# Concrete Water Immersion and Accelerated Weathering Testing

Cancarb performed testing of Thermax® N990 and Carbocolor as pigments in concrete. Loadings of 5.5% by weight of solids were used. Previous studies have shown that the addition of Thermax® imparts a dark grey color with a blue undertone while also providing excellent weathering. Results in this study confirmed that Thermax® can provide excellent UV protection, water resistance, and weathering resistance to concrete. In particular, QUV® accelerated weathering results were superior to those obtained using black iron oxide ($Fe_3O_4$).

## The benefits of Thermax® N990 and Carbocolor in concrete include:

- **Improved weathering resistance**
- **No visible signs of pigment migration**
- **No oxidation or reduction of pigment**
- **Excellent grey to black coloring with blue undertone**

The concrete formulations can be found in Table 1. The pigments used in this study were Thermax® N990, Carbocolor, and Black Oxide 340 ($Fe_3O_4$). Water, Tamol 165, pigment, and sand were dispersed at 1000 RPM for 30 minutes, then cement was added under agitation. The mixture was dispersed for an additional 15 minutes until all the cement was wetted out. Part of the mixture was separated and premixed with the gravel. The bulk of the mixture was poured halfway into a mold, then the gravel premix was poured into the center of the mold. The remaining portion of the mixture was then poured over the gravel premix to fill the mold. Vibration was used to release entrapped air in the mixture. The contents of the mold were allowed to cure overnight at room temperature until fully cured. The next day the brick pavers were released from the mold and allowed to continue to cure for 28 days at room temperature. After full curing of 28 days, the pavers were washed with a mild acid to remove surface alkali. All pavers were then rinsed with deionized (D.I.) water and allowed to air dry. After air drying, all pavers were placed in a low temperature incubator at 90°F for 24 hours to remove all water. The CIELAB color data of the bricks can be found in Table 2.

Two test methods were used to evaluate the brick performance. The first test method was ASTM G154, Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials. The bricks were placed in a QUV accelerated weathering cabinet, manufactured by Q-Lab, containing UVA-340 lamps with an irradiance of 0.77 $W/m^2$. They were exposed to 24-hour cycles of 16 hours of UV light at 60°C and 8 hours of condensation at 50°C for a total of 750 hours.

The second test method was ASTM D870, Standard Practice for Testing Water Resistance of Coatings Using Water Immersion, modified for concrete pavers. The pavers were submerged in water in an Nuaire IR Autoflow Incubator for 30 days with continuous heat. Spacers were placed under the pavers to allow for full exposure. During this test, there was no observable migration of the pigment from the pavers to the water.

Performance ratings and pictures of the samples can be found in Table 3 and Figures 1 to 3.

**Table 1. Concrete formulations**

| Material | Amount (g) | % By Weight of Solids |
|---|---|---|
| Sand (#2 Grade) | 1592 | 49.1% |
| Gravel | 300 | 9.3% |
| **Pigment** | **182** | **5.6%** |
| Water (D.I.) | 546 | N/A |
| Cement (Portland I & II) | 1164 | 35.9% |
| Dow Tamol 165 | 9 | 0.06% |
| **Total Solids** | 3240 | 100% |

**Table 2.** CIELAB color data of concrete bricks. N990 and Carbocolor provide a darker color with a more green-blue undertone than black iron oxide.

| Pigment | L* | a* | b* |
|---|---|---|---|
| **Thermax® N990** | 27.8 | -0.3 | -1.8 |
| **Carbocolor** | 27.0 | -0.3 | -1.7 |
| **Black Oxide 340** | 28.6 | 0.1 | -0.6 |

L* is the lightness value from black (0) to white (100)
a* is the green (-) to red (+) value
b* is the blue (-) to yellow (+) value

**Table 3.** Change Ratings of samples after QUV accelerated weathering and water immersion testing. Carbocolor had the best performance followed by Thermax® N990. Black iron oxide performed the worst in both sets of tests.

| | | **ASTM G154-16** | | **ASTM D870-15** | |
|---|---|---|---|---|---|
| | | QUV Accelerated Weathering | | Water Immersion | |
| **Pigment** | **NSA ($m^2/g$)** | **500 hrs exposure** | **750 hrs exposure** | **15-day exposure** | **30-day exposure** |
| Carbocolor | 11.1 | 9 | 8 | 8 | 6 |
| Thermax® N990 | 9.6 | 9 | 8 | 6 | 4 |
| Black Oxide 340 | | 6 | 4 | 6 | 4 |

*Change Rating Scale: 0 (very severe) to 10 (negligible or no effect)

