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TNO report

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Evaluation of the durability of 15 year old polycarbonate roofing material from the Amsterdam ArenA

Date 18 October 2010
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Project number

Classification report
Title
Abstract
Report text
Appendices

Number of pages 8 (incl. appendices)
Number of appendices

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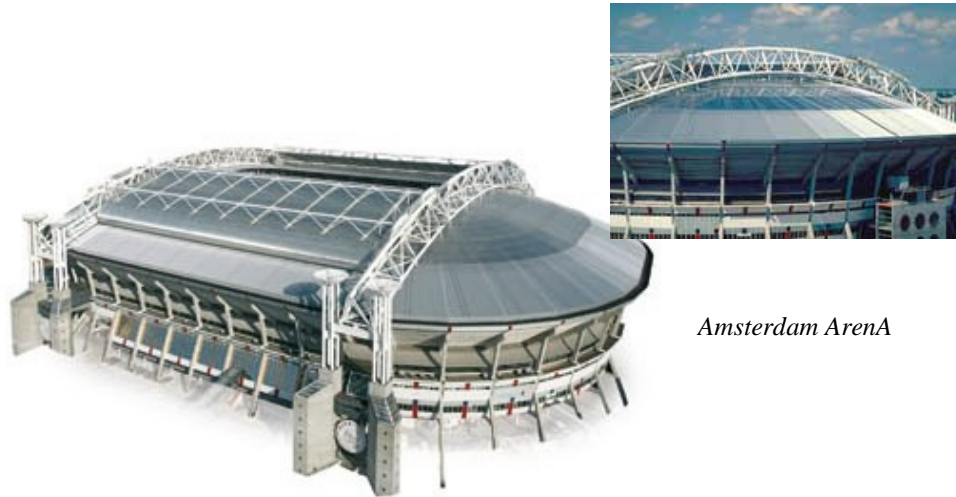
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1 Introduction

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As an independent research organisation TNO Science and Industry, represented by P.C.G. Langeveld B.Sc., was asked to witness the execution of the evaluation of the durability of multi wall polycarbonate (PC) sheet, type LTC16/3NS3000-112, that has been used for 15 years as the overall roof of the Amsterdam Arena.



Amsterdam Arena

The evaluation consisted of the determination of the transparency, the colour, yellowness index, the thickness of the coating, all been carried out at the testing facilities of Sabic Innovation Plastics, Plasticslaan 1, Bergen op Zoom (The Netherlands) and the tensile properties, carried out at TÜV Rheinland, De Rondom 1, Eindhoven (The Netherlands). For comparative purposes the same testing programme has been executed on unused multi wall sheet of the same type, originating from the stock of Sabic Innovative Plastics.

The witnessing took place on October 11th, 2010.



Area where sheets were removed for evaluation



2 Sample material

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On behalf of the investigation two samples of multiwall polycarbonate sheet were present at the location of Sabic Innovative Plastics, one sample called “aged”, pulled from the roof of the Amsterdam ArenA by Licotec Daklicht B.V., Duiven (NL) and one sample called “unaged” from the stock of Sabic Innovative Plastics. The multiwall sheet was single side UV-protected by means of a coating. The Figures 1 - 4 give an impression of the samples.



Figure 1: Unaged multi wall PC sheet.



Figure 2: Aged multi wall PC sheet.

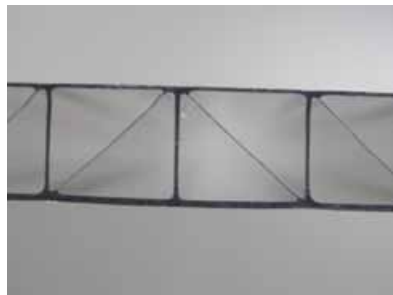


Figure 3: Cross section of unaged material.

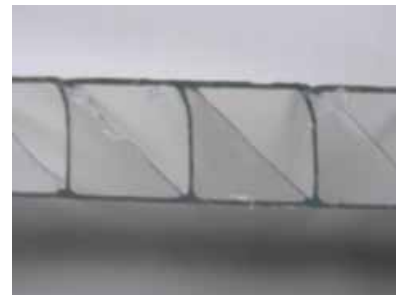


Figure 4: Cross section of aged material.

To determine the coated sample the following procedure has been followed:
Put one drip of concentrated sulphuric acid on the surface of the sheet, wait for several seconds and then remove the sulphuric acid by rinsing with water. In case a coating is present a grey spot is visible (see Figures 5 and 6).



Figure 5: Unaged material.



Figure 6: Aged material.

3 Test programme and results

3.1 Test programme

The evaluation of the durability was based on the following tests:

1. Determination of the light transmittance LT in accordance with ASTM D1003: Equipment Haze Guard Dual (BYK Gardner);
2. Determination of the yellowness index YI: 2° observer angle and light source C;
3. Determination of the colour: UV excluded, gloss included, 10° observer angle, light source D65;
4. Determination of the thickness of the coating;
5. Determination of the tensile properties.

The tests 1-4 have been carried out at the test facilities of Sabic Innovative Plastics, Bergen op Zoom and the tensile properties have been determined at TÜV Rheinland, location Eindhoven, a RvA accredited laboratory.

