Evaluation of Reflective Sheetings

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In 1976 a photometric evaluation of reflective sheetings was begun. Included in the study were 9 white and 10 yellow reflective sheetings. For each color, five 15-in. square aluminum-backed panels were prepared and placed on vertical racks on the sign shop roof in Wisconsin Rapids, Wisconsin. The panels were first put in place near the end of January 1977. From 1977 to 1982, semiannual photometric evaluations of the sheetings were performed with a photometer. From 1983 to 1987, annual reflectivity measurements were obtained with a retroreflectometer. The amount of cold cracking also was measured. All photometer and retroreflectometer tests were taken at a divergence angle of 0.2 degree and at incidence angles of −4 and +30 degrees. In addition to the five panels for each color sheeting, each white sheeting had five panels prepared for the purpose of studying the effect of stone bruising on cold cracking. Artificial stone bruises were made on each of these panels (four bruises per panel, one bruise per quadrant) by means of a dull center punch. (The artificial bruise damaged the sheeting but not the aluminum.)

During the early 1970s, the introduction of various sign sheeting brands, including various grades within each brand, created for the then Wisconsin Department of Highways (DOH) the need of an evaluation procedure for reflective sheeting. Wisconsin Department of Transportation (DOT) experience, plus that of other states, indicates that any evaluation procedure for reflective sheeting must incorporate more than just an initial determination of sheeting qualities, such as reflective intensity. Initial determinations of sheeting qualities cannot help predict the long-term impact of the environment on the behavior and effective service life. Some states have tried to speed up the effects of time and weather by testing the reflective materials in weatherometers. Unfortunately, in 1976 no consistent or reliable correlation existed between weatherometer results and actual performance.

Since the initiation of this study DOT did purchase a photometer, making it possible to quantitatively measure the reflective intensity of sign sheetings. Reflectivity measurements from 1977 to 1982 on signs were made semiannually by using a photometer. Reflectivity measurements from 1983 to 1987 were made annually by using a Gamma Scientific retroreflectometer (model 910). Reflectivity readings from 1977 to 1982 were made compatible with retroreflectometer readings by applying appropriate correction factors.

OBJECTIVES

The objectives of this study were to (a) determine the initial reflective intensities of various brands of reflective sheetings (and for various grades and colors within certain brands), (b) determine the time-loss of reflective intensity of various sheetings exposed to the environment, and (c) determine the cold-cracking propensities of the sheetings.

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SCOPE

The basic plan for this study was to place a number of signs with various reflective sheetings in the field and test them semiannually or annually for reflective intensity. The signs did not contain any messages because they interfere with photometer readings. Because the signs were blank and could not be used for actual highway signing, they were placed in a nontrafficked outdoor exposure site—the roof of the District Sign Shop in Wisconsin Rapids. The signs were placed in racks (15 to 20 signs per rack), which were standing vertically and facing south. The racks were constructed so that the signs could easily be removed for evaluation.

This study was conducted for 10 years to adequately document the loss of reflectivity with time, especially to the point at which the signs were no longer considered adequate for actual signing.

The combination of brands, grades, and colors of sheeting that were tested is presented in Table 1. Five signs of each sheeting type were tested for reflective intensity. In addition to reflectivity tests on the various sheeting types, five white samples from each brand (engineer grade for those brands had multiple grades) of sheeting were selected for stone-bruising and cold-cracking studies.

Thus, the total number of signs used in the test was 125. The test signs were aluminum backed and 15 in. square. The size of the sign was determined by the area actually tested (a 10.5-in. circle) with the photometer and retroreflectometer. All photometer and retroreflectometer tests were taken at a divergence angle of 0.2 degree and at incidence angles of −4 degrees and +30 degrees.

STANDARD SPECIFICATIONS

The DOT 1975 Standard Specifications Section 637.2.2.1, Standard Reflective Sheeting, states that sign face materials shall comply with Federal Specification L-S-300A. A newer federal specification, L-S-300B, may be referred to by the state in future supplemental specifications. Because the state specifies compliance with the federal specification, it is desirable to develop a test program complying as closely as possible with L-S-300B (to ensure measurements with an accuracy and precision as high as possible with the state's photometer).

