COLOURING OF CONCRETE

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Summary

There have been numerous papers given at various conferences on the pigmentation of concrete, givin information on how to achieve consistent colours and which pigments we should use.

Details are given on the possible causes of coloured concrete variation, but the purpose of the paper is to encourage both manufacturers and suppliers alike to get together and improve the colour performance of concrete by producing products that will be compatible and can combine chemically to use the by-products of the chemistry of cement.

Introduction

Colour has for thousands of years been used for visual effect. The ancient Britons painted their skin with woad, the Red Indians also. Even men and women today change their pale skins to brown or suntan by coloured powder. The Romans used various colours in their mosaic patterns to illustrate and make pictures. Nothing really has changed over the last two thousand years, today we colour our concrete products to satisfy the whim of the specifier from very dark colours through black to red to yellow.

The purpose of colouring concrete is to create something a little more permanent than a simple surface coating, but is it possible to fully meet the expectation of obtaining a permanent colouring?

This paper is not meant to give answers to the colouring of concrete, but to provoke discussion between the concrete manufacturer and his raw material supplier in obtaining improved colour usage which will last longer, be more cost effective and, above all, involve those suppliers of raw material to become acquainted with the manufacturers problems and headaches.

The Problem

All too often we are asked to visit sites where the customer complains the concrete product which he has laid has changed colour from a specified shade to a non-descript colour. This is with all the coloured concrete without exception. I do not intend to discuss the relative merits of one manufacturer's pigment against another; I leave that to the various pigment manufacturers who will be present at this conference, presenting papers on pigmenting concrete or participating as a delegate.

Factors affecting coloured concrete and its performance.

Mix Design

(a) Aggregates

The natural colour of the aggregate has an influence on the final shade of the concrete. The natural colour of the sand will affect the coloured concrete. i.e. a light coloured sand will help th lighter shades of concrete more than th darker ones. Added to this, in the ca of fine sand (0-0.2mm), where river san is used, the final colour of the concre will be much less dependent on the mixi ratio than with an aggregate having a high fines content in which a lot of fi fraction material is introduced into th mix and has to be coloured. When usir high fines content, then it is always necessary to adjust the water cement ra this will be discussed later.

(b) Cement

The natural colour of the cement can r from white to light grey to dark grey. The lighter coloured cement has a mark effect on the lighter coloured concret but has little effect on the darker co oured concretes.

(c) Water Content

This is generally quoted as the water cement ratio, and as this increases, t the shade of the concrete becomes ligh this is the case of both unpigment anc pigment concrete. With a higher W/C ratio, the surface of the concrete is also smoother and thus also has an eff on the overall colour impression.

(c) Water content (cont'd)

The reason for the lighter colour is when the concrete dries out, fine pores are formed which have a stronger light scattering than the concrete surrounding them. The higher the water content, more pores form and as the concrete dries out, the lighter the colour.

(d Curing

As concrete hardens, so calcium silicate hydrates are formed. Depending on the curing conditions, these crystals grow at different speeds, the finer the crystals the greater their initial light scattering power. This is why when curing takes place at higher temperatures, that is, autoclaving, the colour is much lighter compared with low curing temperatures. Differences in shades can result from variations in the storage conditions; by moving products outside after a short time, differences in temperature and atmospheric humidity also influence the final colouring.

To quote a major pigment supplier - using high quality synthetic inorganic pigments allows manufacturers of concrete products to produce their concrete in a uniform shade over a long period of time. It does, however, happen that fluctuations in shades occur, the reasons do not as a rule lie - as is often initially supposed - with the pigment, but are generally due to a number of factors. This includes the above as well as efflorescence.

As manufacturers we are aware of all the foregoing statements and we carefully control all aspects of selection and control, and still we get concrete apparently changing colour.

How can we stop this change?

Examining colour change due to formation of efflorescence, we need to distinguish between primary and secondary efflorescence. Primary efflorescence occurs during the setting of the concrete, that is, without exposure to weather. It has been found that in a relatively short time after compaction, there is a major decline in the mobility of the calcium hydroxide - called free lime - which forms during the setting process and when reaching the surface reacts with the carbon dioxide in the air to form the water insoluble calcium carbonate. Therefore, the denser the concrete, the less this will occur.

Secondary efflorescence can occur anywhere and is very dependent on the time of year when exposed to the weather. Protecting blocks by covering them with polythene to prevent wetting by water is probably the best method. Treating the concrete with carbon dioxide at early ages works, because the reaction takes place within the concrete.

In many cases we can rely on the addition of chemicals which by their chemical nature make the concrete more workable, which in essence acts as an internal lubricator allowing the pigment to coat particles of fine material more easily in the mixing process.

Some of us indulge in sophisticated curing chambers applying the correct balance of temperature and humidity.

It has been suggested that we coat the surface of the concrete with a paint film to control the evaporation of the water in the concrete.

What is the alternative technology for pigmenting concrete?

If we examine each component part of the pigmented concrete, then perhaps we can influence the supplier of that component part to consider making adjustments or by physically changing certain properties of the material.

Let us reexamine the two main constituents of colour concrete and how it affects the colour, namely:

Cement

We are informed the causes of lime bloom and efflorescence is due to the excess free lime in the cement being transported by moisture to the surface; the lime being in a solution form. When on the surface, the water evaporates, leaving behind white crystal which mask the coloured surface. The colour of the cement contributes to the intensity of concrete colour.

If we examine unpigmented concrete over a period of time, it changes from a light colour to a yellowy colour. This is more noticeable in white cement.

Pigments

Iron oxide synthetic pigments are assumed to be light-fast, weather-fast and fast to cement; this is generally the case. Pigmented concrete often behaves quite differently depending on the weathering location involved. Intensity of colour is dependent on pigment tinting strength and pigment loadings.

How can our Suppliers help?

The question we need to ask both the cement and pigment suppliers is, how does the pigment colour the concrete? Once this can be answered, then the following questions can be asked.

The first question we have to ask the cement suppliers is:

"What can you do to the cement to reduce this

oundance of free lime in the cement and to
top it coming to the surface and being depos-
ted there?"

he second question to ask is:

How can you stop the cement from changing from grey/white to having a yellow hue to it?"

he questions we have to ask our pigment uppliers are:

). Can you devise a pigment with a strong chemical bond to adhere to the cement seed rather than a weak physical coating? We note in the paint industry this is possible.

2). Can you develop a pigment that improves tinting and colouring ability. At the time of writing there is now a company doing this, commercial production is imminent.

Conclusions

Natural materials are being used more and more and this is eroding our markets and we are losing credibility because we cannot guarantee or assure the customer that the colour of the concrete will remain the same, or similar, over a short life span. The market potential for coloured concrete is vast, and is cost effective against naturally occurring materials.

So, it is in everyone's interest we discuss development ideas and technology and this will only be achieved by getting all the interested parties together and discussing the problem of colouring concrete. We must not be ostriches by burying our heads in the sand and hoping this problem will disappear. This problem will not disappear, coloured concrete is here to stay, so let us move forward with technology and develop a system which will compete in colour performance as many of the naturally occurring materials.