EXPERIMENTS IN COLORING CONCRETE: BY PROF. CHARLES E. PELLEW

SOME two months ago I was asked by a prominent architect of my acquaintance to examine for him the general subject of coloring concrete for building purposes. My friend is engaged on the problem of constructing a large number of workingmen's cottages near the city of New York, and has decided that concrete, when used scientifically as a building material, possesses great advantages over wood, stone or brick, as regards durability, freedom from fire, comfort, and even expense. But the natural color of concrete is not particularly interesting, and, to get satisfactory results from an artistic standpoint, it was evidently necessary to have it colored in one way or another.

The experiments which we have been making on the subject are not yet complete, and, indeed, probably will not be quite finished for some months yet. But the question of coloring concrete is such an interesting one, and promises in the near future to be of such importance, that we have been requested to present the results so far obtained to the readers of THE CRAFTSMAN, without waiting for the work to be entirely completed.

The general problem of coloring concrete naturally separates itself into two main divisions, Body Coloring and Surface Coloring. In the first the pigment is incorporated in the body of the concrete before mixing, and forms blocks of even color all through. In Surface Coloring, on the other hand, the coloring material is applied to the surface of the block, after the concrete has set, and thus forms only a thin film or coating on the outside.

These methods of applying the color each have their special disadvantages, due to the nature of the material. The free lime in the concrete has, when moist, a strong and generally injurious chemical action upon most of the ordinary pigments, and comparatively few coloring matters are able to resist it, especially when mixed right in with it. It has at the same time a strong action upon many kinds of organic matter, such as linseed oil, used in paint. Then, too, the compact, but friable surface of concrete makes it difficult to force a stain or paint into the pores far enough to prevent it from being easily brushed or rubbed off.

For our particular problem, as it happened, the question of expense was of vital importance; and this limited us still further in our range of possible pigments. In the matter of first cost it is evident that some form of surface coloring would be cheapest. But, unless great pains are taken to have a thoroughly hard permanent surface for the pigments to adhere to, and to obviate as far as possible the use of linseed oil, the Body Coloring is probably the most satisfactory.

In this paper we propose to sketch, briefly, the various materials that can be used for Body Coloring, and later, to discuss the different methods of Surface

Coloring, by stains, paints, etc. Our experiments hitherto have been directed toward the following colors,—brown, red, yellow, buff, black and green, and we shall take them up in that order:

Brown.—Some experiments with a vegetable brown made from partially carbonized organic matter, gave results which were unsatisfactory, as the colors were hard and uninteresting. We then made a series of experiments with two mineral dyestuffs, long known and used for staining and coloring textiles, but not, we believe, used hitherto for coloring cement or concrete. These were the orange-brown iron-rust color and the manganese brown.

A. *Iron Rust.*—This color is the same as that known to our ancestors for dyeing homespuns, and is still used for coloring fishing boat sails on the Mediterranean. It is based on the formation in the concrete, of a reddish brown deposit of ferric hydroxide, by the action of the lime of the cement on a soluble salt of iron, like ferric chloride, or ferric sulphate. First we tried ferric chloride as the coloring agent, but we found later that strong solutions of ferric sulphate could be obtained from the chemical manufacturers at a low price, 1.5 to 1.6 cents a pound, far less than any other soluble ferric salt.

Unfortunately, it takes a very large amount, 25 to 30 per cent. (of the weight of concrete) to get at all a decided color with this compound, and this is a serious drawback for our purposes.

B. *Manganese Brown.*—This color is based upon the formation in the concrete of brown manganese hydroxide by the reduction of the salt potassium permanganate. The latter possesses a strong rich purple color, which in the presence of oxidizable material, such as organic matter, turns at once to a full seal brown.

This reaction has been known and used for a long time in the dyeing of textiles, and an interesting application of it was made in England some ten years ago during the Boer War. It was necessary to send to the front all the available troops, and among others the famous old cavalry regiment, "The Scots Greys," renowned for glorious records at Waterloo and elsewhere, was called out for service in South Africa. Ever since its formation, some two hundred years ago, this regiment has been mounted on white or gray horses, and it was strongly hinted to the War Department that it was foolish to dress the cavalrymen with the utmost care in dull khaki and to carefully paint brown all metal work, from their sword hilts and stirrups down to belt buckles and uniform buttons, and yet to have them ride horses of such a conspicuous color. There was no time to train new mounts for them, so an eminent dyeing chemist was consulted, and he advised sponging over the horses every morning on the voyage down, with a weak solution of permanganate. The results were most satisfactory, and long before they reached the Cape each horse was thoroughly stained a quiet soft brown shade.

