COLOURING OF CONCRETE BLOCKS

The State of an Art

Dr. A.E. Jungk and Dr. A. M. Veit
BROCKHUES AG, D-6229 Walluf, Germany

ntroduction

:oncrete blocks in manifold forms and colours the production of coloured concrete has roven to be an art; this is essential if :oncrete is to penetrate further into the looring market. They make it possible for the own planners to conceive his individual city entre, park roads, house entrances and ardens. Concrete blocks compete against nterlocking bricks, asphalt, bitumeneous looring and natural stones. Concrete blocks n manifold forms : they are nearly everlasting and tempting just as natural stones. They have many economic advantages over these in production and road construction. This is especially true for coloured blocks, if you have the know-how of colouring well in hand.

Vhat is the colouring of concrete ?

Coloured concrete requires evenly coloured surfaces that last - and it's an art to achieve this aim. The systematic scheme of a cut-through coloured concrete block is shown n Fig. 1. Right on its surface you find a ransparent coating of calcium hydroxide, carbonate or sulfate. This coating may be well below 1 micron thick - then you just don't see t - or it is a thick and opaque white cover, called efflorescence. In both cases you find no pigment in this coating. Efflorescence falsifies the colour of your stone. It does not last, it is unwanted.

Below this cover of white you find pigments, tiny spherical or needle-shaped particles embedded in the matrix of the cementicious gel and the calcium silicate formed from cement, sand and water. Ideally the fines of the sand and the individual cement grains should be coated all over their surfaces with layers of pigment, before they stick together. There might be free pigment particles just held by the efflorescent coating by the gel pores and capillary pores (abt. 0.07 microns in diameter). The cementicious stone will glue together the fines ,sand and the aggregates, will trap the pigments in empty spaces and pores. Pigment fixing in concrete is a difficult task - due to huge differences in particle size between pigment (abt. 0.1 micron) and cement grains (abt. 30 microns). Although the pigment particles are so tiny, the pigment will not interfere with the paver's mechanical strength - at least in a dosage range below 10 % by weight per cement.

In a well produced paver light will fall onto a flawless surface - the pigment will absorb certain wave lengths and reflect others - the efflorescence coating and cementicious stone will absorb and reflect light over all wave lengths, but reflection will be random and give the impression of grey concrete.

The stone colour will be the optical synthesis of light reflections from pigment grains and cementicious stone.

Coloured concrete should not vary significantly over the years. The next figure shows a scheme of a weathered, coloured block. Its mechanical strength is better then new - but how does it look. The surface structure is composed of the aggregates, sand grains, but the cementicious stone has been worn off. With the years the surface colour becomes a synthesis of the original colours of the individual concrete constituants. Parts of the pigment are mechanically worn-off the concrete surface or washed out of the capillary pores by water. What we want is a stone surface that's as beautiful when it's old as when it was new and this is how we do it.

Pigment Selection

Pigments for concrete are :

weather fast	for beautiful aging
alcali-fast	to resist the reactions taking place in concrete
chemically inert	for high concrete strength
bigger than the capillary pores	for better pigment fixation
harmless	for safer manipulation and protection of the environment
economical	for large volume applications

Synthetic iron oxides are ideal for yellows, oranges, reds and charcoal. For thousands of years they were used as earth colours in their natural form. The synthetic iron oxide pigments excel in comparison to their natural relatives in the purity of shade, in tinting strenght, in particle size distribution, in constancy of colour tinting strength and in tinting costs. Synthetic iron oxides have a proven record for many decades of success in tinting concrete.

Special carbon-based pigments ideally fit the demand pattern for black pigmenting. In form of the **CARBOFIN** and due to a superior particle size distribution they display better fixation in concrete than cement black and more light absorbtion (blackness) than iron oxides. They combine superior tinting strength with good economy.

White and light coloured concrete requires titanium dioxide and/or white cement. The use of grey cement will yield dirty light colours. Yellow turns greenish, red becomes brown. Green will well work with chromium oxide, blue with cobalt and aluminum spinel. Green and blue are exclusive and expensive.

