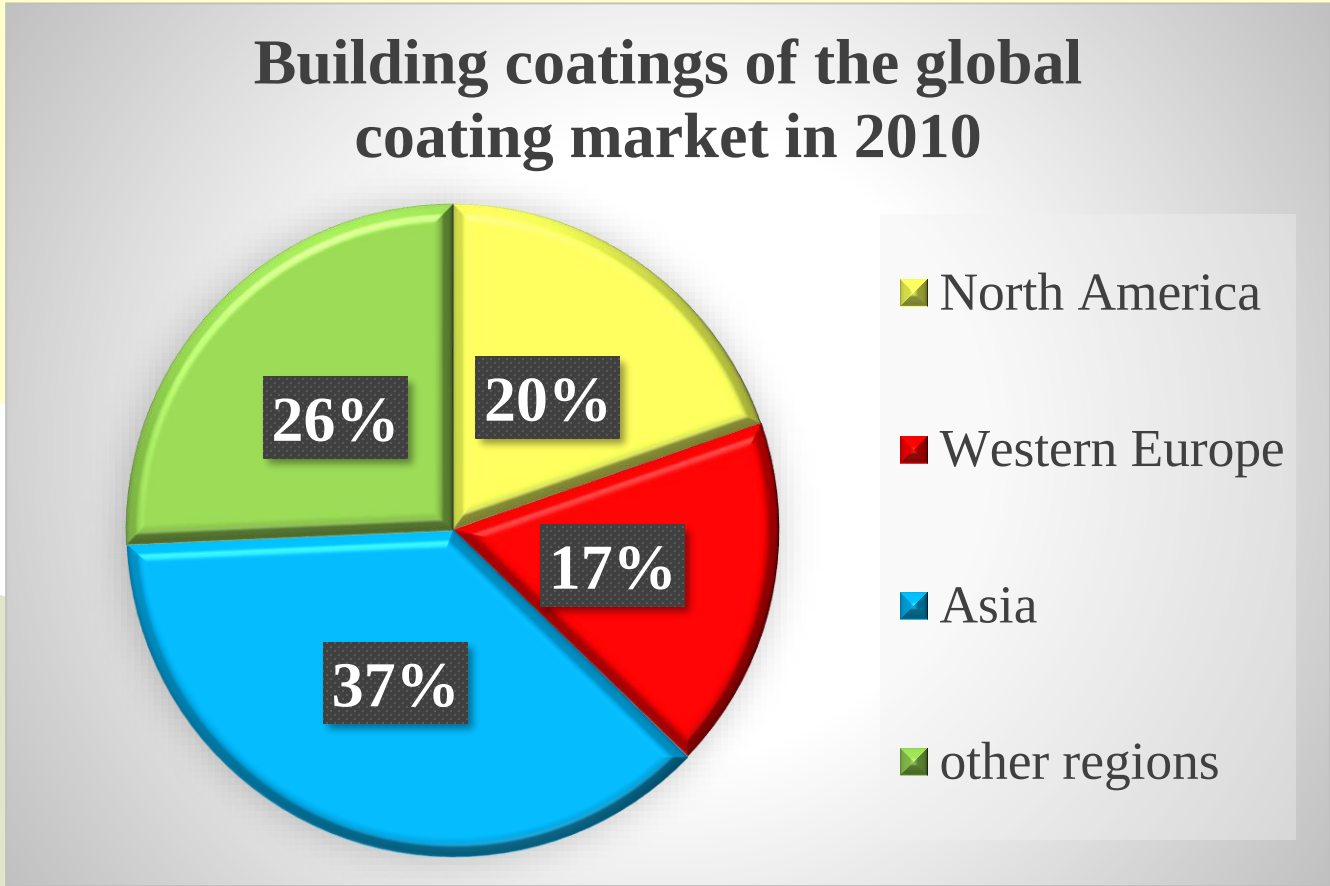


- **Coating is one of the specialty chemicals. In Taiwan, the importance of coating industry is second only to the specialty of the pharmaceutical industry.**

Insulation coatings market

➢According to Freedonia, global architectural coatings market size was about 191.7 million tons in 2010. 2015 was to grow to 215.5 million tons. Building coatings are accounted for 50% of the global coating market. In 2010, the proportion of the region was 19.7% in North America, 17.5% in Western Europe, 37.1% in Asia, and 25.7% in other regions.



