Carbocolor for Concrete Pigmentation

Concrete can be pigmented to a dark grey colour using carbon black. Specifically, Carbocolor® is known to produce a dark grey coloured concrete with blue-green undertones instead of the yellow-red undertones realized with iron oxide. This low blue-green hue value is demonstrated by the a* and b* values during L*a*b* testing and becomes more prominent after aging. The large particle sized carbon black allows for effective colouring and mixing. A loading of 4% Carbocolor, based on total cementitious weight, is recommended. Excess pigment will not provide any additional benefits. To test properties of the cement, Carbocolor pigmentation was measured at 0%, 2%, and 4% loadings by weight. Samples were compared to a black iron oxide (Fe_3O_4) pigment at equal loadings.

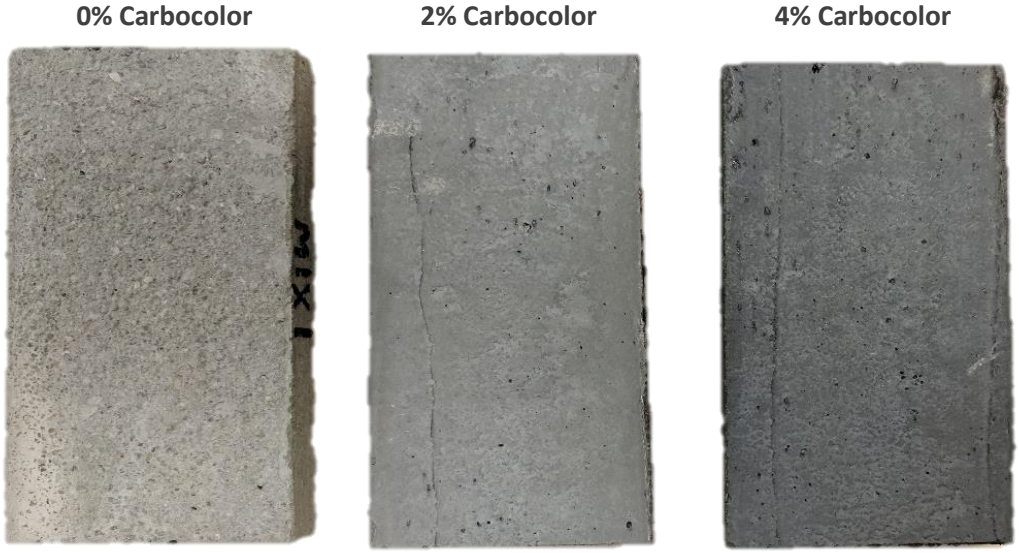


Figure 1. Concrete with Carbocolor at 0%, 2%, and 4% loadings. Note that exact colour depends on the concrete mixture used and may not exactly match those seen above. The concrete darkened with the addition of Carbocolor. This can allow for more heat storage in colder climates.

Colour and Weathering

The data in Table 1 shows that Carbocolor at equal loading provides more darkness, a more neutral undertone that is green-yellow as opposed to yellow-red, and comparable low gloss relative to its iron oxide counterpart in concrete.

Reservations regarding the use of carbon black for concrete colouring are typically concerned with weathering resistance of the coloured concrete. Carbocolor is the largest particle sized carbon black available. The large size limits the leaching of colour over time when exposed to the elements which occurs with other small particle size carbon blacks. Weathering testing was completed using cyclical xenon arc exposure over 1000 hours including spray cycles.[1] After 1000 hours of xenon arc weathering, the concretes with Carbocolor maintained their darkness and moved towards a blue-green hue, as can be seen in Tables 2 and 3. The shift from yellow to blue along the b* axis accounted for the majority of ΔE*. By comparison, the concrete with 4% iron oxide lightened in color

[1] General Motors Worldwide Standard 16146 for Xenon Weathering Testing

significantly which accounted for most of its ΔE*. Both concretes with iron oxide maintained the yellow-red undertone. Gloss was minimally affected by weathering.

