Colouring Concrete

INTRODUCTION

Coloured concrete and related products are visible everywhere in our everyday lives. In fact, you could travel to any country in the world and chances are you would see coloured concrete in one form or another. The most common colouring method is the use of colour pigments and this is used particularly in the manufacture of pressed concrete products such as paving and walling, also in roof tiles and wet cast concrete paving.

The hardened cement paste by which the particles are held together is coloured by adding finely ground pigments. The aggregate itself cannot be coloured, it's particles merely being surrounded by the coloured cement paste. Pigments used for this purpose are generally lightfast and have a high resistance to alkali and weathering. Inorganic pigments, such as iron oxides, chromium oxides, cobalt oxides and titanium dioxide, meet these requirements and are generally regarded as the best pound for pound pigments for the job. Organic pigments such as carbon black can also be used to create shades unachievable with inorganic pigments. However, there are many factors that need to be considered before using organic pigments in a cement based product.

COLOUR SHADE

Many different concrete products are coloured in a similar way, but that's not to say the outcome of the final colour will be the same. There are many factors that affect the finished colour of a concrete such as the water/cement ratio, the curing temperature, the compaction, mould type, mix design and aggregate/sand grading. If you compare for example, concrete block paving and concrete roofing tiles, both coloured with the same pigment, at the same concentration, it will be found that there are differences in colour. This will be mostly due to the difference in water/ cement ratio and the particle size distribution curve of the aggregates.

When colouring concrete, providing inorganic pigments of high tinting strength are used, then an addition rate of 4-5% by weight of cement would be recommended. It's important to note that these pigment types have a saturation point of 7-9% depending on the grade and that additions of pigment beyond this rate yield no additional colour strength. Addition rates of <4% can be used when pastel shades are required. Similarly white cement is often used for lighter shades.

PIGMENT DISPERSION

Mixing time is often limited and so it is important to understand how to get the most out of the pigments that are being used to colour the concrete. Any pigment agglomeration leads to inferior colour strength in the finished products. Likewise any cement agglomeration means that the cement is not being fully utilised and this can lead to reduction in strength. A series of tests were carried out on a forced circulation mixer to ascertain the optimum mixing sequence and time, for the basic ingredients.

ADDITION SEQUENCE				CEMENT AGGLOMERATION	PIGMENT AGGLOMERATION
1	2	3	4	∑	∑
Sand	Pigment (P)	Cement	Water	0	12
Sand	Pigment (L)	Cement	Water	10	0
Sand	Cement	Pigment (P)	Water	3	36
Sand	Cement	Pigment (L)	Water	4	124
Sand	Water	Pigment (P)	Cement	4	11
Sand	Water	Pigment (L)	Cement	8	0
Sand	Cement	Water	Pigment (P)	3	8
Sand	Cement	Water	Pigment (L)	21	27
Sand	Water	Cement	Pigment (P)	12	18
Sand	Water	Cement	Pigment (L)	5	145
Sand	Pigment (P)	Water	Cement	10	0
Sand	Pigment (L)	Water	Cement	0	0
Sand/Pigment	(P)/Cement/Water*			200	200
Sand/Pigment	(L)/Cement/Water*			64	136

MIXING TIME:

1 + 2 = 15 secs
1 + 2 + 3 = 30 secs
1 + 2 + 3 + 4 = 60 secs

Intrinsic moisture of sand: 8%
Particle size distribution: 0-4mm
*All ingredients mixed simultaneously

WATER/CEMENT RATIO
EFFECT ON COLOUR SHADE

There is a clear relationship between colour shade of the concrete and the water/cement ratio. The higher the ratio, the lighter the colour. The evaporating excess water leaves behind fine pores in the concrete which act like white pigment. Fig1 shows pavers having water cement ratios of approx. 0.35 & 0.42 respectively. The aggregate/cement ratio and pigment is constant in both as is the pigment concentration.

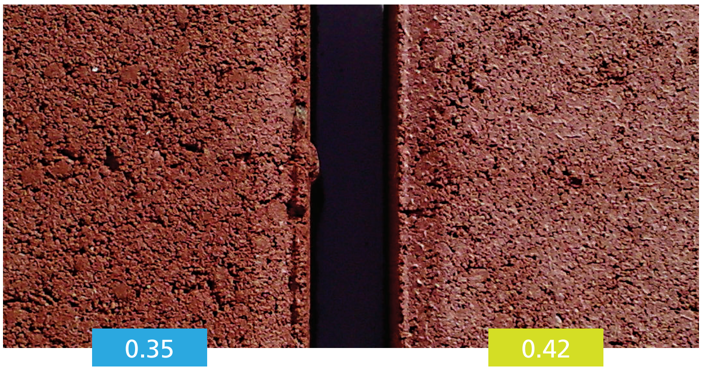

FIG.1:

Both pavers pigmented with PJ126 at 4%.

Water/cement ratio 0.42 gives a lighter colour shade when compared to a water/cement ration of 0.35

It is noticeable that the paver with water cement ratio of 0.42, an 'orange skin' has formed on the surface. This can lead to big differences in colour of individual blocks either at the production stage or later after the blocks have been laid. It should be noted that these differences are also apparent in concretes with no pigment.

SIGNIFICANCE OF THE FINES CONTENT
EFFECT ON COLOUR SHADE

As mentioned above, it is only the cement paste that is pigmented and this in turn coats the aggregate and fine fraction of the mix. Therefore the aggregate grading curve and the binder aggregate ratio play a very important part of determining the finished colour of the concrete. The blocks in Fig.2 are all made with the same pigment & cement and other things such as pigment concentration and water/cement ration have been kept constant. The only variable is the aggregate grading.

FIG.2:

All pavers pigmented with PJ 4960 at 3%.

The variation in aggregate grading shows a huge difference in finished colour.

SUMMARY

The colour shades of both natural and pigmented concrete vary according to the type of concrete, raw materials, curing conditions and so on. Where colouring is required it is important to take these factors into consideration. In any trial matching of colours, the conditions should be similar to those of the production stage as far as possible.

Bibliography:
Inorganic Bayer Pigments, Bayer AG 1977
Pigments for the colouring of concrete, Dr Egbert Puttbach

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