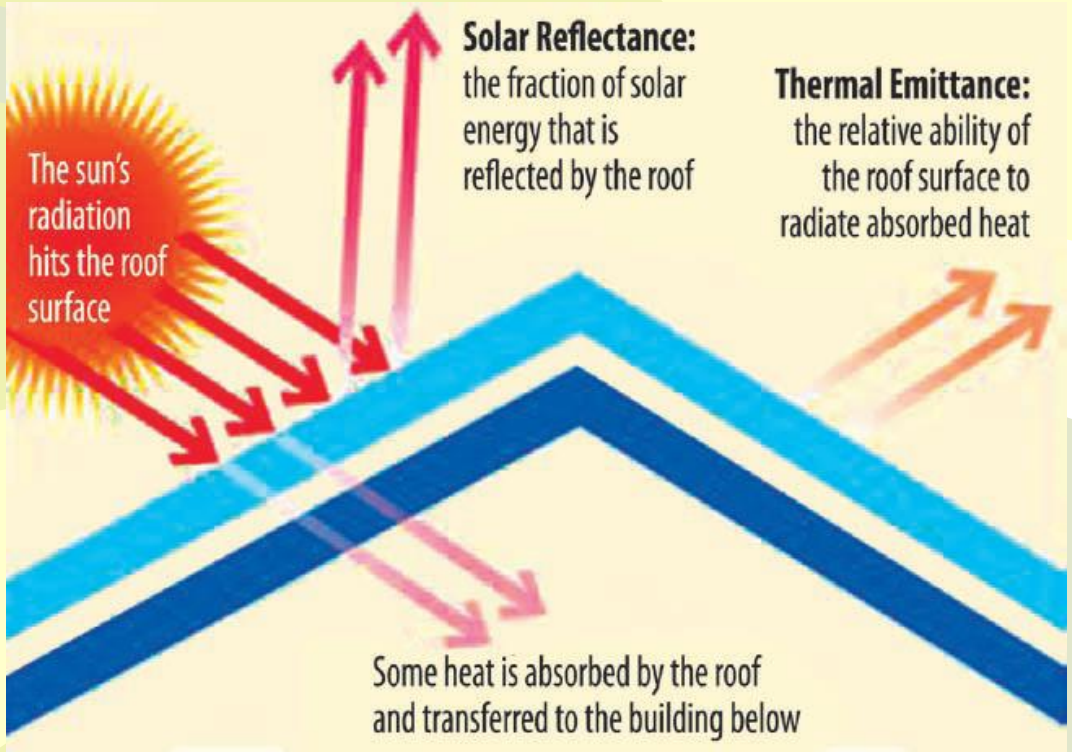


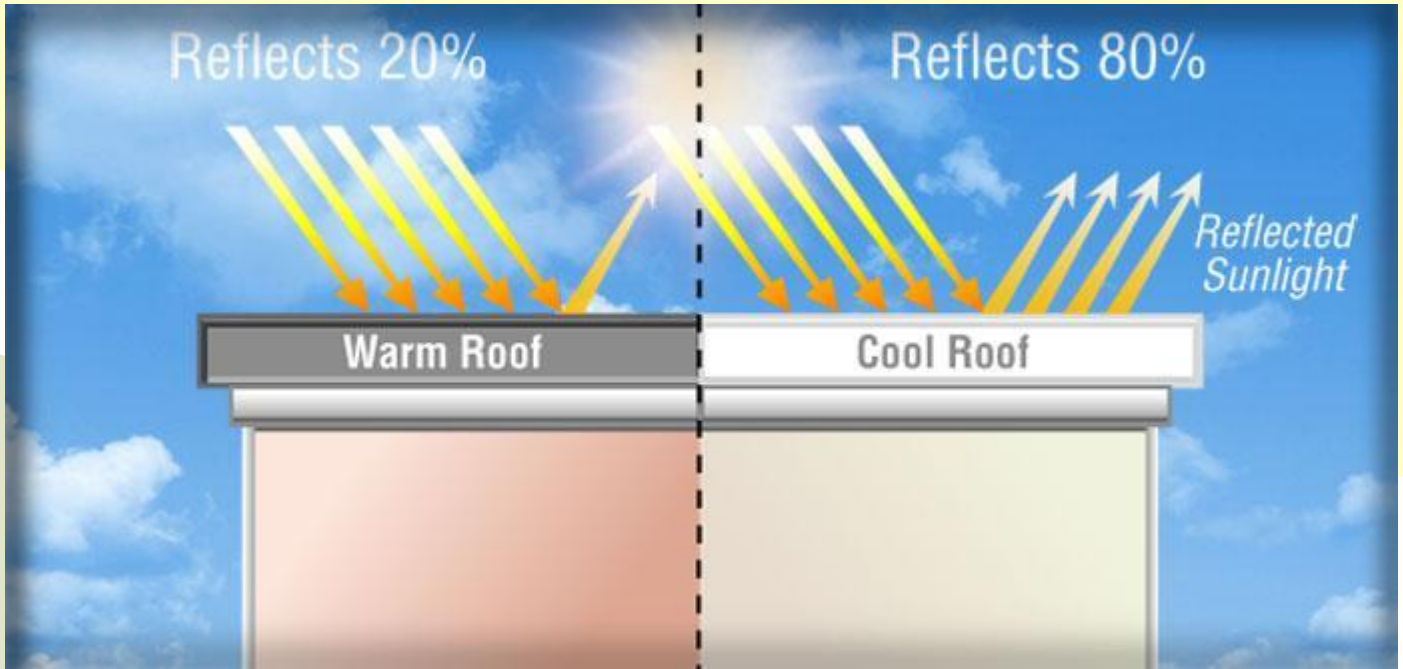
Objective

- This study aims to investigate the relation between optical performance and durability of the heat insulation coatings. 23 kinds of heat insulation coatings on the market were selected as samples to conduct the natural exposure testing and artificial accelerated aging testing, respectively. And, all samples were put into the testing and being compared with their solar reflectance and emissivity .

Cold roof

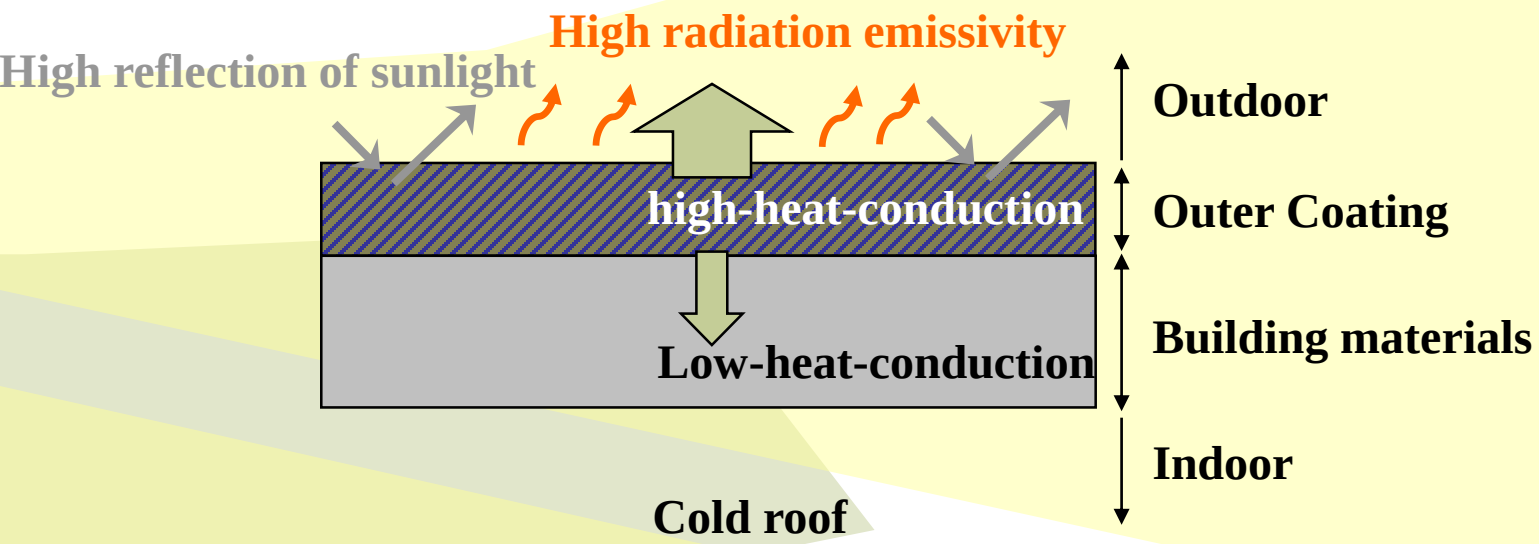
The cold roof is defined as a roof with a high solar reflectance and a high thermal emittance. Cold roof can block solar radiation because the high thermal emissivity makes the roof surface temperature lower than indoor, and thus can reduce the urban heat island effect.





Insulation coating design

ideal insulation coating



Measurement

1. TSR(total solar reflectance)

   -wavelength 0.3~2.5μm(JIS R3106)
2. Thermal emittance: ε
3. Thermal conductivity: k
4. SRI (solar reflectance index)

1.Infrared reflective insulation coating
2.High radiation insulation coating
3.Heat Insulation Coating

