

TROWEL TIPS

an aid to the masonry industry

Mortar Color

Introduction

Many factors are involved in the choice of masonry for use in a building. Certainly masonry offers advantages in durability, building safety, reliable structural performance, and low maintenance that appeal to the discriminating owner. However, a major consideration in selecting masonry is often an appreciation for its inherent beauty. That fact, coupled with the recent trend toward more dramatic architectural use of color and texture in building design, has resulted in greater emphasis on achieving the desired appearance in finished masonry mortar joints. This publication examines the factors that determine the color consistency of mortar joints and how certain construction practices and techniques relate to the final appearance of a mortar joint. The focus of this document is on steps that the mason can implement to assure that the appearance of mortar joints are acceptable to the owner.

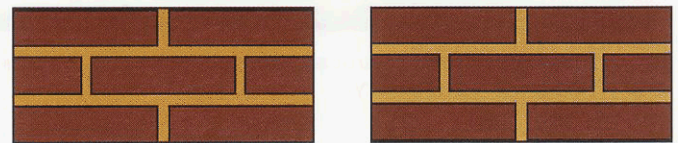
Evaluating Appearance

While the statement "beauty is in the eye of the beholder" rightly points out that evaluation of appearance is subjective, there are certain general principles that are common to our perception of appearance. For example, texture and color are the primary criteria by which we categorize the appearance of mortar joints. These primary appearance criteria are further subdivided. Texture is evaluated subjectively on the basis smoothness or roughness, while colors are classified based on hue, intensity, and shade. Hue is that quality of color described in terms such as red and yellow. Intensity is the degree to which the hue dominates the color of an object, and shade refers to the relative lightness and darkness of an object. Our perception of the appearance of an object is also influenced by the light under which it is viewed and its immediate environment. Thus, two objects may appear to be identical in hue when viewed in direct sunlight, but exhibit perceptible differences when shaded or vice versa. An object viewed against an intensely colored background will be perceived as having a different color than the same object viewed against a neutral gray background. Perceived appearance is a complex interaction of all of these variables.

Acceptance of appearance is further complicated by the fact that individuals may subjectively place more emphasis on the selection and control of some of these variables than



(a) Different hues, same intensity and shade



(b) Different intensities, same hue and shade



(c) Different shade, same hue and intensity

Fig. 1. Color can be classified on the basis of three variables: hue, intensity, and shade as illustrated by these examples in which two of the variables are held constant while two distinct levels were selected for the third variable.

others. For example, one individual may primarily be concerned that a certain hue is achieved while another may place approximately equivalent value on obtaining desired texture and hue. Therefore, achieving acceptable appearance of mortar joints on a project requires: 1) initial agreement between the owner or his representative and the contractor or mason on what constitutes desired appearance, 2) an understanding by both of the inherent limitations of the system, and 3) careful control of influencing variables by the contractor and mason.

Several systems have been developed to measure and categorize the appearance of different objects. These range from complex procedures utilizing instrumental measurement techniques to simple guidelines for the comparative viewing of objects. While the former may have merit when used in control of component mortar materials such as pigments or colored cements during manufacturing, evaluation of finished mortar color is best accomplished by observing certain general guidelines when viewing mock-ups, sample panels, or finished masonry construction.

