cancarb

TECHNICAL BULLETIN

Concrete Colourant I

Cancarb Limited, a wholly owned subsidiary of TransCanada Pipelines Limited, is the world's pre-eminent manufacturer of thermal carbon black. Thermal carbon black is produced via the high temperature cracking of natural gas, in the absence of oxygen. The process yields a product with relatively large particle size and unique surface chemistry. Large particle size and low agglomeration are features which are unrivalled by other grades of carbon black, such as furnace or lamp black grades. Cancarb thermal black is currently used in a wide variety of applications, from rubber & 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 ability. Unfortunately, their durability was poor, forcing most concrete manufacturers to switch back to iron oxide for grey or black pigments. In addition to their fading tendencies, furnace and lamp blacks were also difficult to incorporate into concrete mixtures, causing adverse effects on air entrainment and slump. Iron oxides have a 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 impractical as pigments. Literature[1] indicates that there are several size classifications for pore structure in hydrated cement pastes. The designations have been divided into two categories: capillary pores and gel pores. Gel pores typically have diameters of less than 0.010µm, making them insignificant for most grades of carbon black. Capillary pores are subcategorized into large (0.05 – 10 µm diameter) and medium (0.010 – 0.050 µm diameter) sizes.

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

Under the assumption that a pigment occupies some of the pores of the concrete specimen, its large capillaries are inevitable escape routes. Thermal black, with a mean particle diameter of approximately 0.250 µm and some residual structure after mixing, could still be retained in the "large" capillaries falling in that size category. A large fraction of furnace black grades such as N550 (0.056 µm) or N660 (0.067 µm) would still be able to escape through the medium capillaries, at 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 very similar to black iron oxide, which would lead one to expect a similar amount of either pigment to escape from a given concrete product. In addition, Carbocolor® has a much greater degree of structure, which will increase the effective particle diameter and reduce the amount of material that is able to escape through cement pores. A product which exhibits the tint strength of a carbon black and the durability of an iron oxide would be very attractive to the concrete industry.

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

The fading of a coloured concrete specimen can also occur if the pigment itself begins to fade. Tests performed by the Research & Development 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 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.

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

- **ASTM G53** – Practice for Operating Light Exposure Apparatus (Carbon-Arc Type) With and Without Water for Exposure of Non-metallic Materials.
- **ASTM D2244** – Spectrophotometric method of measuring color differences in exposed and unexposed specimens. Uses Illuminant D, Hunter Lab scale with specular component.

The test categories were:

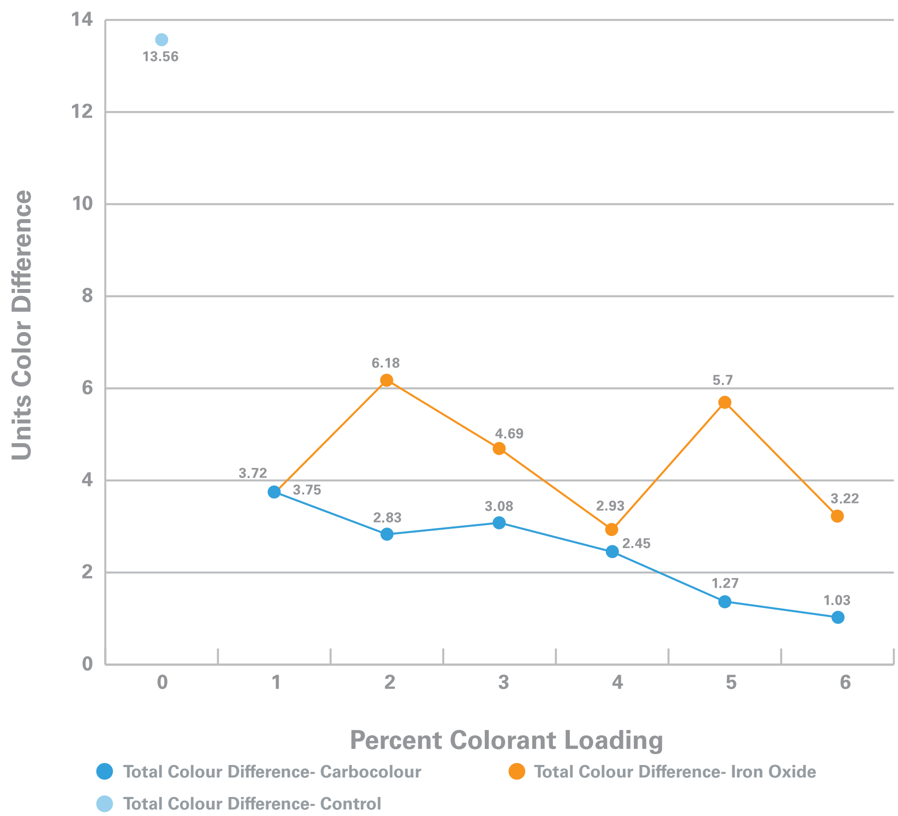
DL **darkness/lightness difference ("+" = lighter, "-" = darker)**
Da **red/green difference ("+" = more red, "-" = more green)**
Db **yellow/blue difference ("+" = more yellow, "-" = more green)**
DC **Total difference in chromaticity (colour without the effects of lightness/darkness)**
DE **Total colour difference**

The data plotted thus far is concerned primarily with DL and DE; in fact, the differences between DL and DE for a given sample are minimal, suggesting that the differences in Da, Db and DC have minimal impact on the total colour difference of the samples. In the tests performed by Powertech (ASTM D2244, G53), the samples were not subjected to any weathering other than ultraviolet radiation.

Figure 1 shows a plot of total colour difference (DE) with respect to the colorant weight percentage. The tests demonstrate that Carbocolor® has superior ultraviolet 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® & Iron Oxide vs. Concentration (500 Hours)



Promising applications for Carbocolor® include:

- Driveways, sidewalks and retaining walls
- Coloured masonry products such as: paving stones, blocks 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. Carbocolor® is available in 25 kg kraft bags, 25 kg water soluble bags and 1000 kg bulk sacks.

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 flyash 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 entrainer 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 colourant 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.

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