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Standard Specification for Pigments for Integrally Colored Concrete[1]

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1. Scope

1.1 This specification covers the basic requirement for colored and white pigments in powder form to be used as admixtures in concrete for the purpose of producing integrally colored concrete. Where the pigments are a constituent of a multicomponent admixture, this specification applies to the pigment constituent of the admixture. This specification is not intended to establish compatibility of pigments with any other concrete admixtures unless they are tested in combination in accordance with 3.7.

1.2 This specification does not include the determination of pigment stability when elevated temperature using low-pressure (atmospheric) or high-pressure (autoclave) steam is used to accelerate the curing process.

1.3 In addition to tests defining the pigments themselves, a limited number of tests on concrete are included to define the effects on setting times, air content, and compressive strength. If more extensive information is required for a particular job, additional testing criteria and procedures should be agreed upon between the seller and user.

1.4 The maximum prescribed dosage rate of a pigment, established in accordance with 3.7, shall be equal to or less than 10 mass % of cement. When a combination of pigments is used to produce the desired color and color intensity, the total dosage rate of all pigments combined shall not exceed any of the individual maximum dosage rates of the component pigments.

1.5 The values stated in SI units are to be regarded as the standard. The inch-pound units in parentheses are for information purposes only.

2. Referenced Documents

2.1 *ASTM Standards:*

C 33 Specification for Concrete Aggregates[2]

C 39 Test Method for Compressive Strength of Cylindrical Concrete Specimens[2]

C 143/C 143M Test Method for Slump of Hydraulic Cement Concrete[2]

C 150 Specification for Portland Cement[2]

C 173 Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method[2]

C 192/C 192M Practice for Making and Curing Concrete Test Specimens in the Laboratory[2]

C 231 Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method[2]

C 260 Specification for Air-Entraining Admixtures for Concrete[2]

C 403/C 403M Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance[2]

D 50 Test Methods for Chemical Analysis of Yellow, Orange, Red, and Brown Pigments Containing Iron and Manganese[3]

D 1208 Test Methods for Common Properties of Certain Pigments[3]

D 1535 Practice for Specifying Color by the Munsell System[4]

G 23 Practice for Operating Light-Exposure Apparatus (Carbon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials[5]

2.2 *ACI Standards:*

211.1 Recommended Practice for Selecting Proportions for Normal and Heavyweight Concrete[6]

3. General Requirements

3.1 *Water Wettability*—The pigment shall be water wettable when tested in accordance with 7.1.

3.2 *Alkali Resistance*—The pigment treated with sodium hydroxide shall not show any significant (Note 1) change of color when tested in accordance with 7.2.

3.3 *Total Sulfates*—Calculated as SO_3, the sulfates shall not exceed 5.0 mass % of the original pigment sample when tested in accordance with 7.3.

3.4 *Water Solubility*—The total matter soluble in water shall not exceed 2.0 mass % of the original pigment sample when tested in accordance with 7.4.

3.5 *Atmospheric Curing Stability*—The magnitude of color differences between pigmented concrete specimens cured in dry air and those cured at high relative humidity when tested in accordance with 7.5 shall not be greater than the magnitude of

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[2] *Annual Book of ASTM Standards*, Vol 04.02.

[3] *Annual Book of ASTM Standards*, Vol 06.03.

[4] *Annual Book of ASTM Standards*, Vol 06.01.

[5] *Annual Book of ASTM Standards*, Vol 14.02.

[6] Available from American Concrete Institute, 38800 Country Club Drive, Farmington Hills, MI 48331.

the color difference between two unpigmented specimens cured under the same conditions.

3.6 *Light Resistance*—The exposed portions of the specimens shall show no significant differences (Note 1) in color from the unexposed portions when tested in accordance with 7.6. While a pigment that fails this test shall not be considered light resistant, a pigment that passes this test may still be subject to fading when exposed to natural weathering conditions.

NOTE 1—A significant difference is defined as one that is readily perceptible by visual observation without close examination. Lighting and viewing conditions as described in Method D 1535, 6.1, may be used.

3.7 *Effects on Concrete*:

3.7.1 When compared with the control mixture, the concrete that is pigmented at the maximum prescribed dosage rate shall have a 28-day compressive strength of not less than 90 % and a water-cement ratio of not greater than 110 % of that of the control mixture when prepared and tested in accordance with 7.7 (Note 2).

3.7.2 The pigment, when added to a concrete mixture at the maximum prescribed dosage rate, shall neither accelerate the initial or final set by more than 1 h nor retard the initial or final set by more than 1½ h, as compared to the uncolored concrete control mixture when tested in accordance with 7.7 (Note 2).

