Architectural concrete and colour – an ideal combination

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Coloured concrete materials, such as concrete roofing tiles, paving blocks and paving slabs nowadays make an important contribution to making our environment more attractive, and they are widely accepted by the general public.

With these materials, builders are able to combine technical functionality with an aesthetically pleasing appearance.

Nevertheless, concrete frequently has a rather negative image even though the outstanding technical properties of this all-purpose material are acknowledged by even the layman. Terms like "concrete jungle" and "as grey as concrete" are often used to describe an environment in which man does not feel particularly contented. The architectural design and, in particular, the colour of a building tend to be the decisive factors in whether a project is viewed as successful or whether it is seen more as a dismal and monotonous structure.

This publication describes how pigments can be used to make concrete attractive.

How do we make coloured concrete?

There are many ways of giving concrete a coloured appearance.

The most simple method, of course, is to paint the concrete surface, but the problem is that a coat of paint only has limited durability, and renewing it would in many cases be a particularly arduous task. Setting up the scaffolding and applying a new coat of paint not only involves considerable cost, it is also in many cases technically impossible.

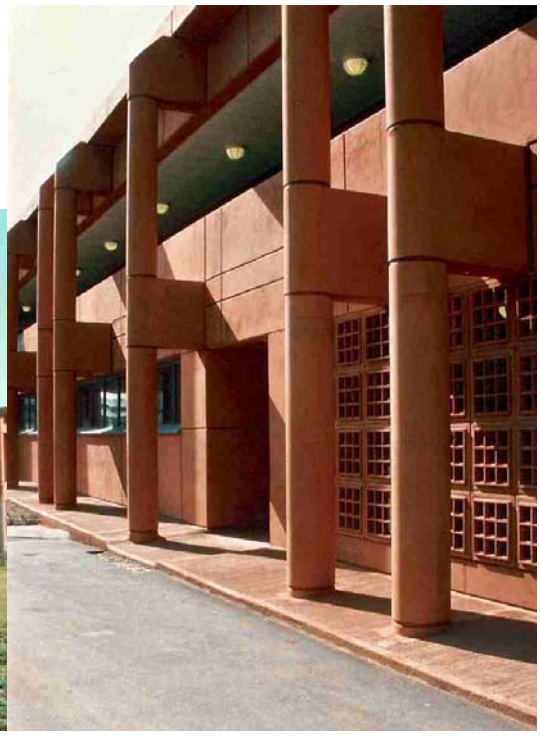
Another method is to give the concrete a more lively appearance by using different aggregate materials. The possibilities for producing a colourful design with this method are nevertheless very limited.

In most cases, the method of choice is to integrally colour the concrete, and a wide range of suitable pigments is nowadays available for this purpose. They enable almost any shade to be achieved, and have virtually unlimited durability.

The production of coloured concrete mixes does not basically differ from that of a grey concrete. We shall now look at what points need to be considered to produce attractive concrete surfaces through the addition of pigments.

South Africa: Administration building of an aluminium works (Alusafi Hillside Smelter), site-mixed concrete, pigmented with Bayferrox® 960

Pigment concentration: 4 %
Built: 1993 – 1995
Architect: (Engineering, Procurement and Management) Alprom
Building company: Murray and Roberts



Norway: Olympic arena, Lillehammer (Lysgaard skijump); Site-mixed concrete, pigmented with Bayferrox® 318

Pigment concentration: 1.5 %
Built: 1992
Architect: ÖKAW Arkitekter AS, Oslo
Building company: Martin M. Bakken Entrepreneurforretning A/S, Elverum

The raw materials

a) The pigment

Due to the formation of calcium hydroxide, cement that is freshly made up with water is highly alkaline. One of the main demands made on the pigment is therefore that it is absolutely resistant to alkalis, in other words, the colouring effect of the pigment must not be impaired by the lime content of the cement.

Furthermore, the pigment must be neither destroyed nor washed out through the effects of the weather - especially sunlight and the constant changeovers between heavy rain, heat and frost.

Many years of observation of coloured concrete products exposed to different climates in various parts of the world have shown that inorganic oxide pigments can satisfy the requirements expected of pigments for colouring concrete.

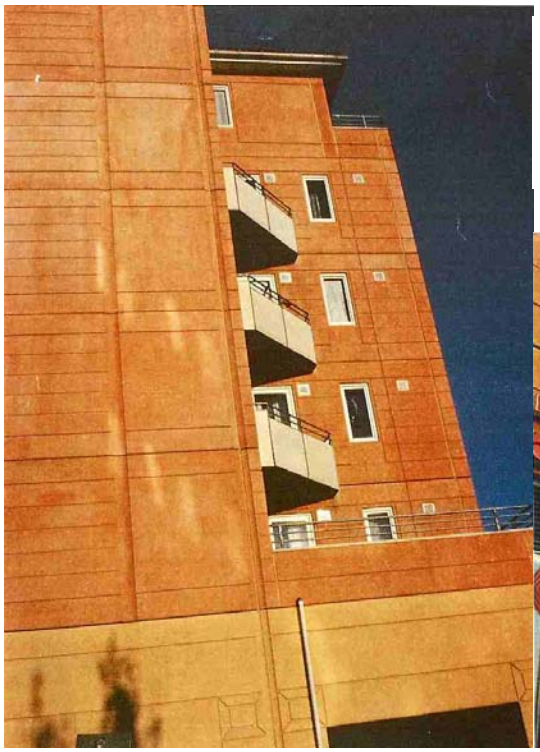
The builder has a choice of various colours. Iron oxide pigments (e.g. the Bayferrox® grades) are available in red, yellow, black and brown. Greens can be obtained by using chrome oxide green pigment. White colours can be created with titanium dioxide pigments, and blues with lightfast pigments if the concrete is made with a light-coloured cement.

b) The cement

It is well-known that the various types of cement can also differ in their inherent colour. Whereas, generally speaking, fluctuations in the colour seldom occur within the production from one cement factory, there can be considerable differences in the shade of the cement from different manufacturers.