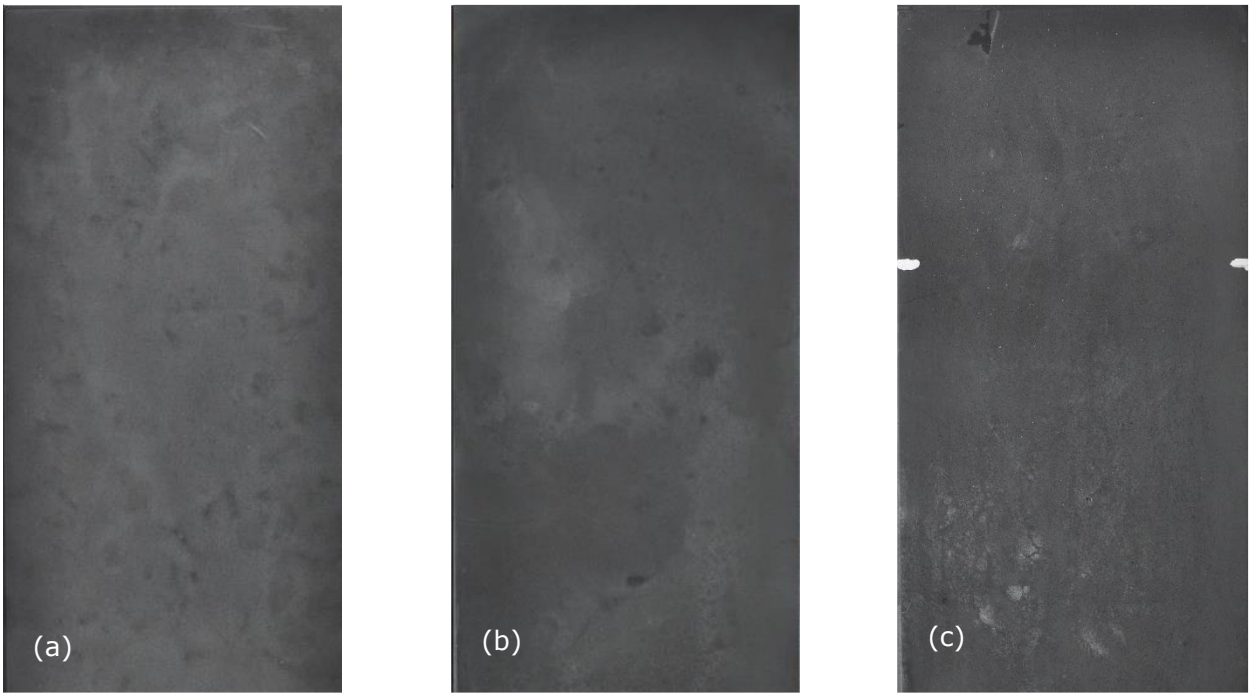


**Figure 1.** Pictures of (a) Thermax® N990 control brick, (b) Thermax® N990 brick after water immersion testing, and (c) Thermax® N990 brick after QUV exposure. The top of the QUV brick was masked off and not exposed to the lamp. Color changes on the surface of the brick were primarily due to efflorescence which occurs when salts in the concrete components migrate to the surface. This presents as white imperfections on the surface.