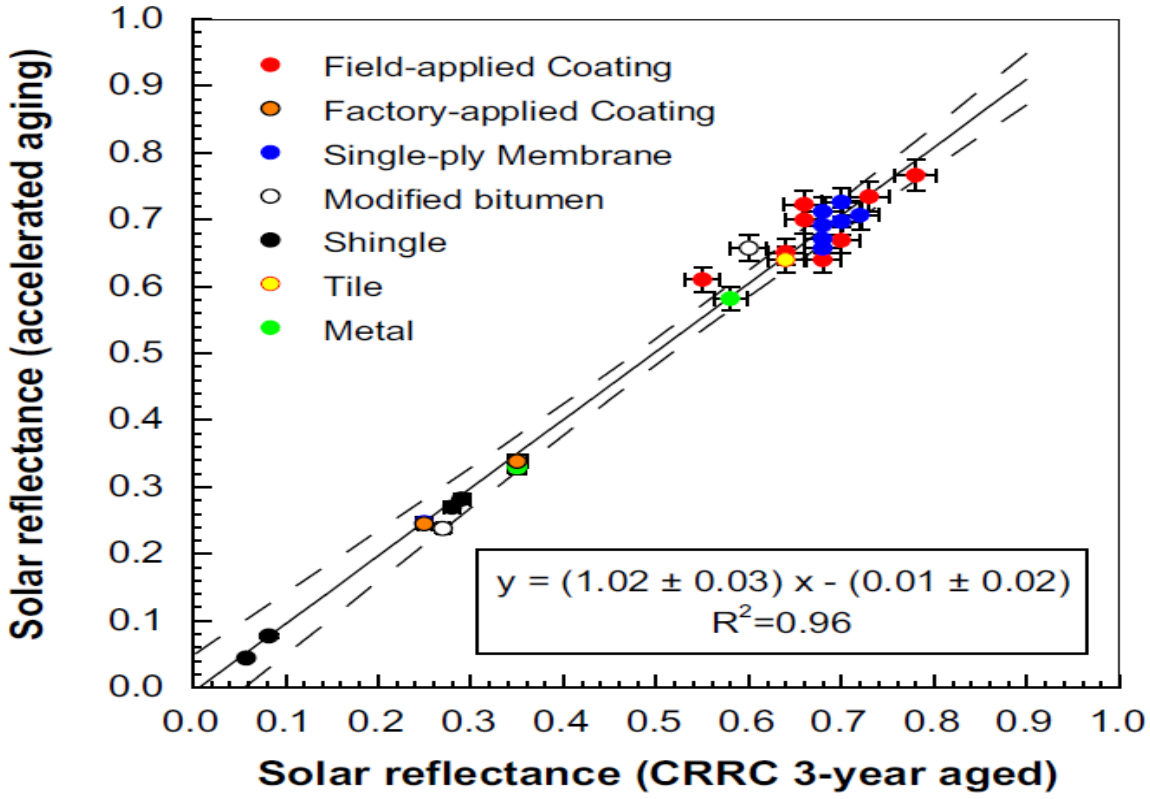
Accelerated outdoor weathering test, Quv test, xenon arc exposure test conditions

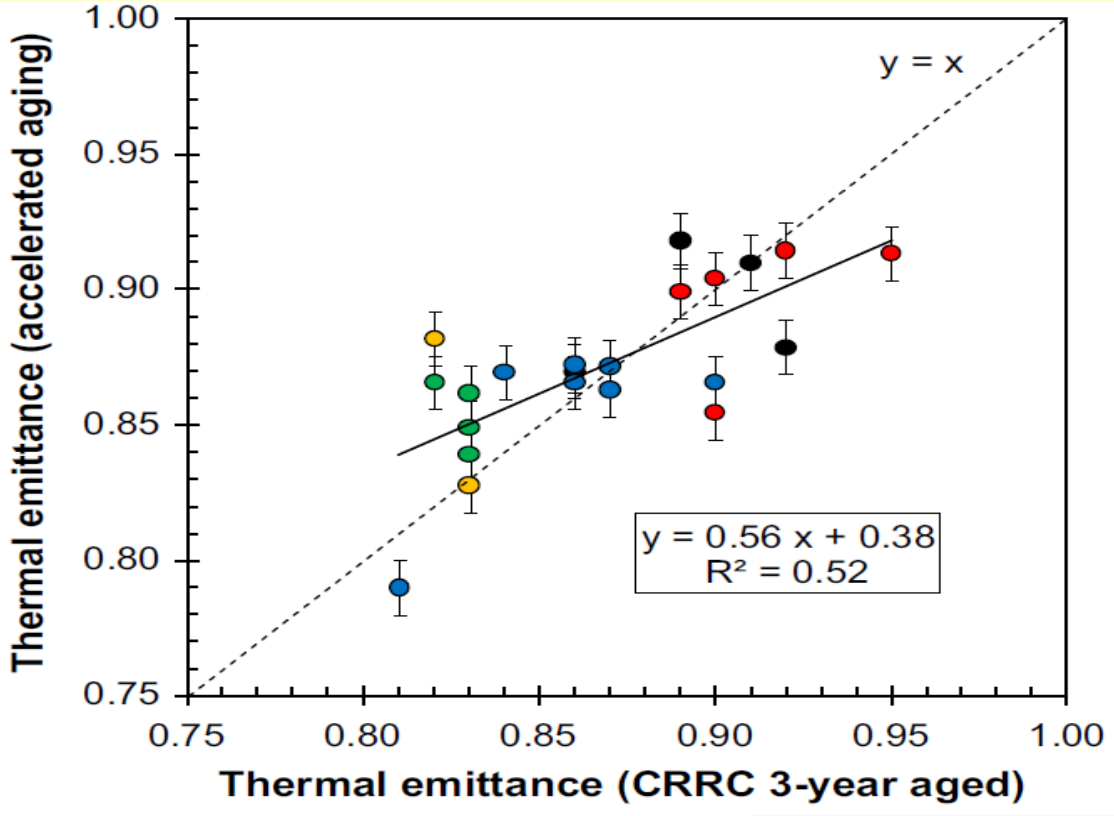
Test conditions	CNS 15200 : Methods of test for coatings − Part 7-5: Long-period performance of film − Natural weathering	CNS 15200: Methods of test for coatings − Part 7-6: Long-period performance of film − Artificial weathering and exposure to artificial radiation(Exposure to filtered xenon-arc radiation)	CNS 1183: Laminated glass 7.3Radiation resistance test
Irradiance	-	290 nm-400 nm	295 nm-360 nm
Water quality	-	conductivity < 2 μS/cm, a residue on evaporation < 1 mg/kg	-
Operating mode	-	Continuous run	Continuous run
Air temperature	27.7 ^{0}C	38±3 ^{0}C	45±5 ^{0}C
Black panel temperature	-	63±2 ^{0}C	-
Relative humidity	75.7 %	40~60 %	-
Wetting time, min	-	(18±0.5) min	-

Weathering tests compared

	Natural weathering	UV lamp accelerated natural weathering	Xenon-arc lamp artificial weathering
Test method	ASTM G7 CNS 15200-7-5 JIS K 5600-7-6	ISO 11341 CNS 15200-7-7 ASTM G151 ASTM G154 JIS K5600-7-8	ASTM G155 CNS 15200-7-6 GB9344-88 ISO4892.2-1994
Time consuming	3years(at least 1year)	0~2000hr(according to experimental requirements)	0~2000hr (according to experimental requirements)
Cost	$2/hr	$83/hr	$150/hr
Strengths	1. Actual outdoor test results 2. Low cost	1. most realistic simulation of sunlight in the short wavelength portion of the spectrum 2. surprisingly economical 3. Fast results	1. xenon test can reproduces the entire spectrum of sunlight 2. Fast results
Weaknesses	Waste time	Can’t reproduces the entire spectrum of sunlight	expensive