TABLE 1 COMBINATION OF BRANDS, GRADES, AND COLORS OF SHEETING TESTED

Sheeting Type	Sheeting Code	Brand Name	Grade	Color	Sign Numbers	Stone Bruised Sign Numbers
1	A	Adcolite	Engineer	White	1-5	91-95
2			Engineer	Yellow	46-50	...
3	X	Fasign	Engineer	White	6-10	96-100
4			Engineer	Yellow	51-55	...
5	O	Fasign	Construction	White	11-15	
6			Construction	Yellow	56-60	
7	K	Maclite	--	White	16-20	101-105
8			--	Yellow	61-65	
9	J	Scotchlite	Type "H"	White	21-25	
10			Type "H"	Yellow	66-70	
11	F	Scotchlite	Engineer	White	26-30	106-110
12			Engineer	Yellow	71-75	
13	D	Scotchlite	Level "B"	White	31-35	
14			Level "B"	Yellow	76-80	
15	Y	Seibulite	---	White	36-40	111-115
16			---	Yellow	81-85	
17	T	Toshiba	Engineer	Yellow	86-90	
18	W	Kewalite	Engineer	White	126-130	121-125
19		Kewalite	Engineer	Yellow	131-135	

PROCEDURES

Because reflective sheeting does not have a uniform reflective intensity from batch to batch, roll to roll, or even within the same roll, it was important and special efforts were made to fabricate the test signs from broad samples of sheeting. Thus, the sheeting for duplicate signs (signs of the same sheeting type) was taken from various transverse and longitudinal positions in the same roll and from different rolls and batches. Shortly after sign fabrication and before field placement the signs were tested with the photometer to establish the initial reflective intensity. On completion of the initial testing the signs were placed in their respective positions in the racks (placed vertically and facing south). The signs remained in the racks for 6 months. They were then washed with water and a sponge. After washing, the signs were taken from the racks, placed in their respective slots in the carrying case and taken to the Research Section in Madison. After testing, the signs were returned to the racks. The same procedure was used in subsequent testing. Great care was exercised in the handling of the signs to ensure that they were not damaged.

Signs set apart for stone-bruising studies were bruised artificially with a spring-loaded center punch to simulate actual stone bruising. The point of the punch was ground to a blunt surface so that it bruised the sheeting but did not dent the aluminum. The artificial stone bruising was done after fabrication of the signs and before testing for initial reflective intensity. (The same testing procedure was followed for these signs as was followed for the nonbruised signs). Each sign made specifically for stone bruising received four artificial bruises. The number of linear inches of cold cracking was documented annually for both the stone bruised and the regular signs.

DISCUSSION OF RESULTS

The focus of this report is on findings, not the causes giving rise to those findings. The average reflective intensity values are presented in Table 2 and are in units of candlepower per foot − candle per square foot ($cp/ft - cd/ft^2$). The cold cracking values are presented in Table 3 and are in units of linear inches per square foot. Discussions of reflectivity and cold cracking for each sheeting type follow.

Adcolite Engineer Grade (White)

Adcolite white sheeting proved to be durable, but the reflectivity was not as high as some of the other sheetings in the test. When reflectivity was measured with an incidence angle of −4 degrees, it had a high value of 104.4*R* (R = retroreflectivity = $cp/ft - cd/ft^2$) and a low value of 73.6*R*, which was above the state's specification (compliance with Federal Specifications L-S-300A) for new sheeting. When reflectivity