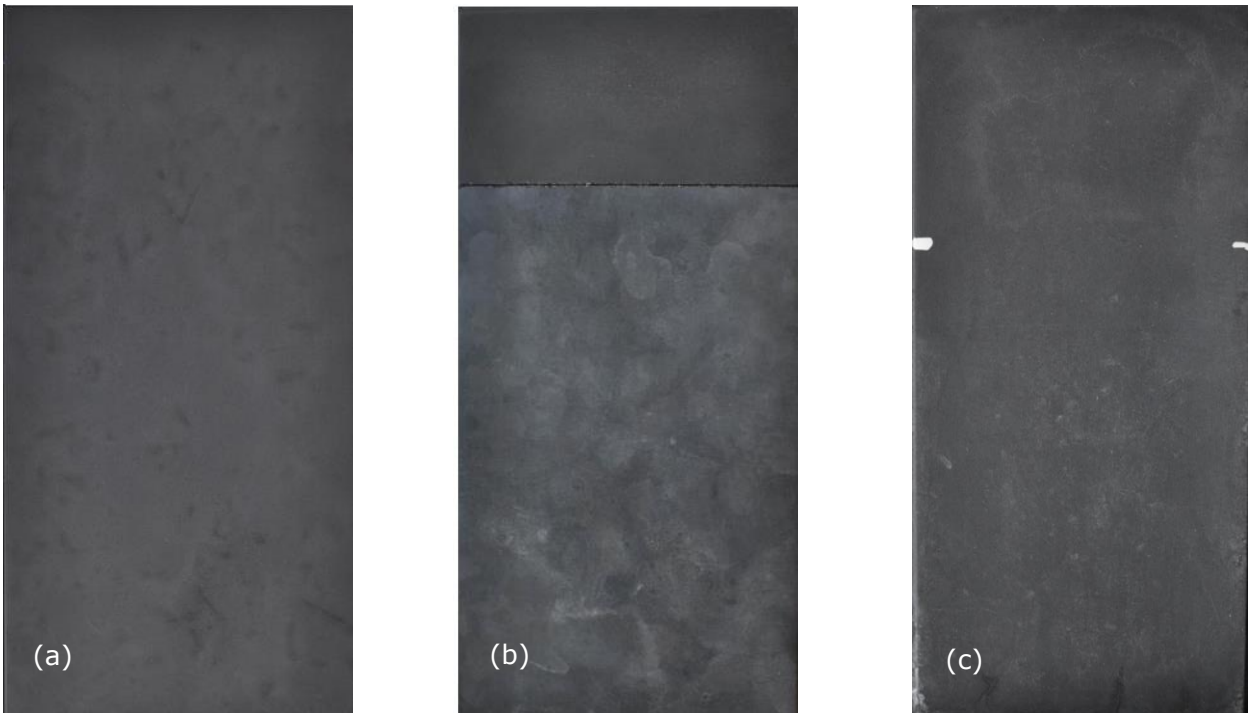


**Figure 2.** Pictures of (a) Carbocolor control brick, (b) Carbocolor brick after water immersion testing, and (c) Carbocolor brick after QUV exposure. The top of the water immersion brick was cleaned with a weak acid solution. The top of the QUV brick was masked off and not exposed to the lamp.

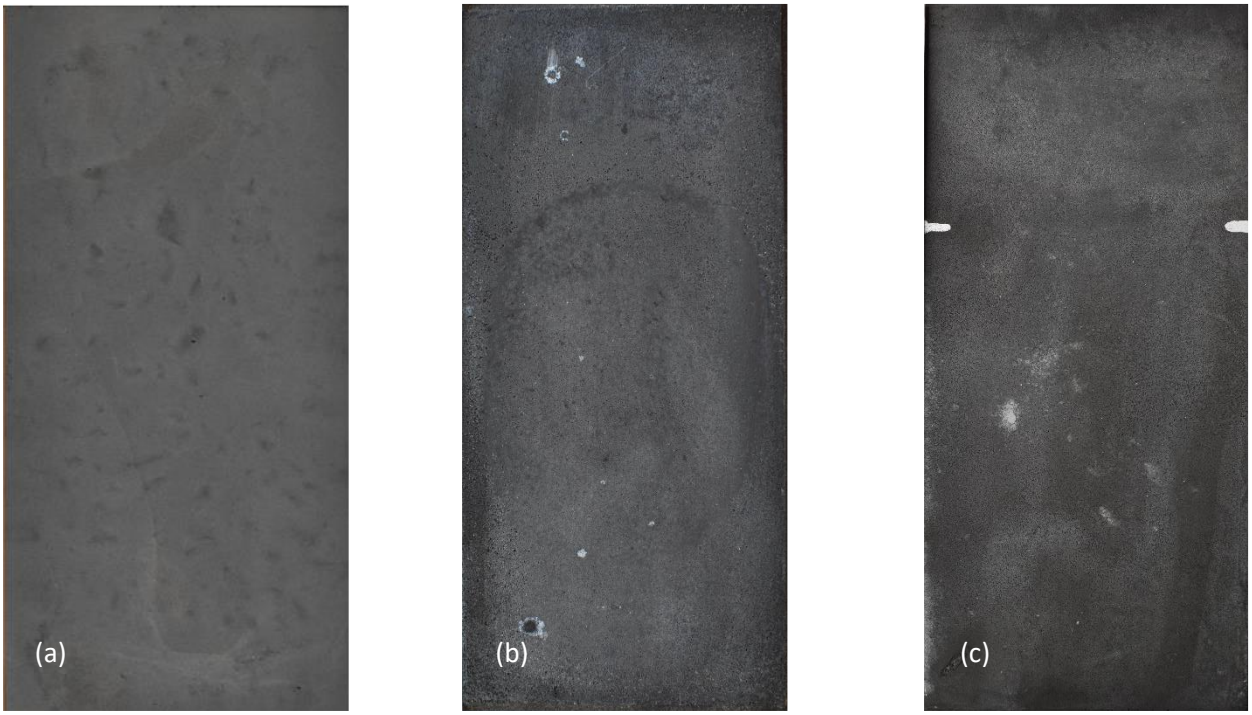


**Figure 3.** Pictures of (a) iron oxide control brick, (b) iron oxide brick after water immersion testing, and (c) iron oxide brick after QUV exposure. The top of the QUV brick was masked off and not exposed to the lamp.