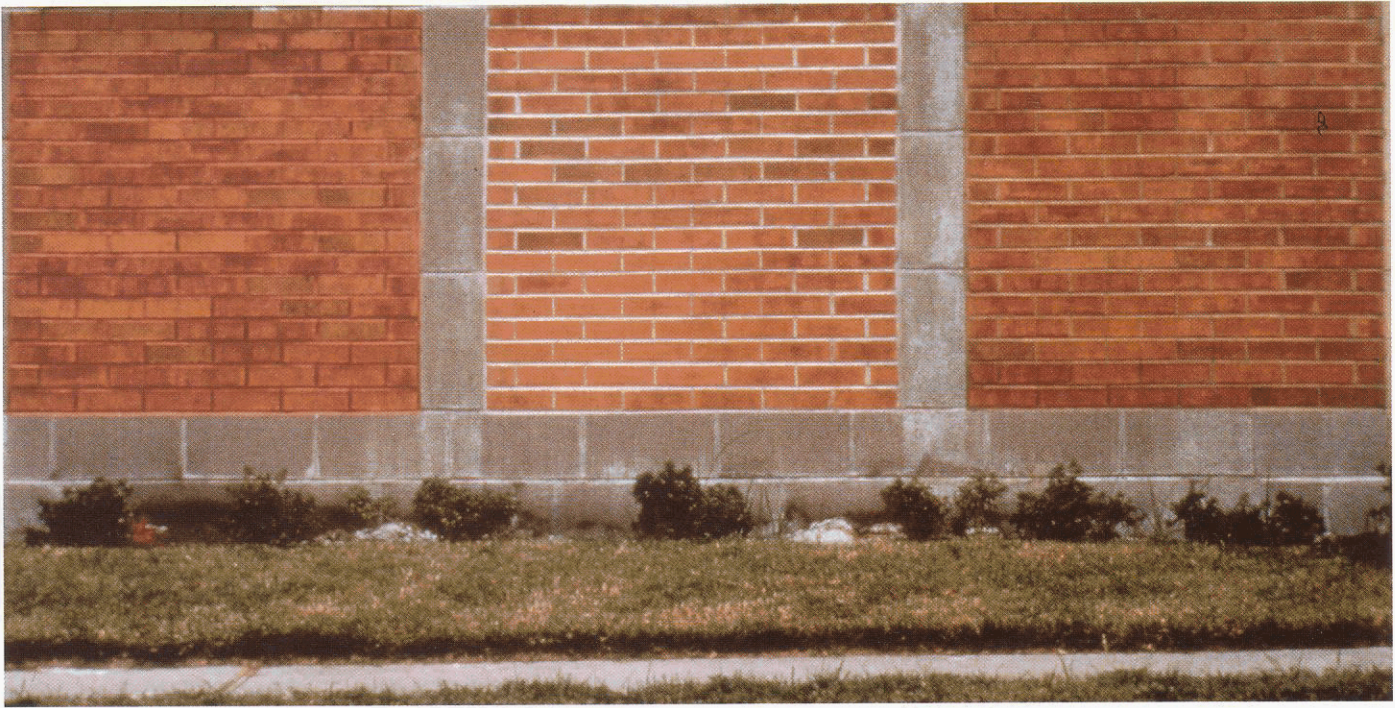


Fig. 2. These panels are constructed with the same brick and different colored mortars illustrating the effect mortar color can have on the overall appearance of masonry.

These guidelines are:

- Construct the panel in a safe area – retain for future reference if necessary.
- View the masonry together – this assures that purchaser (owner) and provider (mason) are examining the masonry under the same lighting and environment.
- Optimize viewing environment – view under strong but indirect sunlight if possible.
- Evaluate as a whole – consider the overall appearance of the masonry as basis for evaluation. Usually this entails observation from a distance of approximately 20-30 ft (6-9 m).
- Examine closely when questions arise – the cause for differences in appearance observed from a distance can often be determined by close inspection of the masonry.
- Discuss what you see – evaluation of appearance is subjective, but most people can agree on the general aspects of appearance.

Establishing Agreement

The masonry sample panel or mock-up is an important means of establishing agreement between purchaser and provider on what is expected and what is achievable. Depending on the complexity of the project, the role of a masonry sample panel or mock-up can go beyond providing a means for evaluating the appearance of masonry. However, establishing appearance criteria for the project is certainly one of the basic reasons for constructing, approving, and retaining sample panels or mock-ups.

In addition to following the general guidelines for evaluating the appearance of masonry previously mentioned, the mason contractor should be certain that the panel is indeed representative of what can be achieved on the project. The materials, batching and mixing procedures, level of workmanship, curing, and cleaning procedures used to construct the sample panel should be consistent with what will be provided in construction of the project. This requires planning on the part of both the owner and the mason contractor, to provide adequate time for the mortar to cure, for the panel to be cleaned, and for it to dry prior to evaluation of its appearance. Honest discussion between the owner or his representative and the mason contractor is required to assure that a clear understanding is reached on what appearance criteria are reasonable to expect in the completed masonry. For example, the mason may need to explain how the combination of the masonry unit's suction characteristics, sand quality, mortar type, and tooling requirements being used on a specific project affect consistency of texture and shade of mortar joints. The owner or the owner's representative may wish to emphasize concern that precautions such as covering units and walls are taken during construction to minimize variability in the appearance of mortar joints.

Understanding Mortar Color

The texture and color of a finished mortar joint are determined by properties of component mortar materials, preparation of the mortar, workmanship, curing conditions, cleaning procedures, and environmental factors. It is important that the mason understand these relationships in order to control the texture and color of mortar joints. It is important that the owner understand these relationships so the owner can better define expectations in achievable terms.