Simulated natural exposure testing results

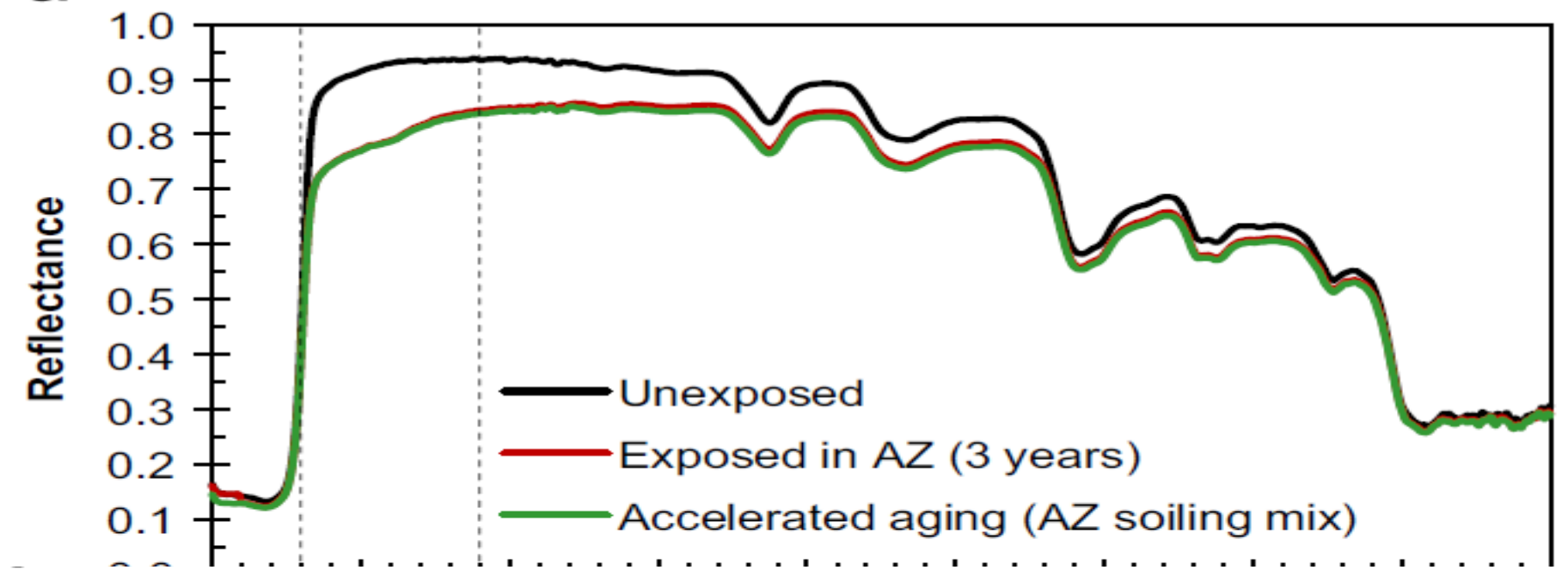


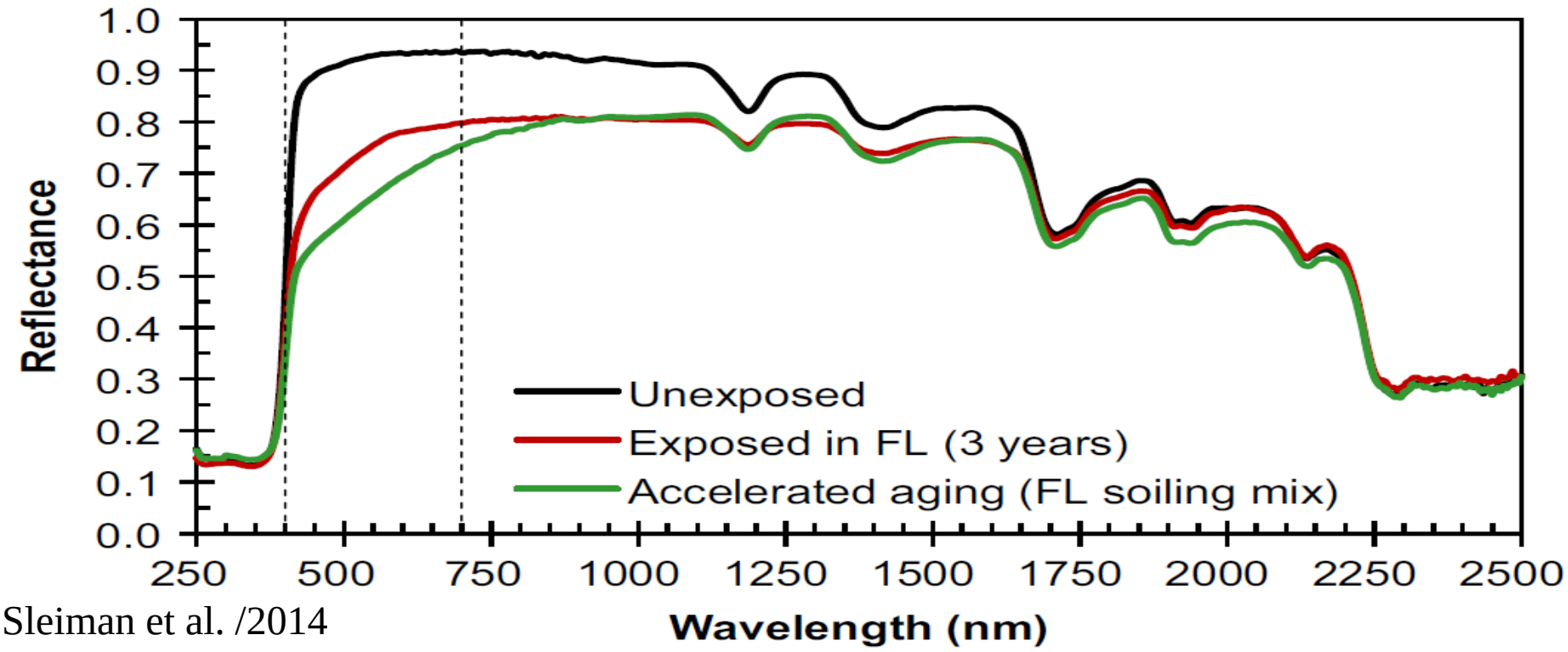


Soiling of building envelope surfaces and its effect on solar reflectance – Part II: Development of an accelerated aging method for roofing materials

Solar Energy Materials & Solar Cells

Source by M. Sleiman et al. /2014





Source by M. Sleiman et al. /2014

Relation between the artificial accelerated aging testing and the natural exposure testing

UVA energy : 0.2844MJ/m^2-hr

UVA energy (300~365nm)for 1 year

6130*1.2341%=75.65MJ/m^2

$$\frac{\text{All-sky solar radiation(75.65)}}{\text{UVA energy(0.2844)}} = 266$$

266 hours UV accelerated aging test is approximately equal to 1 year of Taiwan UV radiation exposure.

2660 hours in xenon arc test chamber or accelerated weathering QUV tester equals 10 years of outdoor exposure.

