Concrete Colourant I

Thermal carbon black is manufactured by the thermal decomposition of natural gas. The thermal process provides a unique carbon black characterized by a large particle size and low particle aggregation which differs from the carbon black grades produced by the furnace black or lamp black processes. Cancarb thermal black is currently used in a wide variety of applications, from rubber and plastic products to metallurgical carbides and other advanced materials, due to its high purity.

Furnace and lamp blacks have been used in concrete applications in the past with great success in terms of colouring strength. Unfortunately, their durability was poor, forcing most concrete manufacturers to switch back to iron oxide for grey or black pigments. In addition to their tendency to fade over time, furnace and lamp blacks were also difficult to incorporate into concrete mixtures causing adverse effects on air entrainment and slump. Iron oxides have much lower tint strength than any of the carbon blacks, but have demonstrated higher durability than furnace and lamp blacks in concrete applications.

The very nature of portland cement renders the use of small particle carbon blacks as pigments impractical. There are several size classifications for pore structure in hydrated cement pastes.[1] The designations have been divided into two categories: capillary pores and gel pores. Gel pores typically have diameters of less than 10 nm making them insignificant for most grades of carbon black. Capillary pores are subcategorized into large (50 – 10,000 nm) and medium (10 – 50 nm) diameter sizes.

There are two mechanisms by which fading can occur in coloured concrete. The migration of a pigment from a concrete specimen will contribute to fading. The degradation of the pigment can also cause fading.

Under the assumption that a pigment occupies some of the pores of the concrete specimen, the large capillaries are inevitable escape routes. Thermal black, with an average particle diameter of approximately 280 nm and some degree of particle aggregation, could still be retained in the large capillaries falling in that size category. A large fraction of furnace black grades such as N550 (56 nm particle diameter) or N660 (67 nm particle diameter) would be able to escape through these capillaries and others with pore sizes much smaller than the vast majority of thermal black particles.

A common accusation made by iron oxide manufacturers is that carbon black pigments fade considerably over time because of the effects of precipitation. Carbocolor®, Cancarb's concrete grade thermal black, has a particle size similar to black iron oxide which would lead one to expect a similar amount of pigment migration in a given concrete product. In addition, Carbocolor® has a much greater degree of particle aggregation which will increase the effective particle diameter and reduce the amount of material that is able to migrate through the cement pores. A product which exhibits the tint strength of a carbon black and the durability of an iron oxide would be attractive to the concrete industry.

The fading of a coloured concrete specimen can also occur if the pigment degrades and alters colour. Tests performed by the R&D department at Cancarb have demonstrated a pronounced tendency for black iron oxide to oxidize to its more stable red oxide form when heated in air for 48 hours at temperatures as low as 140°C. While such temperatures greatly exceed the actual conditions that a coloured concrete will have to endure, they do illustrate the relative instability of black iron oxide

[1]Mindness, S. and Young, J.F., Concrete. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, pp. 99-101

when compared to Carbocolor® which shows no changes at much higher temperatures. Over an extended period and with exposure to acid rain, fertilizers, pesticides, and other domestic chemicals, iron oxide could exhibit the same instability at ambient temperatures.

The services of a Canadian Standards Association approved laboratory, Powertech of Vancouver, Canada, were retained to perform comparative UV light resistance testing of Carbocolor® and iron oxide over 500 hours. The following ASTM test methods were performed:

- ASTM G53 – Practice for Operating Light Exposure Apparatus (Carbon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials
- ASTM D2244 – Spectrophotometric Method of Measuring Color Differences in Exposed and Unexposed Specimens. Uses Illuminant D, Hunter Lab scale with specular component.

In the Hunter Lab color space, L represents the dark-light component, a represents the green-red component, and b represents the blue-yellow component. It was found that differences in a and b were insignificant; thus the changes in L explained nearly all of the total colour differences (delta E) of the samples. In the tests performed by Powertech, the samples were not subjected to any weathering other than UV radiation.

Figure 1 shows a plot of delta E with respect to the pigment weight percentage. The tests demonstrate that Carbocolor® has superior UV light resistance characteristics in concrete, especially at higher loadings. Note the high degree of fading found in the uncoloured control sample; the fading of concrete alone could play a significant role in the fade resistance of the coloured samples.

