SOME NEW ASPECTS TO MAKE COLOURED CONCRETE BLOCK PAVING A SUCCESS

Dr. Gerd von Szadkowski

Technical Service Department, Bayer AG, Federal Republic of Germany

SUMMARY

The popularity of coloured concrete pavements and the development of technologies for the use of pigments having increased so rapidly throughout the world that in general the use of pigments for the colouring of concrete can be considered to be todays technical standard. However, if pigments are being used in concrete automatically questions concerning the durability and limitations of colour in concrete are being discussed. This paper based on many years of careful survey on coloured concrete surfaces explains the reasons why sometimes the colour in the surface does not last and following the well known basic rules of concrete technology it is shown how divergences in mix design for concrete block paving do have significant influence on colour durability.

Above all the ratio of cement to aggregates is of vital importance for long time weathering exposure as a "colour shift" will be observed because aggregates will be exposed in the surface as weathering proceeds. At this very moment the colour of the aggregates must also be considered.

Since the colour durability in the surface is very much a question of a resistance of this surface to wear and tear of mechanical abrasion and outdoor weathering also the pigmentation i. e. the pigment loading is of significant influence, as smaller quantities of pigments - calculated on cement - will not lend sufficient tinting strength to the described phenomena of surface erosion. It will be shown however that sufficient pigment loadings around 4 - 5 % in combination with proper mix designs and sound manufacturing techniques and last not least reasonable laying and placing techniques will produce a sound, durable an long lasting coloured concrete paver surface.

It only appears to be justified to mention that weather-stable and cement-fast pigments are available in the commonly known lively but "earthy" shades especially when in combination with grey cement. However the range of shades and the possibility of blends and combinations are almost unlimited. In addition, the use of white cement is a further outlet for special demands.

The facts responsible for possible colour changes in concrete pavements are due in many cases to mix design, production and laying of such pavements. For economic reasons however the author is aware that not all recommandations for successful long lasting coloured pavements can be followed. Therefore it must be the intention of this presentation to create a better appreciation for pigments and there potentialities and limitations.

At the First International Paving Block Conference in Newcastle we have given basic facts on the effects of pigments on the quality of concrete block paving. Two and a half years have elapsed since and the popularity of coloured pavements plus the development of technologies for the use of pigments have increased so rapidly throughout the world that the colouration of concrete block paving can be considered to be today's technical standard. Pigments can be today metered without difficulty as water-based slurries or dry powders and multicoloured patterns can be obtained just to mention a few topics. Discussing these would be beyond the limits of this paper and therefore stress will be laid on some most interesting subjects such as durability of colour in block paving and - in general - the potentialities of the pigments.

1. DURABILITY

If durability is mentioned in connection with coloured concrete block paving one would expect that colour in concrete lasts as long as the paving itself. This is no problem for the pigment itself, however, a few restrictions must be born in mind for the system pigment/concrete. As far as our experience shows, fortunately these restrictions can be pinned down to mix design and manufacturing conditions. Coloured concrete paving has been used for so long that today statements on colour durability can be made, as examples for "good and bad" are manifold. It cannot be overemphasized that durability here must be strictly associated with the whole system pigment/concrete paving and not only with the pigment itself.

Following the wellknown basic rules of concrete technology it will be shown how divergences in mix design for concrete block paving can have significant influence on colour durability.

1.1 Aggregates

1.1.1 Ratio cement/aggregates

Pigments lend their colour to the cement in a concrete system i. e. the more cement is present the more "slurry" is available in fresh concrete for bonding aggregates together and covering the surface in the fresh as well as in the cured state. As proceeding weathering "erodes" the surface, coloured slurry is disappearing. Mechanical abrasion has a similar effect. A "colour-shift" is observed that shows the influence of the aggregate colour. If enough well pigmented cementicious slurry was available the result of erosion will be less pronounced and colour-shift will be noticed much later. Very "lean" mix designs will ergo be less colour constant.