Experimental equipment

UV-VIS-NIR. Spectrophotometer

Thermal Conductivity Analyzer

Spectral Emissivity Measurement

QUV weathering test(UVA)

xenon-arc lamp artificial weathering

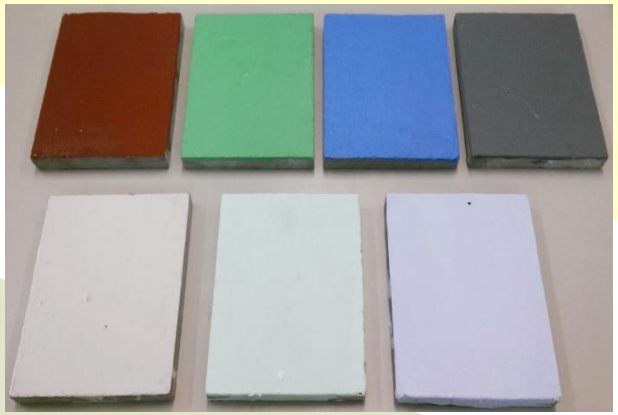
Sample preparation

- **Substrate material：Steel plate, Cement brick。**
  Steel plate size：10 x 10 x 0.05(H x W xD,cm)
  7 x 14 x 0.05(Hx W xD,cm)
  Cement brick size：10 x 10 x 1(H x W x D,cm)。

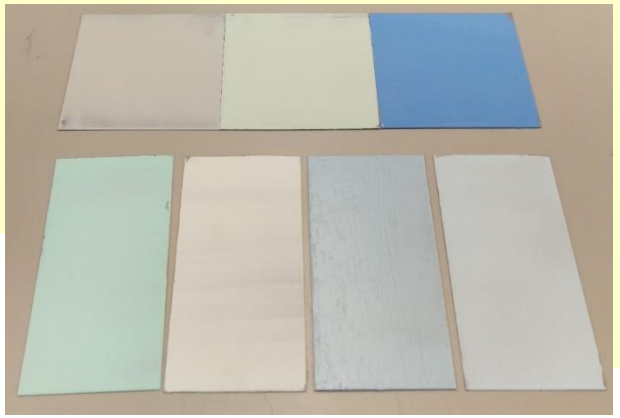
- **Using an RDS coating bar (no. 22, coating thickness: 50.29 µm**