TABLE 2 REFLECTIVITY DATA

		Incidence Angle					
		−4 Degrees			+30 Degrees		
Brand	Grade	White	White Stone Bruised	Yellow	White	White Stone Bruised	Yellow
March 1, 1977 Test							
Adcolite	Engineer	92.9	95.3	53.8	35.6	36.5	29.2
Fasign	Engineer	110.7	113.6	61.3	65.3	66.9	32.0
Fasign	Construction	110.8	[a]	62.5	69.5	[a]	32.4
Kewalite	Engineer	[a]	[a]	[a]	[a]	[a]	[a]
Maclite	Engineer	128.6	127.1	85.1	76.8	84.4	76.4
Scotchlite	Engineer	102.0	101.1	74.6	53.8	55.0	35.0
Scotchlite	Level B	66.6	[a]	72.1	40.5	[a]	28.4
Scotchlite	Type H	301.6	[a]	208.5	213.6	[a]	180.3
Seibulite	Engineer	114.4	116.9	85.1	66.4	66.5	53.6
Toshiba	Engineer	[a]	[a]	62.7	[a]	[a]	47.0
April 20, 1983 Test							
Adcolite	Engineer	85.5	93.2	61.1	27.5	29.2	31.1
Fasign	Engineer	55.2	51.1	21.9	29.0	29.0	11.7
Fasign	Construction	69.4	[a]	25.4	39.3	[a]	12.8
Kewalite	Engineer	124.5	124.4	111.2	65.2	65.2	55.4
Maclite	Engineer	[b]	[b]	4.5	[b]	[b]	4.1
Scotchlite	Engineer	102.0	102.3	79.8	55.4	56.7	34.0
Scotchlite	Level B	49.9	[a]	81.3	32.9	[a]	33.3
Scotchlite	Type H	275.9	[a]	218.5	183.3	[a]	179.2
Seibulite	Engineer	78.1	73.6	87.1	59.5	56.1	60.4
Toshiba	Engineer	[a]	[a]	105.1	[a]	[a]	62.6
March 18, 1987 Test							
Adcolite	Engineer	73.6	81.6	51.6	23.1	23.8	26.6
Fasign	Engineer	[b]	[b]	[b]	[b]	[b]	[b]
Fasign	Construction	[b]	[a]	[b]	[b]	[a]	[b]
Kewalite	Engineer	23.6	32.9	22.4	12.1	15.6	13.3
Maclite	Engineer	[b]	[b]	[b]	[b]	[b]	[b]
Scotchlite	Engineer	90.2	87.2	65.9	48.9	50.3	32.1
Scotchlite	Level B	36.0	[a]	63.1	28.3	[a]	31.1
Scotchlite	Type H	243.9	[a]	165.2	139.9	[a]	149.1
Seibulite	Engineer	43.6	40.2	84.4	43.4	39.6	55.9
Toshiba	Engineer	[a]	[a]	[b]	[a]	[a]	[b]

NOTE: Values are in units of candlepower per foot-candle per square foot.
[a]Not tested.
[b]Retired because of poor results.

was measured at an incidence angle of +30 degrees, the high value was 36.5*R* and the low value was 23.1*R*. The low value is below the specifications for new sheetings, but is still above the usable specifications. Stone bruising had little effect on the reflectivity. Adcolite was one of the first sheetings in this study to start cold cracking. At the conclusion of the study, it also had one of the largest amounts of cold cracking. The cold cracking began after fewer than 2 years. The final average value was 149.6 linear in./ft^2.

The cold cracks, many of which started from the stone bruises, did not affect the reflectivity as much as they affected the reflectivity of some of the other sheeting types.

Adcolite Engineer Grade (Yellow)

Adcolite yellow sheeting also proved to be durable, but it had lower reflectivity than most of the sheetings in this study. At a −4-degree incidence angle it had a high reading of 63.6*R* and a low value of 51.6*R*, which was above specifications for new sheeting. At a +30-degree incidence angle it had a high value of 34.8*R* and a low value of 26.6*R*, which was also above specifications for new sheeting. The yellow did not fade much, as did some of the other sheetings.

The yellow Adcolite also started cold cracking early and had a large amount of cold cracking at the conclusion of the study. It started cracking after 2.2 years and had 75.3 linear in./ft at the conclusion of the study. Again, the cold cracking did not affect the reflectivity as much as it did some of the other types of sheetings. Although the numbers appeared high, the cracks were fine and did not substantially affect the reflectivity of the signs.

Fasign Engineer Grade (White)

Fasign Engineer Grade white sheeting was extremely reflective for approximately the first 4 years, but it had a short life