1.1.2 Colour of aggregates

From these facts it is obvious that the colour of aggregates is also of significant influence on the colour-shift. For best performance with regard to longterm durability aggregates with colours similar or at least very much like the colours of a pigmented concrete are recommended. It must be admitted that not all of these rules for longterm durability can be followed precisely but their knowledge might lead to a compromise between possibilities of the manufacturer of coloured concrete paving and a long lasting pigmentation.

1.2 Pigmentation

It has been explained so far that a cementicious slurry in and mainly on top of a concrete paver can be considered to be the "carrier system" for the pigmentation. Hence all factors influencing the quality and resistance of that system are important for estimating its durability. In addition longterm observations have clearly revealed that the amount of pigment present in the cementicious stone is responsible also for the colour durability as weathering or mechanical erosion proceeds. Such cementicious stone with a low pigment loading will not show good longterm colour durability as the previously mentioned colour-shift is not disguised by enough pigment particles. If, on the other hand, a sufficient number of pigment particles is present in the cured cementicious stone of a concrete paver, the structural change upon exposure will not be delayed but the mentioned colour-shift would proceed only until a equilibrium between exposed aggregates and coloured cementicious stone has been reached. Sufficient pigment loading is therefore an essential factor in mix design of coloured concrete paving and by far no simple commercial argument.
Weathering attacks a paver surface especially in winter when de-icing salts are being applied and thus freeze and thaw cycles strain the concrete surface. This produces quite rapidly the same effect as long lasting mechanical abrasion and the effects of stabilizing the mentioned equilibrium between cementicious stone with proper pigment loading can be convincingly demonstrated.

1.3 Colour change of cement

It has been observed for many years that ordinary portland cement klinker - depending on its composition - undergoes a process under weathering leading to a "colour-shift" towards yellow. It has not yet been evaluated, however, whether this is due to mere restructuring processes of the cementicious compounds or a decomposition of the cement matrix. As no detrimental effect on mechanical properties is noticed this phenomenon is only of interest for questions concerning the colouring of concrete.
In both cases a marked colour shift is observed and this change of colour in the "carrier-system" is also transferred to a pigmented system i. e. pigmented concrete "shifts" in colour and the resulting shade depends of the original colour showing a yellowish hue.

2. POTENTIALITIES OF PIGMENTS IN CONCRETE BLOCK PAVING

The previous section has delt with well known factors of concrete technology - to the experience of the author not well known at all if it comes to considering the efficiency of pigments.
Many examples of faulty production and placing of concrete paving have been pinned down to the pigmentation but careful analyses over the years have shown that pigments can lend colour to concrete but cannot camouflage any bad performance. Basic concrete technology and machine operation are alone responsible for the surface appearance of a concrete paver and as we have learned, also for colour durability.
Weather stable and cement fast pigments are available in the commonly known lively but "earthy" shades and they can eliminate the colour of grey cement to a very large extent but not completely. Their colour appearance over a large paved surface and the advantage of the impression of coloured concrete as opposed to uniform grey, however, should be beyond discussion. The range of shades and thus the possibility of blends and combinations are almost unlimited, as long as the basic tendency of subdued colours is maintained.

The use of white cement opens the wide range of pastel shades provided that - for long term durability - also white aggregates are used; an operation possible in theory but very unlikely in practice for economic reasons.
Synthetic inorganic pigments are not promoting efflorescence and one can just as little expect them to avoid this appearance. To at least minimize this phenomenon lies in the hands of the manufacturer of concrete pavers.
One must be aware that many of the facts mentioned in this paper can only be considered to be guidelines. Modern economy calls for very profound calculations in a concrete plant and for this reason it must be admitted that not all recommendations for successful long lasting coloured pavement can be followed. However, it has been the intention of this presentation to create a better appreciation for pigments, there vast potentialities and also their few limitations. As soon as this has been achieved the widespread use of coloured concrete paving will become a valuable and successful contribution to environmentalconscious building of today and tomorrow.