Coating Bar

Coating process

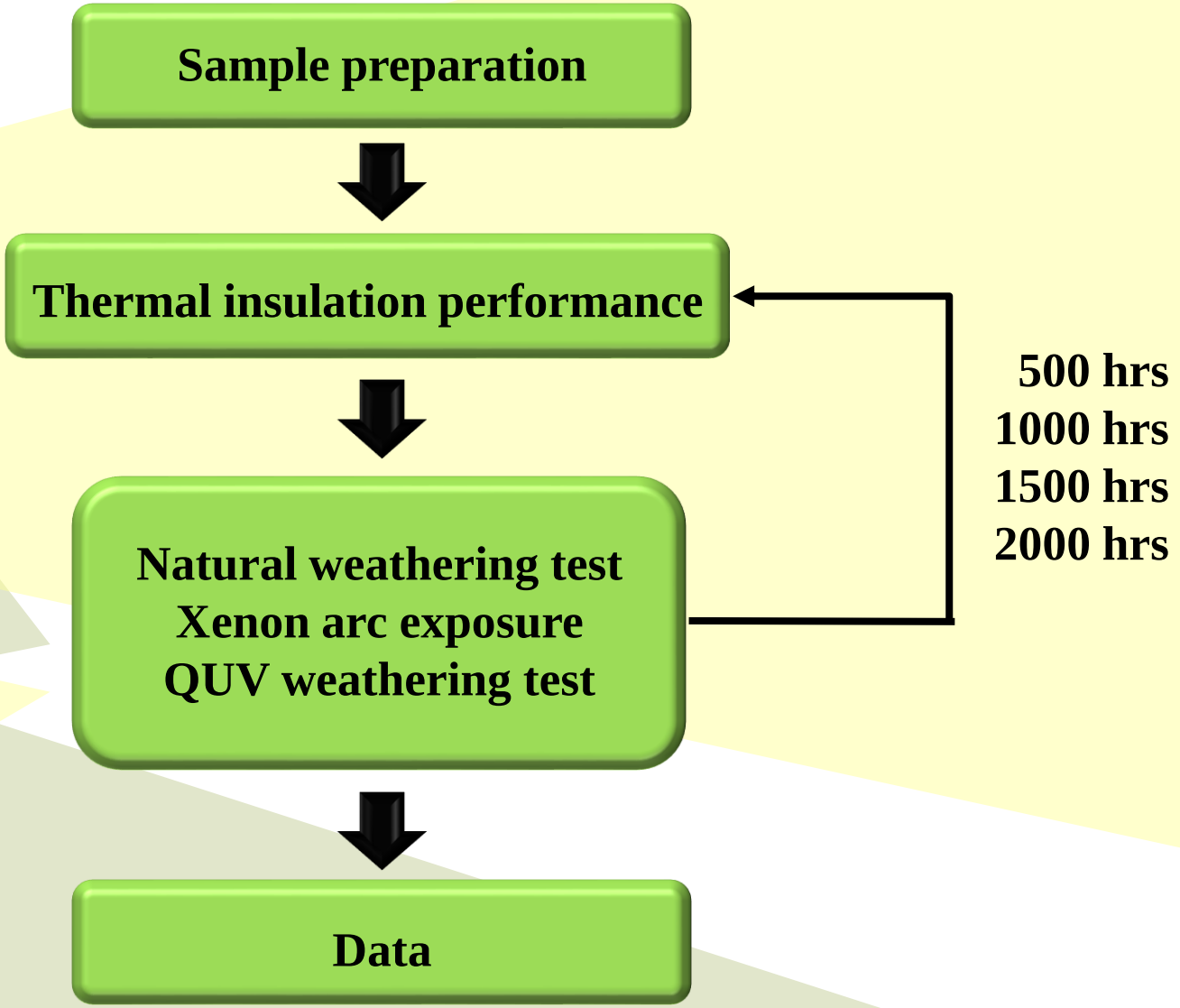


Coating on cement b rick

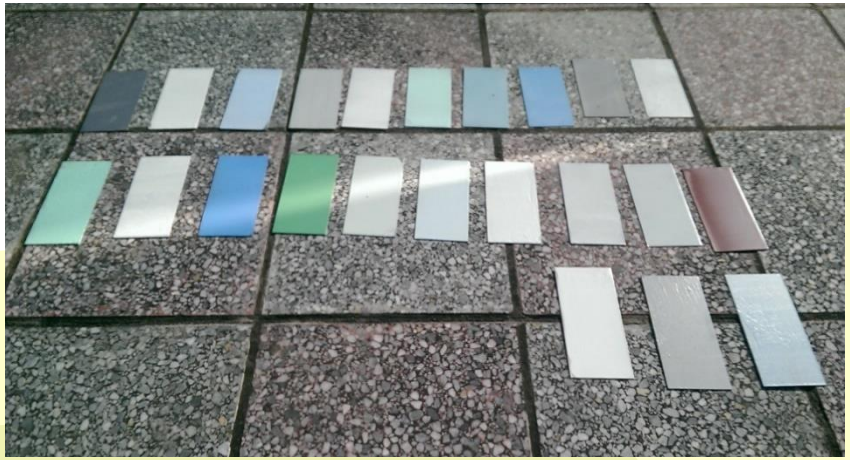


Coating on steel substrates

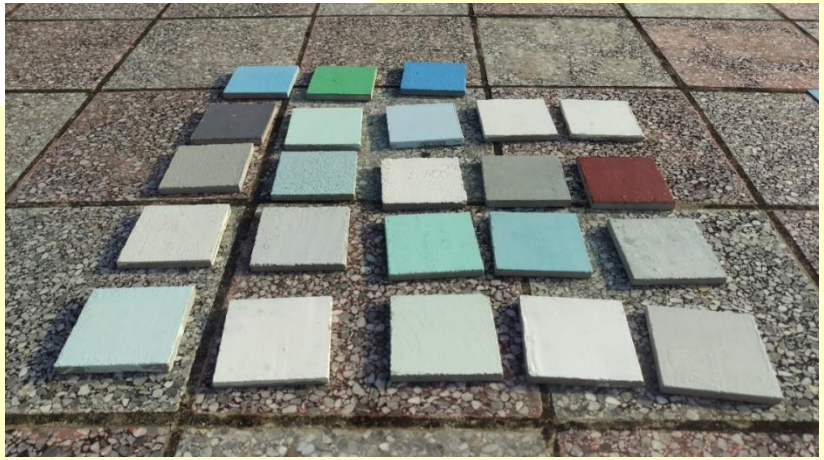
Experimental Procedure



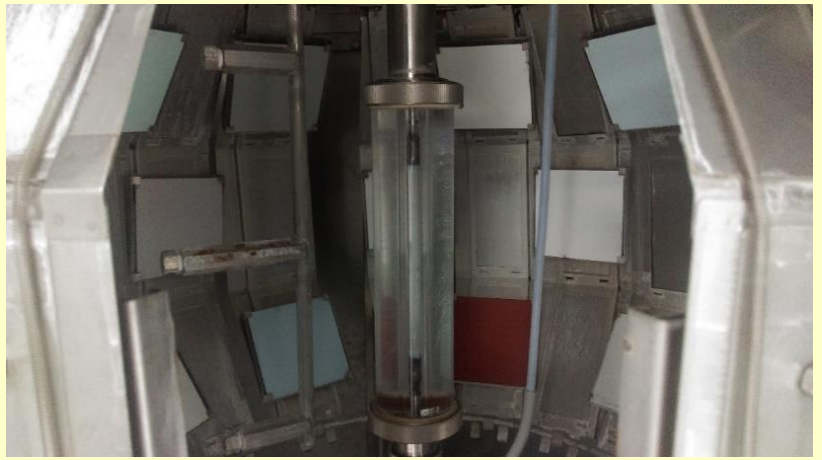
Testing process



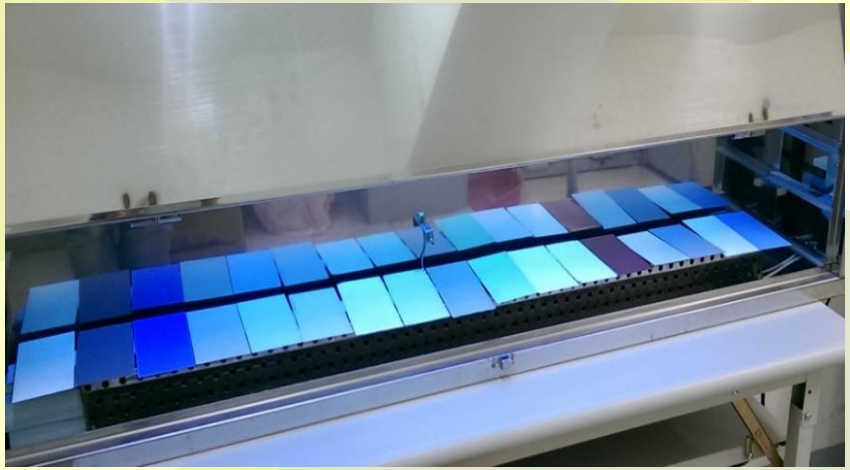
Natural weathering
(steel substrates)



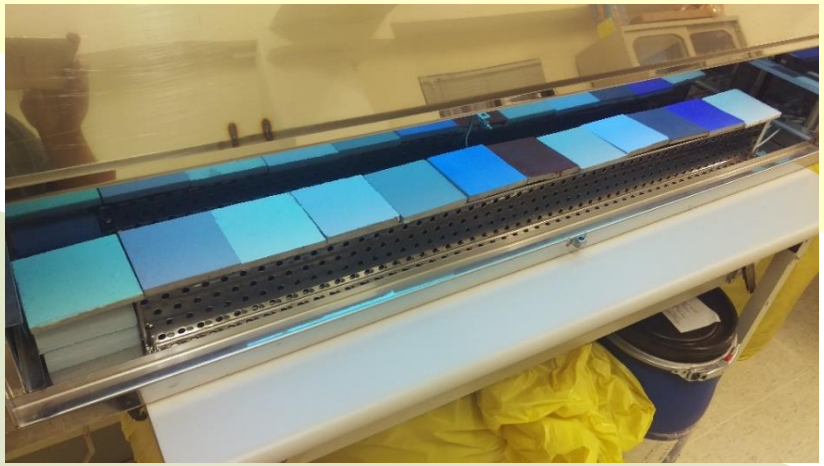
Natural weathering
(cement brick)



Xenon-arc lamp artificial
weathering(steel substrates)

