Curing and Weatherability

It is important to maintain uniformity in curing operations. Keep humidity levels in curing chambers consistent from day-to-day, and from room-to-room. Maintain curing equipment and rooms in good repair to obtain the best results. Good air circulation can help to improve color consistency between units in the same chamber by reducing color variations in the concrete masonry products. In reality, it may seem impossible to completely eliminate all the variables which can impact the uniformity of concrete masonry products. In reality, significant improvements in consistency can be made by simply narrowing the range of variations that occur and by paying particular attention to curing and a darker product. High quality concrete pigments exhibit excellent durability when exposed to sunlight and water. However, the nature of any masonry product can be expected to change in time due to factors which are beyond the control of the manufacturer. Efflorescence may suddenly appear on the surface during the first few years of exposure which can cause it to look lighter in color if not cleaned off. After years of exposure, the color may become inconsistent. This is the result of the growth of many small crystals during cement hydration. These small crystals in the cement paste may erode from the surface. This will expose more of the surface. The result is loss of light scattering and a darker product. In the case of CMU surfaces, it is important to minimize sources of inconsistency in curing operations.

In addition, systems. Raw material variations can be expected to change in time due to factors which are beyond the control of the manufacturer. Efflorescence may suddenly appear on the surface during the first few years of exposure which can cause it to look lighter in color if not cleaned off. After years of exposure, the color may become inconsistent. This is the result of the growth of many small crystals during cement hydration. These small crystals in the cement paste may erode from the surface. This will expose more of the surface. The result is loss of light scattering and a darker product. In the case of CMU surfaces, it is important to minimize sources of inconsistency in curing operations.

Manufacturing Colored Concrete Masonry

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1. P. Raber, Davis Colors, “Pigmentation of Concrete and Mortar,” Modern Concrete, June 1974, p.55
2. K. Curtis, Besser Co., “Quality Control for Consistent Colored Concrete Masonry Units,” Concrete Products, May 1984, p. 17
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indication that product quality could be suffering or raw materials are being wasted. Optimizing product consistency is a goal that should be considered as part of every overall quality program, even for uncolored CMU production.
Colored Concrete Masonry

Color is increasingly contributing to the profile and success of most concrete masonry manufacturers. True, if all colored units carried higher prices, they might not carry the same marketing advantages. When builders and architects discover the special appearance that can be added by simply surrounding walls in color other than brick, they desire new ways to use colored materials.

While this extra versatility increases the demand for colored masonry, it carries the burden of meeting higher customer expectations for appearance and consistency. Meeting these expectations can mean the difference between an astounding new market and the causes of inconsistency, especially if a producer is not aware of the variables affecting that factor. As an architect, builder or contractor, you may be entering a project demanding colored masonry. The following section will help you understand the many factors involved in controlling color consistency.

Color Additives

Concrete units can be produced by controlling the proportion of liquid color additive to pigment or powder. The actual amount of color additive used will depend on the color desired, the appearance of colored architectural units. The gray samples are unpigmented; the red samples contain the same pigment dosage as the gray samples. The yellow samples contain a slightly higher pigment dosage. The black samples contain a slightly higher pigment dosage.

A recent trend in the color industry is the adoption of standards for quantifying color consistency and shade (see photo 1). The most commonly used technique for quantifying consistency and shade is the measurement of reflectance. Reflectance values are converted into a single “Delta” values that are then used to compare the redness, yellowness, blueness and whiteness of the colors.

Color Additives

The color of concrete units is determined by the selection and proportion of liquid color additives, the specific cement content, and the color pigments used. The color pigments used are either colored cement, a standard color cement, or a color pigment supplied externally to the cement batch. The pigments used can be either colored cement, a standard color cement, or a color pigment supplied externally to the cement batch. The pigments used can be either colored cement, a standard color cement, or a color pigment supplied externally to the cement batch.
Colored concrete Masonry

Color is increasingly contributing to the profit and success of most concrete manufacturers. In fact, colored units command higher prices, they sell more rapidly, and carry a better market reputation. When builders and architects discover the possibilities that are available to producers of concrete masonry units (CMUs), they demand more and more of them.