TABLE 3 COLD CRACKING DATA

Brand	Grade	Cold Cracking (Linear in./ft²) White	White Stone Bruised	Yellow
March 1, 1977 Test				
Adcolite	Engineer	0.0	0.0	0.0
Fasign	Engineer	0.0	0.0	0.0
Fasign	Construction	0.0	[a]	0.0
Kewalite	Engineer	[a]	[a]	[a]
Maclite	Engineer	0.0	0.0	0.0
Scotchlite	Engineer	0.0	0.0	0.0
Scotchlite	Level B	0.0	[a]	0.0
Scotchlite	Type H	0.0	[a]	0.0
Seibulite	Engineer	0.0	0.0	0.0
Toshiba	Engineer	[a]	[a]	0.0
April 20, 1983 Test				
Adcolite	Engineer	42.0	39.3	21.6
Fasign	Engineer	3.5	7.0	1.7
Fasign	Construction	4.1	[a]	0.5
Kewalite	Engineer	48.9	48.6	34.4
Maclite	Engineer	[b]	[b]	3.6
Scotchlite	Engineer	31.7	46.1	4.0
Scotchlite	Level B	[c]	[a]	5.4
Scotchlite	Type H	0.0	[a]	0.0
Seibulite	Engineer	0.0	0.0	0.0
Toshiba	Engineer	[a]	[a]	48.6
March 18, 1987 Test				
Adcolite	Engineer	149.6	124.9	75.3
Fasign	Engineer	[b]	[b]	[b]
Fasign	Construction	[b]	[a]	[b]
Kewalite	Engineer	[c]	[c]	[c]
Maclite	Engineer	[b]	[b]	[b]
Scotchlite	Engineer	130.9	177.8	45.6
Scotchlite	Level B	[c]	[a]	39.0
Scotchlite	Type H	0.4	[a]	8.7
Seibulite	Engineer	0.1	0.0	0.0
Toshiba	Engineer	[a]	[a]	[b]

[a]Not tested.
[b]Retired because of poor results.
[c]More than 224 linear in./ft².

span. It was retired in 1984 after a service life of approximately 7 years. At a −4-degree incidence angle, it had a high value of 124.9*R* and a low value of 24.8*R* when it was retired. It dropped below the usable specification range at approximately 6.5 years. At a +30-degree incidence angle it had a high value of 79.0*R* and a low value of 7.8*R* when it was retired. It dropped below the usable specification range for this angle at 7 years. Stone bruising had little effect on the reflectivity.

Cold cracking was not a big problem with the Fasign sheeting. Cold cracks could not be seen for more than 5.5 years. Cracking started in October 1982 and measured 20.7 linear in./ft² when the sheeting was retired. The cold cracking seemed to decrease the reflectivity.

Fasign Engineer Grade (Yellow)

Fasign Engineer Grade yellow sheeting did not prove to be substantially reflective or durable. At a −4-degree incidence angle, it had a high value of 79.0*R* and a low value 7.8*R*. It dropped below usable specifications in fewer than 5 years and was retired in April 1984. At a +30-degree incidence angle it had a high value of 42.7*R* and a low value of 6.4*R* when it was retired. It dropped below usable specification after 6 years. The yellow coloring faded moderately.

Cold cracking was not a problem. It began in April 1983 after 6 years of weathering. When it was retired, the sheeting had 16.1 linear in./ft² of cold cracking, which did not appear to decrease the reflectivity.

Fasign Construction Grade (White)

Fasign Construction Grade white sheeting was similar to Fasign Engineer Grade. The reflectivity and cold cracking data proved to be consistently higher than the Engineer Grade but was close. This sheeting also proved to be less durable than the other reflective sheetings tested. At a −4-degree incidence angle it had a high value of 127.2*R* and a low value of 18.1*R* when it was retired in April 1984. It dropped below usable specifications for approximately 7 years. At a +30-degree incidence angle it had a high value of 127.2*R* and a low value of 18.1*R*. It dropped below specifications for approximately 7 years.

Cold cracking was not excessive, but it did appear to affect the reflectivity. When the cold cracking began, the reflectivity dropped rapidly. It started after 6.2 years and increased to 27.6 linear in./ft.

Fasign Construction Grade (Yellow)

Fasign Construction Grade yellow sheeting performed poorly. The initial reflectivity was low compared with the other sheeting tested, and this sheeting had a short life span. For a −4-degree incidence angle it had a high value of 78.7*R* and a low value of 10.7*R* when retired in April 1984. At a +30-degree incidence angle it had a high value of 43.3*R* and a low value of 7.7*R* at retirement. It dropped below usable specifications after approximately 7 years. The yellow also faded substantially.

Cold cracking was not excessive. It began in April 1983, and when the signs were retired in 1984 cold cracks measured 7.4 linear in./ft². The cold cracking seemed to increase the loss in reflectivity.