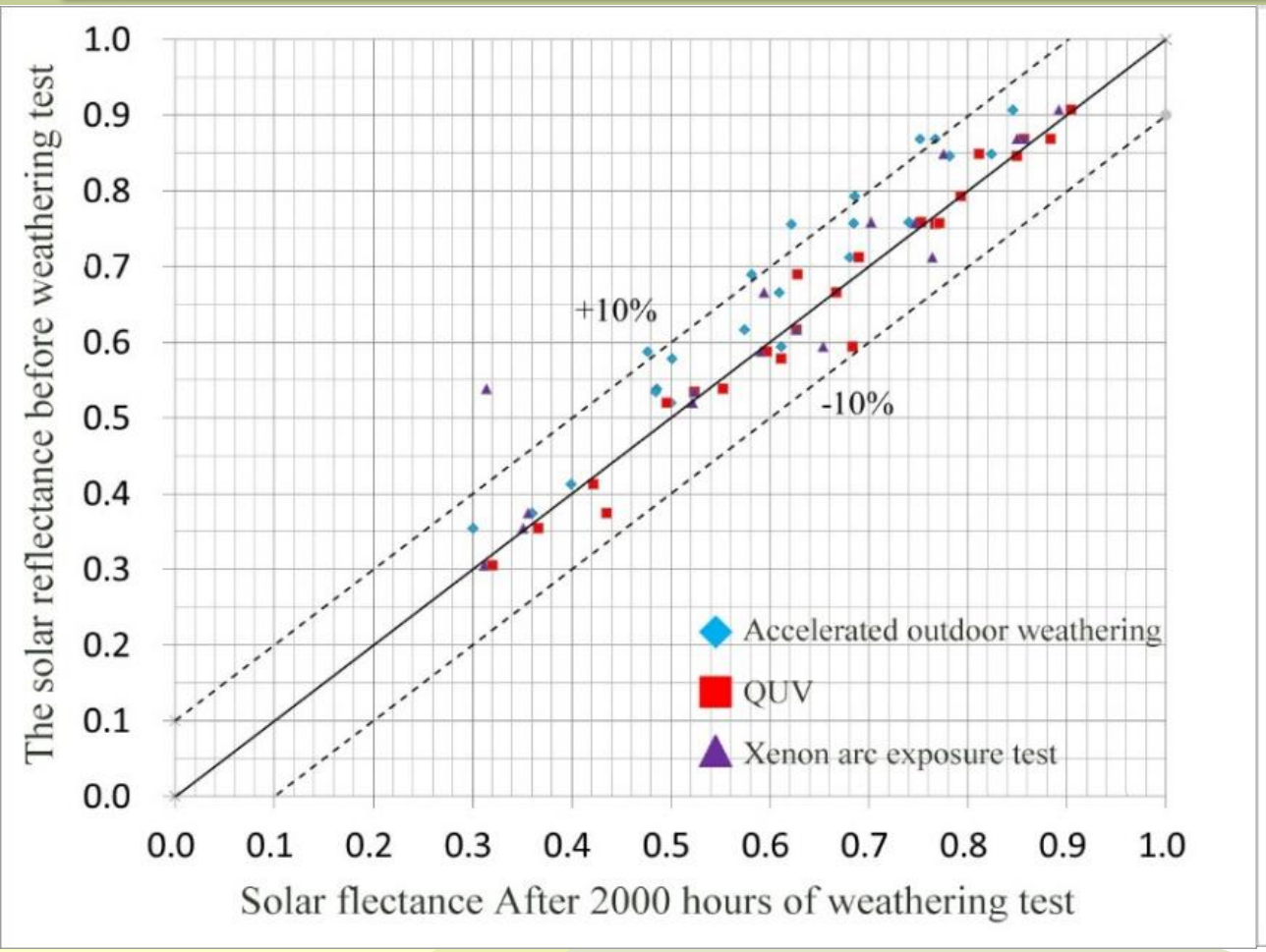


UV lamp accelerated natural
weathering(steel substrates)

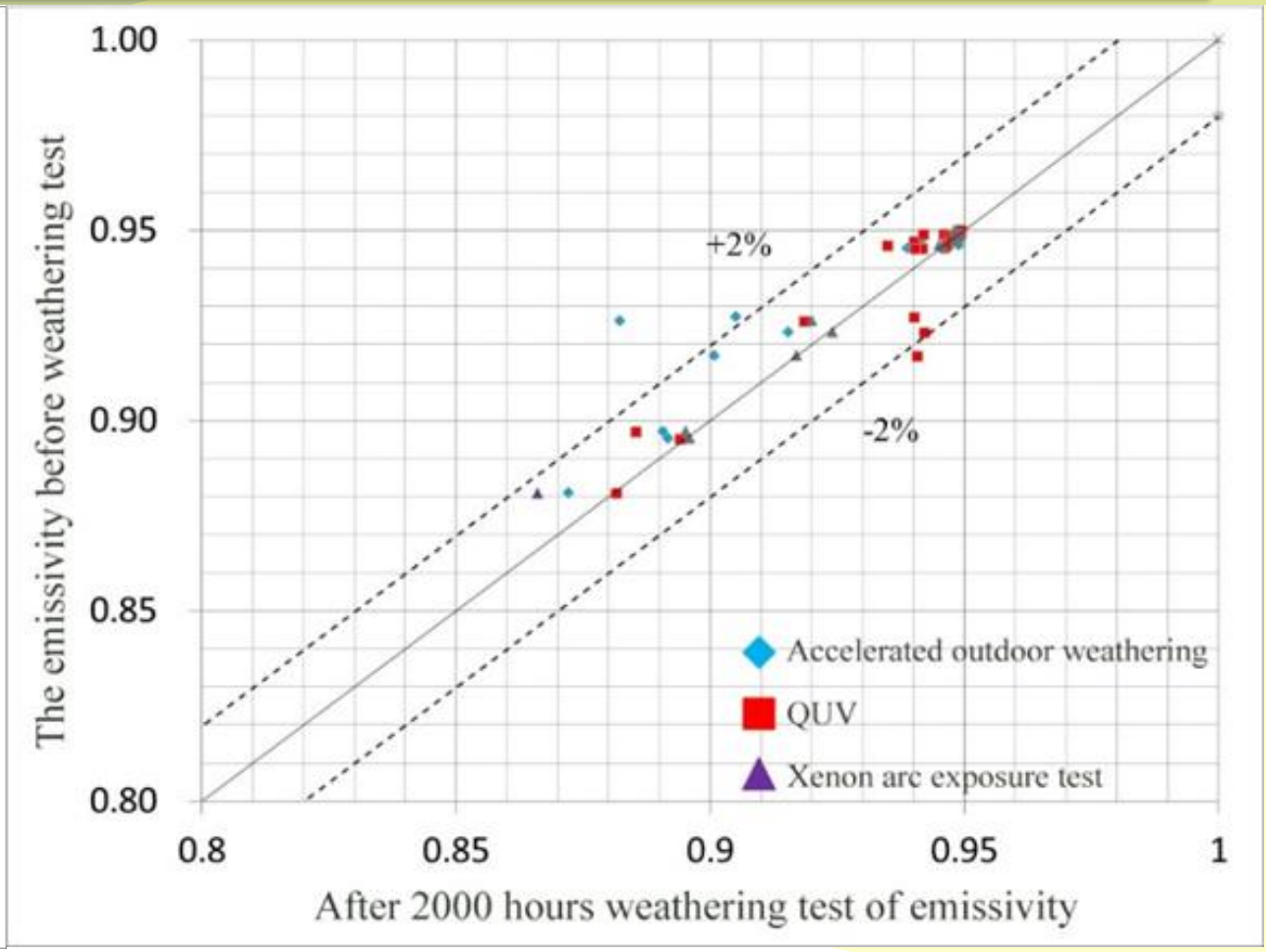


UV lamp accelerated natural
weathering(cement brick)