In dyeing textiles the organic matter needed for the reaction is taken from the cloth or yarn itself, and care must be taken not to "tender" it in the process. In staining concrete the organic matter must be supplied in the form of glucose or sugar, which in quite small quantities will change the deep purple color of the permanganate into a rich seal brown. To get a full deep color in our experiments we were obliged to use some 24½ per cent. (by weight of the cement) of permanganate, and about ½ per cent. of glucose. The price of permanganate is about 8 cents a pound and the glucose can be obtained, in the form of a thick concentrated syrup, at a little less than 3 cents a pound.

Red.—The only red colors practically available for Body Coloring are the various forms of red oxide of iron, some of them natural, finely ground hematites from Europe or this country, and others artificial, usually a residue from the distillation of copperas for fuming sulphuric acid.

These colors differ greatly in shade, price and coloring power, and it is impos-

sible to cover more than few of the innumerable varieties of red oxide that can be obtained for this purpose. In general, the cheaper colors are either native oxides of rather unsatisfactory shades and low coloring power, or else are more expensive and powerful pigments mixed with a neutral adulterant, like gypsum. As a pigment adds nothing to, and indeed distinctly detracts from, the strength of the concrete, it is evidently best to get the desired shades by small amount of a strong, though high-priced, color, than by using a cheap and weak color in proportionately larger quantities.

After experimenting with twenty or more different colors from various manufacturers the best results were obtained from a red color at 5 cents a pound, from 7½ to 10 per cent. (of the weight of cement) being needed to give a full shade. The addition of small amounts of permanganate brown, as described above, modifies the bright red color and gives a more pleasing shade, like red terra cotta.

Yellow.—For this color the only available pigment is some form of yellow ocher which can be obtained both strong and cheap. The best results that we have had came from the use of a strong bright color, price 2½ cents, which when used to the extent of 8 per cent. of the cement gave a bright tan color. This yellow can be used for shading the red, but is not so effective for this as the manganese brown.

Buff.—The same yellow ocher when mixed with small amounts of the permanganate brown will give various shades of yellowish brown or buff color. Pleasant shades are obtained by using 5 per cent. of yellow ocher and 2½ per cent. of permanganate.

Black.—In case black shades are desired they can be obtained without difficulty by using some of the carbon or lampblacks, sold by the manufacturers for 1½ cents a pound and upward. For a bluish shade of black we experimented with some success with a black iron oxide, imported for the use of gas works at 1¾ or 2 cents a pound. Full shades would need some 8 or 10 per cent. of the pigment.

Green.—The high price of chromium oxide, the only green mineral pigment, which will stand the action of lime, prevents its use for body coloring. Good qualities of chromium oxide cost from 40 cents a pound upward, and while cheaper grades are in the market, their coloring value is, as a rule, proportionally lower.

In the absence of a strong blue which will stand the action of lime, it is not possible to obtain a good green by modifying the color produced by yellow ocher. Ultramarine blue is indeed fast to lime; but possesses a very low coloring power when mixed with other pigments, while the strong blue, Prussian blue, which is commonly used as a constituent of green paints, is very easily attacked by the cement.

It is sometimes possible, with light colored materials, to obtain pleasant shades of olive green by mixing yellow ocher with black pigments, if the latter have a tendency to bluish black. We made several experiments to see if this was possible with concrete, using both carbon black and the black iron oxide just mentioned for the purpose. Unfortunately, the color of the natural concrete was such that none of these experiments gave any satisfactory results.

It seems probable that for greens we must depend upon some form of surface coloring and not of body coloring; that is, if we are to use ordinary cement, and sand and gravel of the usual brown shade. By using the more expensive white cement, and crushed bluestone of assorted sizes, for sand and gravel, it is probable that pleasing effects can be obtained with the above combination. With the ordinary materials, however, the color was killed.

EDITOR'S NOTE:—Professor Pellew has signified his willingness to answer all letters sent to him through THE CRAFTSMAN on the question of coloring concrete. He feels that many questions may arise in the desire for certain variation of color and tone or material, and he places his knowledge at the disposal of the readers of this magazine. Letters should be addressed to Professor Pellew, care of THE CRAFTSMAN, 41 West 34th St., New York.