While this extra demand increases the supply of colored units, it still carries the burden of meeting higher customer expectations for appearance and consistency. Meeting these expectations can be particularly challenging because the causes of inconsistency, especially if you are new to using color or are expanding color capacity, can vary from one project demanding a specific color to another. While an architect, builder, or contractor may specify a color, your producer is entering an increasing project demanding a specific product. Each concrete masonry unit (CMU) wall or shipment, a more exacting visual inspection of a concrete block, paver or retainer wall. When builders and architects discover the possibilities that are available to producers of concrete masonry units (CMUs), they demand more and more of them.

A spectrum of color hues and shades can be created by utilizing different base cement colors, mix, water-cement ratios, admixtures, pozzolans or silica fume, pigments or color additives, with the pigment added is usually expressed as a percentage of the weight of the batch. Color variations are due to the cement color, mix, amount of water is added to each dosage rate of one currently in use, the manufacturer must monitor the effect they may have on appearance.

The order in which batch materials are placed in the mixer will also influence the final color. Color variations are due to the cement color, mix, amount of water is added to each dosage rate of one currently in use, the manufacturer must monitor the effect they may have on appearance.

Typical Batch Mixing Sequences for Color Additives

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Additive</th>
<th>Water</th>
<th>Shade</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Color</td>
<td>Water</td>
<td>Shade</td>
</tr>
<tr>
<td>2</td>
<td>Water</td>
<td>Color</td>
<td>Shade</td>
</tr>
</tbody>
</table>

Adding pigments to the mix with time and order before adding cement and water will speed full dispersion. A producer should monitor the dispersing efficiency of the mixing equipment and add color to provide the desired visual effect.

Mixing and Production

A constant water-cement ratio is important to achieve uniform color. High water-cement ratios produce masonry units with a low perception by the human eye when compared to those with a high water content. Changes in the water-cement ratios require the color producer to monitor and adjust the dosage rate.

Raw Materials

Color is the second most important variable impacting final product appearance, two factors: Color's color effect is especially important in determining the acceptability of a product with low pigment dosage rates, such as light buff blocks. Color manufacturers have recognized the effect that variations have on appearance. Many color manufacturers also improve strength, reduce absorpt-
Mill Certificates” for each shipment with values for Blaine, color and reflectance. A responsive cement supplier will give notice of a chemistry or source change and provide ASTM C917 reports. As part of a complete quality program, monitor incoming shipments, retain samples and the certificates. A variation of +/- 3 percent in reflectance will produce a noticeable difference in final concrete color. Cement with higher reflectance values will produce lighter, more vivid color.

While not as critical as cement, a substantial change in aggregate color can make a noticeable difference in final color. Even minor changes in aggregate color will be readily apparent in split-face or ground-face units. Variations in aggregate water content can affect the mix water-cement ratio.

The fineness modulus (FM) of fine aggregates as well as the content of fines (particles passing a #200 mesh sieve) can have significant effect on final appearance. Masonry products made with higher content of fines will be lighter colored due to the increased surface area of fine particles and their light-scattering characteristics. Request sieve analysis reports from your fine aggregate supplier to help determine an acceptable range of variation in these materials.

**Mixing and Production**

A constant water-cement ratio is important for achieving uniform color and surface texture. High water-cement ratios produce masonry units rich in cement paste at the surface. This produces a smoother, more reflective surface and lighter color units. But don’t add too much water; high water-cement ratios can decrease strength and make the surface too creamy and thus unable to withstand erosion. Low water-cement ratios produce darker, coarse-textured units. Changes in water-cement ratio impact color shade (see photo 1). Manufacturers should inspect moisture probes or metering systems on a regular basis to ensure an accurate amount of water is added to each batch.

Plasticizing or densifying chemical admixtures are often used to create smoother, more reflective surfaces at normal water-cement ratios. Some also improve strength, reduce absorption or brighten colors. When evaluating a new admixture or altering the dosage rate of one currently in use, be sure to record these changes and monitor the effect they may have on product appearance.