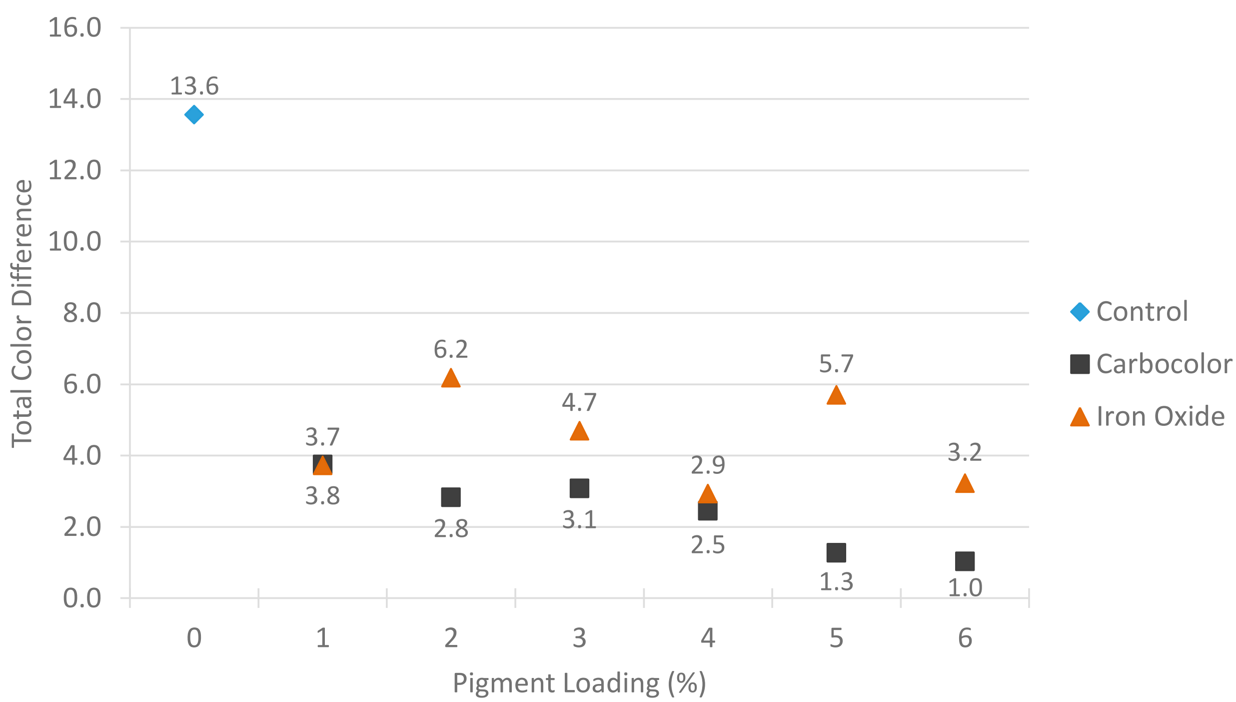

Figure 1. Total colour difference of Carbocolor® and iron oxide versus loading after 500 hours of UV light aging. Carbocolor® provided superior UV light resistance to the concrete.

Promising applications for Carbocolor® include:

- Driveways, sidewalks, and retaining walls
- Coloured masonry products such as paving stones, block, and bricks
- Concrete roofing tile
- Precast products such as bird baths and fountains
- Curbstones

Carbocolor® represents a promising alternative to iron oxides and other carbon blacks. Its large particle size makes it a much more suitable concrete pigment than any other carbon black. Its inert nature gives it colour stability not found in iron oxides.

Tips for Using Carbocolor®:

1. Measure out the appropriate quantity of pelletized Carbocolor®. This quantity is taken as a percentage of the total cementitious material in the concrete. The quantity of fly ash is to be included as part of the cementitious amount.
2. Ensure that the Carbocolor® is incorporated into the mixer before the cement or aggregate material. Hand mixing is not recommended. If hand mixing is necessary, use powder grade Carbocolor® and mix vigorously.
3. Allow at least 15 minutes of mixing time for maximum effectiveness.
4. Carbocolor® has a tendency to deplete the level of air entrainment in concrete. Raise the level of air entrainment additive accordingly. Establishing the optimum amount of air entraining agent may require several trials.
5. Have a large enough supply of water to dilute the mixture if necessary. The slump of the wet concrete is often higher when a pigment is used.
6. Avoid performing pours in hot dry weather as it may cause cracking in the curing concrete.
7. Avoid performing pours in wet, rainy weather as it will result in a spotty and unappealing surface finish.