3.2 Test results

The results of the tests carried out at Sabic Innovative Plastics are summarised in Table 1 and 2. Table 3 gives the relative changes of the multiwall sheet after 15 years of use. The results of the tensile test are given in Table 4.

Table 1: Properties of multiwall sheet “unused”.

Sample	Colour			Yellowness Index		Light transmittance
	L*	A*	B*	YID1925	YIE313	LT HG Dual
1	84.97	-0.09	0.69	1.48	0.91	71.0
2	85.04	-0.10	0.67	1.44	0.88	70.6
3	86.76	-0.14	0.82	1.69	1.12	71.9
4	87.07	-0.15	0.74	1.48	0.94	70.5
Average	85.96	-0.12	0.73	1.52	0.96	71.0
St. dev.	1.11	0.03	0.07	0.11	0.11	0.64
N=	4	4	4	4	4	4

Table 2: Properties of multiwall sheet “used” from the Amsterdam ArenA roof.

Sample	Colour			Yellowness Index		Light transmittance
	L*	A*	B*	YID1925	YIE313	LT HG Dual
1	85.44	-0.57	1.50	2.55	2.13	70.3
2	84.38	-0.58	1.71	3.00	2.52	69.7
3	85.43	-0.53	1.50	2.59	2.15	70.0
4	84.52	-0.57	1.80	3.17	2.65	69.5
Average	84.94	-0.56	1.63	2.83	2.36	69.88
St. dev.	0.57	0.02	0.15	0.31	0.26	0.35
N =	4	4	4	4	4	4

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Table 3: Relative changes after 15 years of use in the roof of the Amsterdam Arena.

	Colour			Yellowness Index		Light transmittance LT HG Dual	Coating thickness []
	L*	A*	B*	YID1925	YIE313		
Difference Δ	-1.02	-0.44	0.90	1.31	1.40	-1.12	-2.33

Despite that the difference between the coating thickness of the unused and the used sheet is acceptable, this rather large difference might be caused by either the use of the sheet or by the production or the location where the measurement took place. It was therefore decided to also measure the coating thickness of the used sheet at two different locations. One location was the exposed part of the sheet and the other location where the sheet had been covered with aluminium tape on behalf of fastening the sheet in the profile of the construction.

An overview of the results is given below.

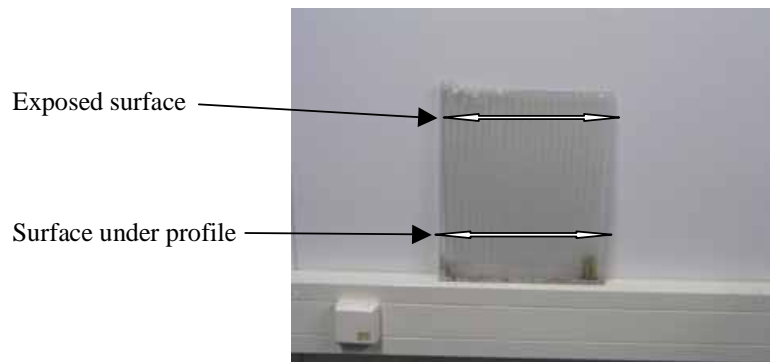


Figure 7: Location of the measurements.

Table 4: Coating thickness of used sheet.

Channel	Location	
	Exposed surface	Surface under profile
1	6.852	6.168
1	6.945	6.519
2	6.671	6.176
2	6.595	6.137
3	6.296	6.296
3	7.029	6.291
4	6.682	6.086
4	6.627	6.380
5	6.739	6.224
5	6.621	6.104
Average	6.71	6.24
St. dev.	0.21	0.14

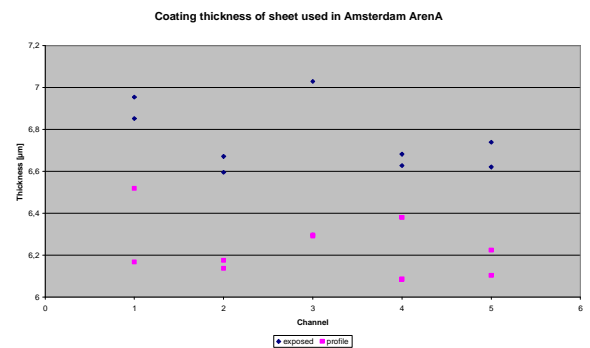


Figure 8: Chart of the coating thickness of the used sheet.

From the results it can be concluded that there is no erosion of the coating layer.

Tensile properties

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The tensile properties have been determined in accordance with ISO 527, part 1 and 2 under the following conditions:

Specimen type : 1BA
 Distance between grips : 60 mm
 Number of specimens : 6
 Speed E-modulus : 1 mm/min
 Tensile speed : 25 mm/min
 Conditions : (23±2)°C and (50±5)% RH

Table 4: Results of the tensile test.

Sample	E-modulus [MPa]	Yield strength [MPa]	Elongation at break [%]	Tensile strength [MPa]
Unused				
Used				
Difference Δ				

Note: The value between brackets (..) is the standard deviation.

4 Signature
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Eindhoven, October 2010

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