Materials. Conventional masonry mortar is made from sand, water, and masonry cement; sand, water, and mortar cement; or from sand, water, and a mixture of portland cement and hydrated lime. In order to achieve the desired mortar color, pigment may be added to the system, either as an ingredient of pre-pigmented cements or as an admixture. Each of the component materials influences the mortar appearance.

Sand primarily affects texture and shade of color. However, if a sand contains an appreciable percentage of clay or silt fines, it will also affect the hue and intensity of a mortar joint. The gradation of a sand will influence the water demand of the mortar and the texture of the mortar joint surface.

The color of the masonry cement, mortar cement, or the portland cement and lime used in a mortar mix influences the hue, shade, and intensity of a mortar joint. However, the dry powder appearance of these materials is not always indicative of their effect on mortar color. Cement and water (or cement, lime, and water) forms a paste that coats sand particles. The paste hardens as the cement reacts with the mixing water, and the hardened paste tends to dominate the color of the mortar. The color of the hardened paste is influenced by the inherent color of the cement (or combination of cement and lime) plus the ratio of water to cement in the paste. Mortars having higher water to cement ratios tend to be lighter in color than those having lower water contents.

Pigments are incorporated in a mortar to achieve a specific desired appearance. Having an extremely high fineness compared to other components of the mortar system, pigments become part of the cement paste and dominate the color of the paste and mortar. Since they have such a dramatic influence on mortar color, pigments are best incorporated into the mortar system as part of a pre-blended pigmented cement or in pre-weighed packages. Mineral oxide pigments (usually natural or synthetic iron oxides) are recommended for use in mortar, since they are compatible with cement and lime and provide color stability in the finished mortar joint. Carbon black pigments exhibit poor color stability in masonry mortar exposed to weather. Their use in exterior masonry should be avoided.

Proportioning and Mixing. Controlling mortar texture and color requires consistent materials and adequate procedures for assuring that these materials are properly proportioned and mixed. A change in the aggregate ratio of a mortar will result in a change in the amount of water required to achieve the desired workability, thus affecting both texture and color of the finished mortar joint. When cement and lime are used, changes in relative amounts of these components will also affect color and texture. As previously noted, mortar color is so sensitive to pigment content that proportioning is best accomplished by using pre-pigmented cements or pre-weighed pigment packages. Proper mixing is needed to assure uniformity within and between batches of mortar.

Unit Suction, Tooling, and Curing. When freshly mixed mortar is placed between absorptive masonry units, much of the water contained in the mortar is absorbed by the units. Thus the actual ratio of the water to cement in a mortar joint when the mortar sets may be substantially lower than what the ratio was when the mortar was initially mixed. How



Fig. 3. In this example, a masonry prism was constructed using one batch of mortar. The top mortar joint was tooled immediately after placement of the unit. Remaining mortar joints were tooled at progressively greater time intervals and thus stiffer consistency. The relationship between mortar consistency when tooled and mortar color is quite apparent.

much lower will depend on the absorptive characteristics of the unit and the water retentive characteristics of the mortar.

The effect of tooling on the appearance of a mortar joint is dependent on the type of jointer used and the stiffness of the mortar at the time it is tooled. Tooling of mortar when it is highly plastic or flowable will tend to pull a high-water-content paste to the surface, resulting in a porous light-colored joint surface. If the mortar is allowed to become stiff before tooling, the joint surface will not readily yield to the pressure of the jointer, and friction developing between the metal jointer and the mortar joint will result in a dark streaked surface. When tooled at the proper consistency, the surface of the mortar joint is compacted, and a uniform appearance consistent with the body of the mortar is achieved. Since pigments, due to their high fineness, are easily concentrated on the surface of a mortar joint by tooling, the appearance of colored mortar joints is especially sensitive to the tooling technique used in finishing the mortar joint.

The cement paste hardens as it reacts with water. This process will continue over an extended time period, provided sufficient moisture is present and temperatures are well above freezing. Since the curing environment affects the micro-structure of the paste, slight permanent variations in shade may result from differences in curing conditions. However, when mortars are cured under different moisture conditions, the most dramatic differences in lightness and darkness are usually associated with variations in the free moisture content of the mortar. Mortars having high free moisture will appear darker than those having low moisture content. Such differences in appearance are temporary and will diminish as moisture levels reach an equilibrium.