In practice, it is therefore normal - particularly with larger building projects - to purchase all the cement from the same supplier. This is strongly recommended when producing a coloured concrete, because it should largely eliminate any fluctuations in colour due to differences in the colour of the cement.

As mentioned before, white cement is naturally also particularly recommended for coloured concrete, because it is also possible to produce pastel shades.



Norway: Residential and office building Grønland Tork, Oslo
Site-mixed concrete, pigmented with Bayferrox® 110 and Bayferrox® 960

Pigment concentration: 4 %
Built: 1991
Architect: Anker & Hoklaas, Architektkontoret A/S, Oslo
Building company: Selmer A.S., Oslo

Sweden: Bridge: Kvick Bron, Helsingborg
Site-mixed concrete, pigmented with Bayferrox® 130

Pigment concentration: 6 %
Built: 1995 – 1996
Architect: Nilsson & Rahmquist, Helsingborg
Building company: Ballast Syd, Helsingborg

c) The aggregates

The colour of the sand and pebbles also affects the colour of the final concrete.

If the exposed concrete surfaces are to be subsequently treated by sandblasting, bush hammering etc., the colour of the pebbles should not differ too much from the coloured concrete. The question regarding the choice of aggregate materials can be resolved by carrying out a few preliminary tests, which do not take up much time and are not particularly costly. On the basis of these trials, the manufacturer can see exactly which combination of sand, pebbles, cement and pigment produces the best colour.

d) The water

Accurate control of the water supply in a concrete mixing unit is, of course, an integral part of efficient concrete production. For this reason, particular importance is attached anyway to ensuring that the volume of water added to the individual batches of concrete is precisely regulated.

However, apart from the technological properties, the colour of the concrete is also dependent on the selected water-to-cement ratio. Excess water evaporates from the concrete and leaves behind cavities in the form of fine pores. These scatter the incident light and thus make the concrete lighter. In other words, the higher the water-to-cement ratio, the lighter the concrete looks, regardless of whether it is a grey concrete or one which has been coloured by the addition of pigments.

Production of the concrete mix

In practice, it has proved best to add the pigment dry to the aggregates in the mixer, and to premix it for around 30 seconds. Only then should the cement be added. After further premixing for about 30 seconds, the water can be added and the mixing process completed.

This method of adding the pigment during the mixing process is more the ideal than the norm, because it is sometimes simply not possible in practice where on-site concrete is concerned. However, one practical possibility for colouring on-site concrete is to add the pigment directly to the readymix trucks. This procedure is, of course, only advisable if the mixing action of the truck mixer is adequate and homogenous distribution of the pigment can be guaranteed. The question should be clarified by carrying out suitable practical trials before beginning the concreting work.

Germany: Administration Building of Zueblin AG, Stuttgart, Precast Elements, pigmented with Bayferrox® 110

Built: 1984
Architect: Prof. G. Boehm, Cologne
Building company: Zueblin AG, Stuttgart

Application of the concrete

For working with coloured, ready-mixed concrete, the same principles basically apply as for producing exposed grey concrete surfaces. Care should nevertheless be taken with the choice of release agent. If too much release agent is applied, it will get on to the fresh concrete and stain the surface.

The above points, which need to be observed to obtain perfect results, should also be taken to heart for the production of non-coloured exposed concrete surfaces. Experience has shown that only a short time is needed for workers to become so familiar with the technique of colouring concrete that they can produce perfect results every time. The manufacturer will in any case be rewarded for the extra care by the success he achieves in complying with the wishes of the architects and building clients as regards the colour of the concrete.

From what has been said so far, the impression may be gained that the process described for colouring concrete is something new. This is certainly not the case. The possibility of using colour pigments for colouring architectural concrete has existed for some time now. Examples of buildings in Germany which demonstrate the perfect symbiosis of architecture and colour are the Züblin House in Stuttgart and the Landratsamt in Waldshut, which have lost none of their charm more than twenty years after their completion.

Chile: Hotel and Information Centre for the European Southern Observatory at Cerro Paranal
Site-mixed concrete, pigmented with Bayferrox® 600 N

Pigment concentration: 2,3 %
Built: 2001
Architect: Auer + Weber, Munich

In most cases, it is this combination of design and colour which gives a building its unique flair. Nevertheless, it has to be admitted that colour on its own will seldom be able to make up for a lack of attractive architecture. However, if the element of colour can be used as a supporting element to an attractively designed building, the result will most certainly be well worth looking at, as is illustrated by the following examples:

Belgium: Bureaux Tractebel, Woluwe St. Lambert
Combination of natural stone and prefabricated concrete, pigmented with Bayferrox® 660

Pigment concentration: 1 %
Built: 1989
Architect: Jaspers, Hasselt
Building company: Decomo, Belgium