Table 1. Initial concrete colour properties

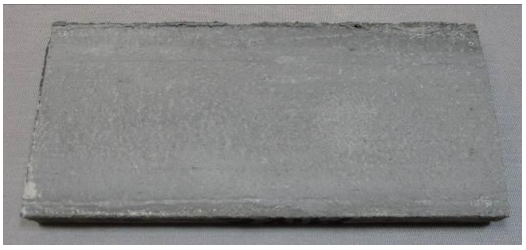
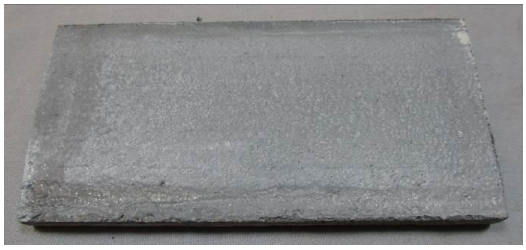
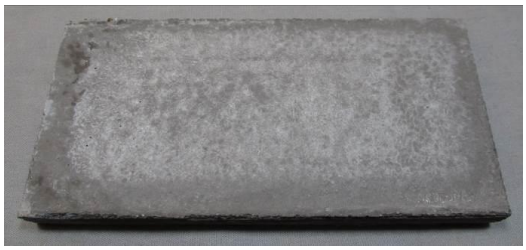
Concrete Colour	**Mix 1**	**Mix 2**	**Mix 3**	**Mix 4**	**Mix 5**
Carbocolor pigment, % by weight of cement	**-**	**2**	**-**	**4**	-
Iron Oxide pigment, % by weight of cement	-	-	2	-	4
Lightness (L*)	63.7	**51.5**	59.6	**45.7**	49.4
Green-Red (a*)[2]	0.0	**-1.0**	0.4	**-0.7**	0.6
Blue-Yellow (b*)[3]	4.4	**0.1**	3.3	**1.0**	2.3
Chroma (C*)[4]	4.4	**1.0**	3.4	**1.3**	2.4
Hue (h)[5]	89.7	**173.5**	83.4	**125.2**	75.0
Gloss 20°	0.9	**0.4**	0.6	**0.3**	0.4
Gloss 60°	0.9	**1.7**	1.9	**1.0**	1.2
Gloss 85°	0.1	**3.2**	0.8	**1.3**	0.8

Table 2. Final concrete colour properties after xenon arc weathering (SAE J2527)

Concrete Colour	**Mix 1**	**Mix 2**	**Mix 3**	**Mix 4**	**Mix 5**
Carbocolor pigment, % by weight of cement	**-**	**2**	**-**	**4**	-
Iron Oxide pigment, % by weight of cement	-	-	2	-	4
Lightness (L*)	65.1	**51.5**	59.8	**47.2**	55.3
Green-Red (a*)	-0.2	**-1.2**	0.4	**-1.1**	0.4
Blue-Yellow (b*)	3.7	**-1.5**	2.8	**-1.5**	0.4
Chroma (C*)	3.7	**1.9**	2.9	**1.9**	0.6
Hue (h)	92.7	**231.2**	82.3	**234.1**	42.8
ΔE*	1.6	**1.6**	0.6	**3.0**	6.2
Gloss 20°	0.6	**0.4**	0.5	**0.3**	0.4
Gloss 60°	0.9	**1.9**	1.8	**1.1**	1.2
Gloss 85°	0.1	**3.4**	1.6	**1.2**	0.8

[2] a* represents the green-red component, with a negative value indicating green and a positive value indicating red.
[3] b* represents the blue-yellow component, with a negative value indicating blue and a positive value indicating yellow.
[4] A neutral grey would have a chroma of zero.
[5] Hue goes from red (0°) to yellow (90°) to green (180°) to blue (270°) as angles around circle.

Table 3. Pictures of samples before and after xenon arc weathering tests

	Before Weathering	After Weathering
No pigment		
2% Carbocolor		
2% Iron Oxide		
4% Carbocolor		
4% Iron oxide		

Samples with Carbocolor were poured outside the Cancarb manufacturing plant in Medicine Hat, Alberta to observe the effects of the demanding climate. In Figure 2, the weathered concrete (right) shows little to no leaching or loss of colour, consistent with the lab results shown above.

Figure 2. Untouched (left) and weathered (right) samples of Carbocolor in concrete.

Mechanical Properties

Table 4. Concrete properties with the addition of 2% and 4% pigment

Concrete Properties	Mix 1	Mix 2	Mix 3	Mix 4	Mix 5
Carbocolor pigment, % by weight of cement	**-**	**2**	**-**	**4**	-
Iron Oxide pigment, % by weight of cement	-	-	2	-	4
Unit Weight, lb/ft³	151.4	**149.3**	151.1	**149.7**	148.7
Slump, in.	4.0	**4.5**	5.5	**5.0**	6.0
Air Content, %	1.0	**1.4**	1.5	**1.6**	0.9
Water-Cement Ratio	0.62	**0.62**	0.62	**0.62**	0.62
Workability (cohesiveness)	Good	**Good**	Good	**Slight Fluid**	Good
Initial Set (min)	249	**288**	277	**322**	287
Final Set (min)	327	**401**	369	**427**	381
28-day Compressive Strength (psi)*	5150	**5780**	5340	**4520**	4980

*average of three cylinders, except for the un-pigmented control, which was an average of two cylinders.