Organic pigments have not been seen yet in pavers. Very small particle size in the range of .02 microns or smaller, favour the pigments leach-out from the pavers surface. Weather exposure and cement chemistry tend to alter and destroy these pigments even though they are more brillant and concrete-fast systems - I think - may be developed in the future.

Cement black made from small particle size carbon black has shown leaching-out problems, especially in porous and/or badly compacted concrete surfaces.

Reliable pigment suppliers offer a quality certificate for their pigments securing tinting strength, constancy in shade, concrete- and weather-fastness. They apply test procedures close to what happens in concrete to ensure good quality in concrete colouring.

Raw Material Choice

Light colours require light cement and light filler. Aggregates, sand and fines determine the appearance of old concrete. Therefore, their colour should be near to the pigments. For quality colouring the natural colour of the raw material must be monitored regularly. Changes in the cement and/or filler quality are changes in their specific surfaces, which are covered by the pigment when tinting. Smaller surfaces require less pigment. More fines need more pigment. Your pigment supplier will help you with suitable testing methods.

Water Cement Ratio

A change in the water cement ratio of a concrete mix can significantly affect colour. Even a small change on the paver surface might be sufficient to cause a colour change. Such a change may result from a batch to batch variation or from spraying the tamperhead during paver production for a smoo surface. A higher water cement ratio usually produce a light coloured concrete pores and weather sensitive surface.

Pigment Dosing and Mixing

In todays rationalized world of product pigment dosing should be automatic. Powd are weighed, liquid pigment-slurries either dosed by weight or volume - for ex tinting. Dr. Veit later on the day will into more detail.

Powder pigments form aggregates agglomerates when supplied. For opti pigment dispersion you use your concrete mi as a sand mill. After your dosing machine poured powder pigment into the sand aggregates in your concrete mixer, subsequent mixing will mill the pigme agglomerates down for maximum tinti strength. This might last 30 seconds or minutes, depending upon your mixer. Dry sa mills better than wet sand, cement and wat act as lubricants in the mixing process. leave pigment and sand alone for a whil Short mixing cycles of 15 seconds f instance, might not be enough for optim colour development, thus resulting in a colo variation in your concrete.

With such a short mixing cycle some pigme lots might display different dispersi characteristics. After pigment milling, ceme and a well defined volume of water is add and your coloured concrete homogenized.

Pigment dosing into the ready concrete mi requires longer pigment mixing times - eve after minutes of mixing you might find smal pigment lumps that will be the surface fault you find later in your paver surface. Don' empty your pigment bucket onto the transpor belt of your sand. If you do, the colour dus will spread all around your factory, eve though you have a dust filter above you concrete mixer and could use it for you pigments.

The use of pigment slurries is easier an cleaner. Here the pigments are predispersed When dosed into the sand, mixing time i shorter than with powders. But if the pigment slurry comes into contact with cement before pigment dispersion, it will lose water, form lumps of undispersable pigment. Pigments should be dosed from 5 to 7 kg dry weight per 100 kg cement. In this range small pigment differences will have negligeable effects on the concrete colour, because colouring is close to saturation. Low pigment dosage may give a satisfactory colour initially, but the colour is sensitive to pigment loss. If you are working without pigment reserve in concrete weathering, the pigment will leach out of the cementicious stone quicker than the cementicious stone degrades during weathering and the colour of your concrete will change.

Compaction

Good concrete compaction and a low water cement ratio are reliable means for cutting down efflorescences and improve weathering due to small pore volume on your paver surface.

Curing

Curing should take place in a draught-free hall with high moisture in the air. This moisture must not condense on your blocks surface, because any drop of water would bring about efflorescences; so coloured concrete should be stored under cover and prevention of water condensation.

These are the main features in the art.

Use pigments from the range iron oxide, carbon, chromoxide and titaniumdioxide with guaranteed technical data.

Create a colour harmony between your raw materials.

Monitor your raw materials on colour and specific surface.

Work with low water cement ratio and a good compaction.

Dose powders by weight and liquids by volume.

Dose in the range from 5 - 7 % by cement weight for decent aging.

Make a premix of sand and pigment for maximum tinting and minimum mixing time.

Make coloured concrete for expanding markets.