Cleaning. Cleaning procedures often completely alter the appearance of a mortar joint, changing both texture and color. Most cleaning techniques are designed to remove mortar droppings or smears from the surface of newly constructed masonry. However, if these techniques dissolve the cement paste from the surface of a mortar joint, the appearance of that joint is no longer dominated by the color of the hardened cement paste, but reflects the appearance of sand particles that are exposed on the surface. The effect of improper cleaning is most dramatic on colored mortar joints, since the pigmented cement paste is relied upon in these systems to produce the desired color. In addition to altering the appearance of mortar joints, improper cleaning may damage masonry units and compromise the ability of the masonry to resist water penetration.

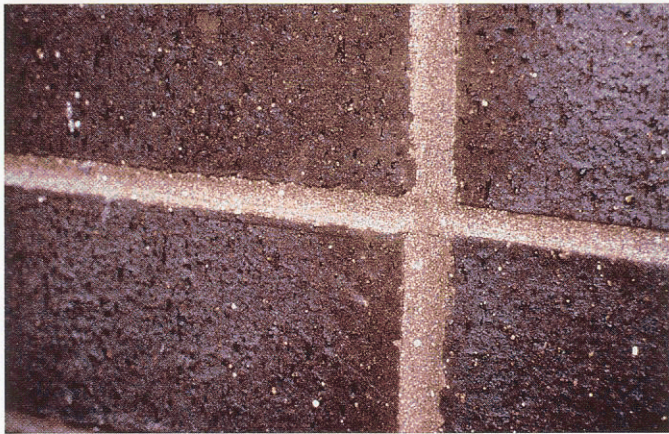


Fig. 4. The use of a strong acid cleaning solution has etched the surface of these mortar joints, exposed sand particles, and significantly changed the appearance of the mortar joint.

Controlling the Appearance of Mortar Joints

Understanding what factors affect the appearance of mortar joints provides a basis for establishing control of the texture and color of mortar joints. Masonry walls and mortar joints will not exhibit the uniformity of appearance characteristic of flat painted surfaces. Indeed, since part of the attractiveness of masonry is rooted in its earthy appearance and hand-assembled heritage, paint-like uniformity is not generally desirable. However, aside from minor fluctuations in shade and texture that tend to impart depth and

character to the masonry, the mason contractor and his crew can control the appearance of mortar joints by controlling key variables as follows:

Use the Same Mortar Materials. Changes in brands of masonry cement, mortar cement, portland cement, hydrated lime, or pigments during construction of a project should be avoided. All of the sand should be from the same source. When multiple sand shipments are required, the mason contractor should visually check the appearance of successive shipments to assure that sand color and gradation has not changed significantly. For jobs having particularly demanding requirements on mortar color, it may be advisable to keep a small quantity of sand from the first shipment in a sealed container for comparison with subsequent shipments.



Fig. 5. The difference in mortar color in this example was determined to be the result of a change in both sand and type of cement used in the mortar.

Control Proportioning and Mixing of Mortar. Masonry cement, mortar cement, portland cement, and hydrated lime are typically delivered in pre-weighed packages. Thus, consistent proportioning of these ingredients is assured by adding these ingredients to the mixer in bag increments or sometimes in increments of a simple fraction of a bag. For example, a Type S mortar can be made adding one bag of Type S masonry cement and 3 parts by volume of damp loose sand to the mortar mixer or by adding one bag of Type N masonry cement, half a bag of portland cement, and 4 1/2 parts by volume of damp loose sand to the mortar mixer.

Some positive control should be established to assure that the proper amount of sand is used. This can be accomplished by periodically checking the required shovel count with a cubic foot (0.28 m³) box, by using a cubic foot measuring box to add the sand to the mixer, or by using other containers of known volume to measure the sand. Since the bulk volume of sand is influenced by its moisture content, sand should be maintained in a damp loose condition to assure uniform proportioning (see *Trowel Tips: Mortar Sand*, IS242).