Test result

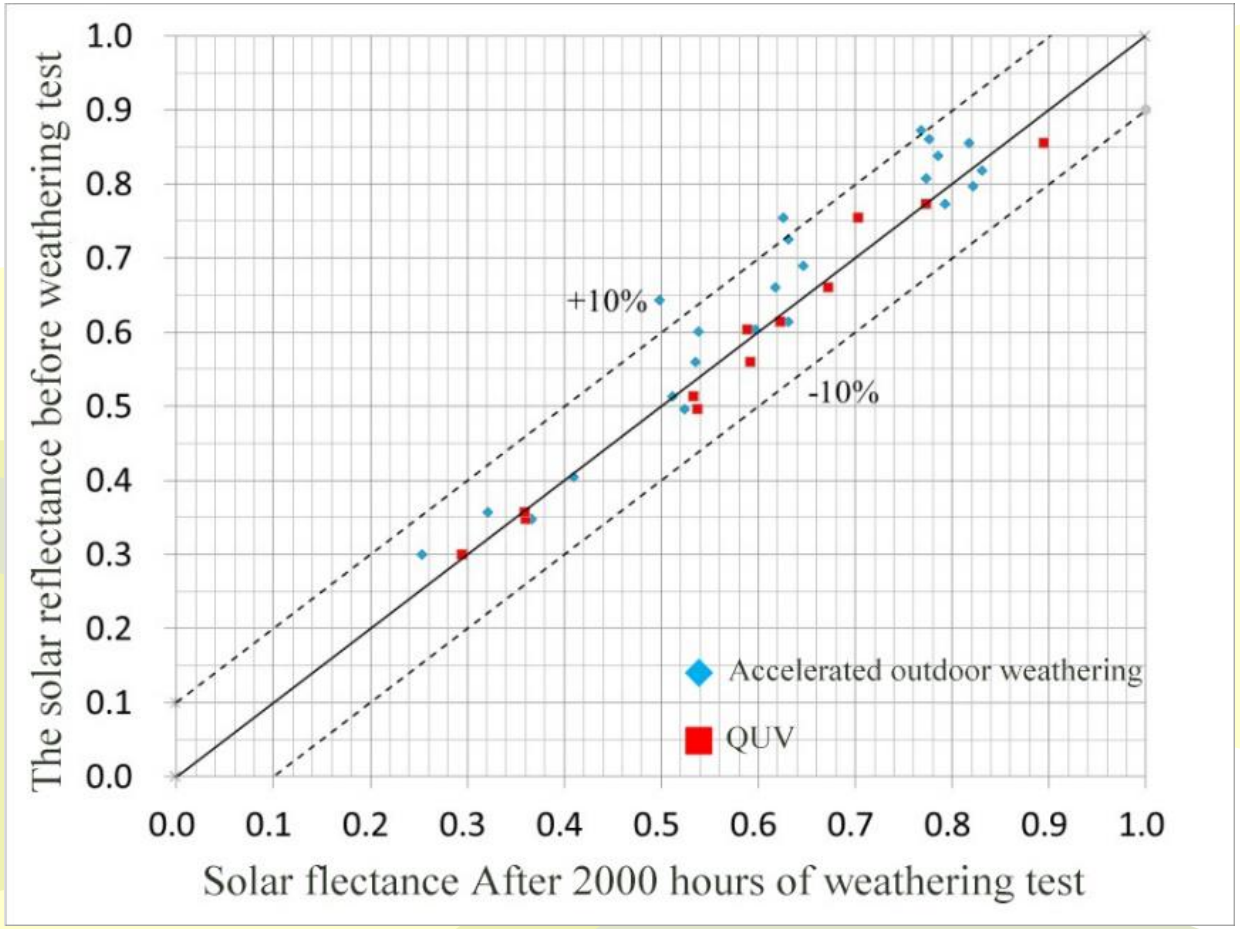


Comparison between the solar reflectance of samples before weathering test and those of after 2000 hours weathering test (steel plate)

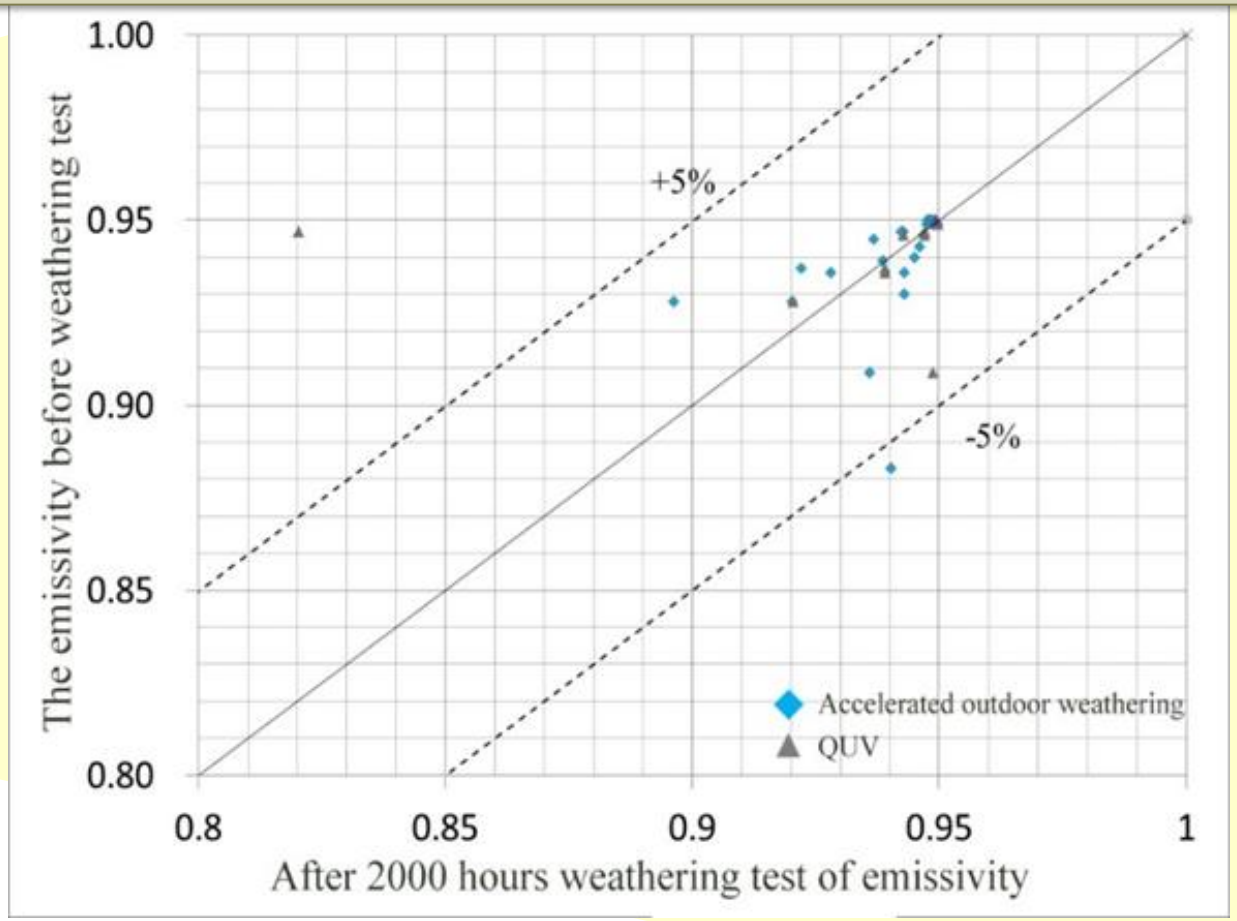


Comparison between the emissivity of samples before weathering test and those of after 2000 hours weathering test (steel plate)

Test result



Comparison between the solar reflectance of samples before weathering test and those of after 2000 hours weathering test (cement brick)



Comparison between the emissivity of samples before weathering test and those of after 2000 hours weathering test (cement brick)

Conclusion-I

- The xenon arc exposure test and QUV weathering test are suitable for evaluating the durability of coatings in Taiwan.
- A sample subjected to 2,660 hours in xenon arc test chamber or accelerated weathering QUV test equals to 10 years of outdoor exposure.

Conclusion-II

- In the natural weathering test, the average solar reflectance degradation are 8.38% and 5.13% for steel plate specimens and cement brick specimens.
- The specimen in outdoor natural weathering test could produce alga on the surface due to moisture in the atmosphere, and then make solar reflectance to decline the most.

alga

Conclusion-III

- In the cases of xenon arc exposure and QUV weathering test, the most samples declines in reflectance by only 1.43% and 3.62% over the 2000 hours period.
- The thermal emissivity also declines in a similar way with the influence of alga to the solar reflectance.
- The declines are smaller in magnitude.

Thank you for listening