Kewalite Engineer Grade (White)

Kewalite Engineer Grade white sheeting performed fairly well. It consistently had the highest reflectivity readings but dropped quickly after 7 years. At a −4-degree incidence angle it had a high reading of 135.7*R*, which was the highest reading of all the sheetings tested. It had a low reading of 23.6*R*. It dropped below allowable specifications after approximately 9 years. At a +30-degree incidence angle it had a high value of 84.9*R* and a low value of 12.1*R*. It dropped below usable specifications after approximately 9.5 years. Stone bruising did not seem to affect the reflectivity.

Cold cracking was substantial for the Kewalite, and it seemed to be directly related to the decrease in reflectivity. It began

after 5.2 years and increased quickly to more than 224 linear in./ft^2 by the end of the test.

Kewalite Engineer Grade (Yellow)

Kewalite Engineer Grade yellow sheeting performed fairly well. It consistently had the highest reflectivity, but it dropped quickly after 7 years. It did have a few major flaws. It faded to the same color as the white sheeting after only 6 years. At a −4-degree incidence angle it had a high value of 123.6*R* and a low value of 22.4*R*. It dropped below the usable specification after 9 years. At a +30-degree incidence angle it had a high value of 68.5*R* and a low value of 13.3*R*. It dropped below usable specifications for this angle after 9 years.

Cold cracking was substantial. This sheeting had by far the highest amount of cold cracking of any of the yellow reflective sheetings. The cracking started after 6.2 years and increased quickly to more than 224 linear in./ft^2 by the conclusion of the study.

Scotchlite Level B Grade (White)

Scotchlite Level B Grade sheeting did not perform well. At a −4-degree incidence angle it had a high value of 66.6*R*, which is below specifications for new sheeting. It had a low value of 36*R* and dropped below usable specifications after approximately 4 years. At a +30-degree incidence angle it had a high value of 41.3*R* and a low value of 28.3*R*. It never dropped below usable specifications for this incidence angle.

Cold cracking was also a problem. It began after approximately 1.7 years and quickly increased to the limit of 224 linear in./ft^2 after 5.7 years. Although the amount of cold cracking was large, the cracks were fine and did not stand out as much as they did on many of the other sheetings tested.

Scotchlite Level B Grade (Yellow)

Scotchlite Level B Grade yellow performed fairly well. Although the reflective intensity was not as high as that of many of the other sheetings, the sheeting proved to be durable and had a long life. At a −4-degree incidence angle it had a high value of 81.3*R* and a low value of 63.1*R*, which never dropped below the specifications for new sheeting. At a +30-degree incidence angle it had a high value of 57.2*R* and a low value of 24.2*R*. Fading was insignificant after 10 years of testing.

Cold cracking was not a problem. It began after 3.3 years and reached a maximum value of 39.0 linear in./ft^2 after 10 years. Cold cracking appeared to have little effect on the reflectivity of the signs.

Scotchlite Engineer Grade (White)

Scotchlite Engineer Grade white sheeting was one of the best sheetings in the study. At a −4-degree incidence angle it had a high value of 117.4*R* and a low value of 90.2*R*, which was the highest reflectivity at the end of the study. This is also 20.2*R* above specifications for new sheeting. At a +30-degree incidence angle it had a high value of 64.9*R* and a low value of 48.9*R*, which was also the highest value for white sheeting after 10 years. Stone bruising had no effect on the reflectivity, but it caused some of the worst cold cracking on these signs.

Cold cracking, which began after 1.7 years, was fairly high but did not seem to affect the reflectivity. At the conclusion of the test, the sheeting had 130.9 linear in./ft^2 of cold cracks. These cold cracks were fine but darkened and consequently stood out more.

Scotchlite Engineer Grade (Yellow)

Scotchlite Engineer Grade yellow sheeting performed fairly well. It proved to be durable, but the reflectivity was somewhat lower compared with other sheetings tested. At a −4-degree incidence angle it had a high value of 79.8*R* and a low value of 65.9*R*, which never dropped below specifications for new sheeting. At a +30-degree incidence angle it had a high value of 37.4*R* and a low value of 31.4*R*, which was also above specifications for new sheeting. A minimal amount of fading occurred.

Cold cracking, which began after approximately 3.3 years, was not a problem with this sheeting. At the conclusion of the test the sheeting showed 45.6 linear in./ft^2 of cold cracking. These cracks did not seem to affect the reflectivity because they were extremely fine.