Adequate mixing is required to assure uniformity within and between batches of mortars. Mechanical mixing of

mortar is recommended. The mixer should be conveniently located next to the sand pile and water. Conventional mortar mixers are of rotating-spiral or paddle-blade design with tilting drum. *After all batched materials are together, they should be mixed for 3 to 5 minutes.* For pigmented mortars, mixing the full five minutes is advisable. Batching procedures will vary with individual preferences. Experience has shown that good results can be obtained when about three-fourths of the required water, one-half of the sand, and all the cementitious materials are briefly mixed together. The balance of the sand is then charged and the remaining water added to bring the mortar to optimum working consistency. The amount of water added should be the maximum that is consistent with satisfactory workability. Evaluation of optimum consistency by the mason requires an understanding of how absorption characteristics of the masonry units and ambient weather conditions affect masonry construction.

Schedule the mortar production to keep pace with the progress of construction. Mortar that has been mixed but not used immediately tends to dry out and stiffen. Loss of water by absorption and evaporation on a dry day can be reduced by wetting the mortar board and covering the mortar in the mortar box, wheelbarrow, or tub. Avoid producing mortar too far ahead of expected use to minimize retempering requirements. Retemper colored mortar cautiously to avoid color changes. Water content and stiffness of mortar during tooling affect color (see section on unit suction, tooling, and curing).

Control Unit Moisture Content. Variable IRA within a given brick blend can make tooling difficult and affect color. While the Initial Rate of Absorption (IRA) is an inherent property of the units and is probably beyond the control of the mason contractor, covering brick and block stored at the project site will eliminate variations in mortar appearance resulting from the use of wet and dry units. If it is necessary to wet high IRA clay units, the contractor should make certain that all units used are subjected to the same procedure. PCA's *Trowel Tips: Hot-Weather Masonry Construction*, IS243, outlines some procedures that can be used to accomplish uniform wetting of clay units. Concrete masonry units should never be wet when placed in the wall.

Use Proper Tooling Techniques. Different joint finishes are often selected to provide a desired appearance in the completed masonry. The mason must have the appropriate equipment to provide the desired finish and know how to use it to achieve a consistent appearance. In general, he should allow mortar joints to stiffen before tooling until the surface is hard enough that a thumbprint just barely shows. Special care must be taken with white or very light-colored mortars to assure that joint surfaces are not discolored with metallic deposits from the jointer. Use ceramic, stainless steel, or plastic jointers when working with such mortars.

Minimize Cleaning Requirements. When it comes to cleaning masonry, less is better. Careful workmanship includes implementing skills that minimize mortar droppings and smears on the face of the masonry. The mason contractor can use straw, sand, or plastic to protect the base of the wall from rain-splashed mud and mortar splatter, and he can assure that the inside scaffold board is

turned on edge at the end of each working day to prevent rain from splashing mortar and dirt onto the masonry wall. Covering the tops of walls at the end of each working day will prevent rain from entering walls and help reduce the possibility of efflorescence.

Clean Masonry Carefully. Use the least aggressive cleaning technique possible. Make certain that the cleaning procedure is consistent with the recommendations of the manufacturer of the units, and pre-qualify the procedure on the sample panel and a small test area of the building. When acid based cleaning solutions are used, the mortar should be allowed to cure at moderate temperatures for about seven days prior to cleaning. After cleaning a trial area, allow the area to dry, and closely examine mortar joint surfaces to ascertain that the procedure has not etched the surface. A more detailed discussion about this topic is contained in PCA's *Trowel Tips: Cleaning Masonry*, IS244.

View with Pride. It was noted at the beginning of this document that an appreciation for the inherent beauty of masonry is often the reason it is selected by the owner as a building component. Hopefully, that appreciation of masonry is shared by the mason contractor and his crew and will motivate each person to do his part to assure that the finished project is one in which all can take pride.



Fig. 6. With care and cooperation, consistent mortar color producing the appearance desired by the owner can be achieved.

Related Publications

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Concrete Masonry Handbook, EB008M

Mortars for Masonry Walls, IS040M

Masonry Cement Mortars, IS181M

Trowel Tips: Efflorescence, IS239M

Trowel Tips: Tuckpointing, IS240M

Trowel Tips: Mortar Sand, IS241M

Trowel Tips: Field Testing Mortar, IS242M

Trowel Tips: Hot-Weather Masonry Construction,
IS243M

Trowel Tips: Cleaning Masonry, IS244M

*Trowel Tips: Workmanship Part I, Preparing for
Quality*, IS245M

*Trowel Tips: Workmanship Part II, Imparting Quality to
Masonry*, IS246M

Recommended Practices for Laying Concrete Block,
PA043M

*Recommended Practices & Guide Specifications for
Cold Weather Masonry Construction*, LT107M

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