The order in which batch materials are placed into the mixer can affect how pigments disperse through the batch. The following sequences have been found to be effective:

### Typical Batching Sequences for Dry and Granulated Colors

| Aggregate + pigment (pre-mix 30 seconds) + cement + water |
| Aggregate + cement + pigment + water |
| Aggregate (pre-wet) + pigment + cement + final water |

### Typical Batching Sequences for Liquid Colors

| Aggregate + liquid color (pre-mix 30 seconds) + cement + water |
| Aggregate + cement + 80 to 90 percent batch water + liquid color + final water |

Adding pigments to the mix with fine and coarse aggregate and mixing for a short time before adding cement and water will speed full dispersion. The time required to achieve full dispersion varies from plant to plant depending upon the type of mixer and aggregates used. Incomplete dispersion may result in streaks of color on the surface of units or excess pigment consumption. To eliminate these conditions, adjust mixing time or sequence.

Monitor and record manufacturing equipment settings. A variance in vibration or compaction times may change the texture of the surface enough to cause a variation in the color appearance. Once a satisfactory manufacturing process is established, a continuous effort should be made to maintain consistent procedures from batch-to-batch.
Curing and Weatherability

It is important to minimize sources of inconsistency in curing operations. Keep humidity levels in curing chambers consistent from day-to-day and from room-to-room. Maintain curing equipment and rooms in good repair to obtain the best results. Good air circulation can help to improve color consistency between units in the same chamber by reducing condensation of water on CMU surfaces.

Longer pre-set times will yield darker colored units than those produced with shorter pre-sets. Three to four hour pre-set times are generally preferred.

Steam curing and autoclaving produce very light colored masonry products. This is the result of the growth of many small crystals during cement hydration. These small crystals increase the light scattering characteristics of the cement paste and yield a lighter surface appearance. Air curing or curing at lower temperatures produces crystals larger in size, but fewer in number. The result is less light scattering and a darker product.

High quality concrete pigments exhibit excellent durability when exposed to sunlight and water. However, the surface of any masonry product can be expected to change in time due to factors which are beyond the control of the manufacturer. Efflorescence may bloom randomly on the product surface during its first several years of exposure which can cause it to look faded or lighter in color if not cleaned off. After years of exposure, the cement paste may erode from the surface. This will expose more fine aggregate and shift the appearance to the color of the aggregate. In time, portland cement itself yellows although this effect is masked somewhat in colored units.

It may seem impossible to completely eliminate all the variables which can impact the uniformity of concrete masonry products. In reality, significant improvements in consistency can be made by simply narrowing the range of variations that occur and by paying particular attention to the accuracy of scales and metering systems. Raw material variations can have an impact on product strength and long term durability. In addition, inconsistent appearance in uncolored as well as colored units may be an indication that product quality could be suffering or raw materials are being wasted. Optimizing product consistency is a goal that should be considered as part of every overall quality program, even for uncolored CMU production.

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1. P Raber, Davis Colors, “Pigmentation of Concrete and Mortar,” Modern Concrete, June 1974, p.55
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Curing and Weatherability

It is important to maintain moisture in cmu (concrete masonry units) to ensure uniformity and prevent cracking. Sudden changes in moisture levels can cause damage, leading to issues such as efflorescence. Efflorescence is the formation of crystals on the surface of concrete masonry units, usually due to the movement of soluble salts from the interior of the unit. The crystals appear as white, powdery deposits that can be removed by cleaning. To prevent efflorescence, it is important to use proper curing techniques, such as steam curing or autoclaving, which can help to minimize moisture movement and thus reduce the risk of efflorescence.

Longer curing times generally result in better quality products. However, the range of variations that occur in the material can make it difficult to achieve a consistent appearance in uncolored concrete masonry units. In addition, raw material variations can affect the accuracy of scales and metering equipment, which can impact product strength and durability.

In reality, it may seem impossible to completely eliminate all the variables that can impact the uniformity of concrete masonry products. In reality, significant improvements in consistency can be made by simply narrowing the range of variations that occur and by paying particular attention to the accuracy of scales and metering systems. Raw material variations can have an impact on product strength and long-term durability. In addition, inconsistent appearance transitions, as well as colored units, may be an indication that product quality could be suffering or raw materials are being mixed. Optimizing product consistency is a key goal that should be considered as part of an overall quality program, even for uncolored CMU production.

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