Seibulite Engineer Grade (White)

Seibulite Engineer Grade white sheeting performed very well. It had one of the best reflective intensity ratings in the first five years. At −4-degree incidence angle it had a high value of 126.3*R* and a low value of 43.6*R*. It never dropped below specifications and finished second most reflective at 10 years of age. Stone bruising did not affect the reflectivity.

Cold cracking resistance was excellent. The sheeting almost looked like new and was by far the most resistant to cold cracking. The final appearance of the sheeting was excellent.

Seibulite Engineer Grade (Yellow)

Seibulite Engineer Grade yellow sheeting performed very well. It started out as one of the most reflective yellow sheetings in the study. At a −4-degree incidence angle it had a high value of 89.5*R* and a low value of 83.7*R*. This value never dropped below specifications for new sheeting. In fact, it never came within 30*R* of specifications for new sheeting after 10 years of testing. At a +30-degree incidence angle it had a high value of 60.4*R* and a low value of 51*R*, which is 29*R* above specifications for new sheeting.

Cold cracking was nonexistent for this sheeting. It had the least amount of cold cracking of any of the yellow sheetings.

Toshiba Engineer Grade (Yellow)

Toshiba Engineer Grade yellow sheeting performed fairly well. It was reflective for approximately 6 years and then declined

quickly. At a −4-degree incidence angle it had a high value of 115.3*R*, which was the highest value for yellow sheeting. It had a low value of 18.8*R*, and it dropped below usable specifications after approximately 8 years. At a +30-degree incidence angle it had a high value of 78.6*R* and a low value of 11.6*R*. It dropped below usable specifications after 8 years and was retired after 8.2 years. Fading seemed to be a problem with this sheeting, which turned from bright yellow to light peach after only 5 years.

Cold cracking was fairly high for this sheeting. It began after approximately 5 years and increased quickly to 107.8 linear in./ft^2.

Maclite Engineer Grade (White)

Maclite Engineer Grade white sheeting started with high reflectivity but quickly dropped. At a −4-degree incidence angle it had a high reading of 128.6*R* and a low reading of 10.3*R* when it was retired in October 1982. It dropped below usable specifications after fewer than 4 years. At a +30-degree incidence angle it and a high value of 76.8*R* and a low value of 6.1*R* when it was retired. Stone bruising did not affect the reflectivity.

Cold cracking was not a problem for the first 3 years but increased dramatically thereafter. The clear coat blistered and fell off early in the test.

Maclite Engineer Grade (Yellow)

Maclite Engineer Grade yellow sheeting performed poorly. The reflectivity started out fairly high but dropped quickly. At a −4-degree incidence angle it had a high value of 85.1*R* and a low value of 2.9*R* when it was retired in 1982. At a +30-degree incidence angle it had a high value of 76.4*R* and a low value of 3.7*R* when it was retired. It dropped below specifications for usable sheeting in fewer than 4 years and was the worst yellow reflective sheeting in the test.

Although the numbers for cold cracking were low, they did not show the problems with this sheeting. Fifty percent of the clear covering on the face of the sheeting had blistered and peeled off by 1979; 80 percent did so by 1982. Cold cracking began after 6 years and increased to a maximum value of 40.6 linear in./ft^2 when the sheeting was retired in 1984.

Scotchlite Type H Grade (White)

Scotchlite Type H white sheeting had very high reflectivity. At a −4-degree incidence angle it had a high value of 307.7*R* and a low value of 243.9*R*. It dropped below specifications for new sheeting after approximately 9 years but never dropped below specifications for usable sheeting. At a +30-degree incidence angle it had a high value of 223.3*R* and a low value of 139.9*R*, which is above specifications for new sheeting.

Cold cracking was almost nonexistent, with only 0.4 linear in./ft^2 after 10 years of testing. Overall, this sheeting was excellent. This sheeting cannot be compared with the other sheetings in this test because it is a Type H sheeting and not a standard or engineering grade.

Scotchlite Type H Grade (Yellow)

Scotchlite Type H yellow sheeting was very reflective. At a −4-degree incidence angle it had a high value of 230.8*R* and a low value of 165.2*R*, which was above specifications for new sheeting. At a +30-degree incidence angle it had a high value of 199.5*R* and a low value of 149.1*R*, which was also above specifications for new sheeting.

Hardly any cold cracking was present in this sheeting; the few cold cracks that did occur were barely visible.

CONCLUSIONS

At the end of the 10-year study the white sheetings had the following average reflective intensities at an incidence angle of −4 degrees:

- Adcolite Engineer Grade: 73.6*R*,
- Fasign Engineer Grade: retired in 1984,
- Fasign Construction Grade: retired in 1984,
- Kewalite Engineer Grade: 23.6*R*,
- Maclite Engineer Grade: retired in 1982,
- Scotchlite Engineer Grade: 90.2*R*,
- Scotchlite Level B: 36.0*R*,
- Scotchlite Type H: 243.9*R*,
- Seibulite Engineer Grade: 43.6*R*, and
- Toshiba Engineer Grade: not tested.

The reflective intensities for the following white sheetings were high: Scotchlite Type "H," Scotchlite Engineer Grade, Adcolite Engineer Grade, and Seibulite Engineer Grade. The reflective intensities for Fasign Engineer Grade, Fasign Construction Grade, and Maclite-Engineer Grade were extremely low, and consequently the sheetings were retired before the end of the test period.

At the end of the 10-year study, the yellow sheetings had the following average reflective intensities at an incidence angle of −4 degrees:

- Adcolite Engineer Grade: 51.6*R*,
- Fasign Engineer Grade: retired in 1984,
- Fasign Construction Grade: retired in 1984,
- Kewalite Engineer Grade: 22.4*R*,
- Maclite Engineer Grade: retired in 1982,
- Scotchlite Engineer Grade: 65.9*R*,
- Scotchlite Level B: 63.1*R*,
- Scotchlite Type H: 165.2*R*,
- Seibulite Engineer Grade: 84.4*R*, and
- Toshiba Engineer Grade: not tested.

The reflective intensities for the following yellow sheetings were high: Scotchlite Type "H," Seibulite Engineer Grade, and Scotchlite Engineer Grade. Fasign Engineer Grade, Fasign Construction Grade, Maclite Engineer Grade, and Toshiba Engineer Grade sheetings were retired because of poor reflectivity and fading color.

At the end of the study cold-cracking measurements for the white reflective sheetings were as follows:

- Adcolite Engineer Grade: 149.6 linear in./ft^2,
- Fasign Engineer Grade: retired because of poor results,

- Fasign Construction Grade: retired because of poor results,
- Kewalite Engineer Grade: excessive cold cracking,
- Maclite Engineer Grade: retired because of poor results,
- Scotchlite Engineer Grade: 130.9 linear in./ft^2,
- Scotchlite Level B: excessive cold cracking,
- Scotchlite Type H: 0.4 linear in./ft^2,
- Seibulite Engineer Grade: 0.1 linear in./ft^2, and
- Toshiba Engineer Grade: not tested.

Seibulite Engineer Grade and Scotchlite Type H sheeting had virtually no cold cracking. The rest of the sheetings were susceptible to cold cracking and cracked severely.

At the end of the study the cold-cracking measurements for the yellow sheetings were as follows:

- Adcolite Engineer Grade: 75.3 linear in./ft^2,
- Fasign Engineer Grade: retired because of poor results,
- Fasign Construction: retired because of poor results,
- Kewalite Engineer Grade: excessive cold cracking,
- Maclite Engineer Grade: retired because of poor results,
- Scotchlite Engineer Grade: 45.6 linear in./ft^2,
- Scotchlite Level B: 39.0 linear in./ft^2,
- Scotchlite Type H: 8.7 linear in./ft^2,
- Seibulite Engineer Grade: 0 linear in./ft^2, and
- Toshiba Engineer Grade: retired because of poor results.

The Seibulite Engineer Grade and Scotchlite Type H yellow sheetings showed virtually no cold cracking. The rest of the sheetings were susceptible to cold cracking and cracked severely.

Stone bruised white sheeting did not have significant increased cold cracking when compared with non-stone-bruised white sheeting. The reflectivity of white stone-bruised sheeting was almost the same as the white non-stone-bruised sheetings.

RECOMMENDATIONS

On the basis of the 10-year evaluation of reflective sheetings, the following recommendations appear to be warranted: Scotchlite Type H, Scotchlite Engineer Grade, and Seibulite Engineer Grade sheetings are recommended for high reflectivity, minimal cold cracking, and durability. Fasign Engineer Grade, Fasign Construction Grade, Maclite Engineer Grade, and Toshiba Engineer Grade sheeting should not be used because of poor reflectivity, excessive cold cracking, and shorter life.