3.7.3 Using the same quantity of air-entraining admixture, the pigments, when added to a concrete mixture at the maximum prescribed dosage rate, shall not change the air content by more than 1.0 %, as compared to the uncolored control mixture when tested in accordance with 7.7.

NOTE 2—These values include allowance for normal variations in test results. The object of the 90 % compressive-strength requirement is to require a level of performance of the pigmented concrete comparable to that of the reference concrete when tested in accordance with 7.7.

3.8 *Color Match of Shipment*—The color produced by the shipment of pigment shall not be significantly different (Note 1) from the color produced by the standard supplied by the pigment manufacturer when samples of both the shipment and the standard are tested in accordance with 7.8. New concrete specimens containing the standard sample of the particular pigment must be prepared whenever a new shipment is evaluated. This is necessary to eliminate color variations caused by any of the other mortar ingredients, specimen preparation, or curing.

4. Rejection

4.1 A pigment may be rejected if it fails to meet any of the applicable requirements of these specifications.

4.2 Individual packages or containers varying more than 5 % from the stated mass may be rejected. If the average weight of 50 packages taken at random is less than that stated, the entire shipment may be rejected.

5. Packaging

5.1 Packages or containers shall be clearly marked as to color designation and the net mass.

5.2 The package or container shall not be added to the concrete with the pigment.

6. Materials for Tests

6.1 *Cement*—For the atmospheric curing stability and the light resistance tests, using white cement is suggested. The cement used in all other tests shall be either a Type I or Type II cement conforming to Specification C 150 or the cement proposed for specific work.

6.2 *Aggregates*—The aggregates used in all tests shall conform to Specification C 33 or shall be the aggregates proposed for specific work. For the atmospheric curing stability and the light resistance tests, clean silica sand shall be used. For both the reference and the pigmented mixtures, the aggregate grading shall be controlled by determining the mass of separate fractions.

6.3 *Admixtures*—If any of the test mixtures contain any admixtures in addition to pigment other than an air-entraining admixture complying with Specification C 260, the pigment shall be considered to comply with this specification only when used in conjunction with such other admixture(s).

7. Test Methods

7.1 *Water Wettability*—Add 10.0 g of the pigment to 150 mL of deionized water in a 250-mL beaker. If the pigment does not readily mix with the water when stirred with a spatula, but instead a substantial portion of the pigment floats on the surface of the water, the pigment is repellent and not water wettable.

7.2 *Alkali Resistance*—Add two 10.0 g-portions of the pigment to separate 250-mL beakers, each containing 150 mL of deionized water. Stir until thoroughly mixed. Add 10 mL of 10 mass % sodium hydroxide solution to one beaker, and stir thoroughly once more. Let the slurries stand 1 h, then remix and filter on separate Buchner funnels. Wash the filter cake with three replacement washes of hot deionized water. Dry the cake on the filter paper in an oven at 110 ± 3°C (230 ± 5°F) for 4 ± 0.5 h. Remove from the oven, cool, and crush the pigment into a fine powder in a mortar. Make two small adjacent piles of the pigment powders and press them flat with a spatula. Compare the color of the control and treated pigment powders.

7.3 *Percentage of* SO_3—Perform the sulfates soluble in hydrochloric acid test and determine the percentage in accordance with Methods D 50.

7.4 *Water Solubility*—Perform the matter soluble in water test in accordance with Test Methods D 1208.

7.5 *Atmospheric Curing Stability*—The composition and method of preparation of the test specimens shall be in accordance with Annex A1. Pigments shall be tested at both ½ % and 6 % levels (based on the cement mass). Two sets of specimens (designated as control specimens and test specimens) shall be prepared at the same time under identical conditions except for curing. Each set shall consist of two pigmented mortar specimens, one at each of the two levels of pigmentation, and one unpigmented specimen. If, for a particular pigment being tested, the specimens that contain the pigment at a dosage rate of ½ % of the cement mass do not provide a significant difference (Note 1) in color when compared to the corresponding unpigmented specimen, the pigment dosage rate shall be increased until but not beyond the

rate at which the difference in color becomes significant. In addition, tests using the higher dosage rate of 6 % of the cement mass shall continue to be performed as specified. Compare for color the specimens that were cured under different conditions. For evaluating the color stability of the pigment tested, also compare the uncolored mortar specimens for color variations. Differences in the curing conditions or efflorescence, or both, can affect the color shade of any finished mortar or concrete, either colored or uncolored.

7.6 *Light Resistance*—The test shall be conducted in a Type E or EH exposure apparatus as described in Practice G 23. Type EH apparatus shall be operated without automatic humidity control. The exposure apparatus shall be operated in accordance with Practice G 23, except that no water spray or dark cycles shall be employed. The black panel temperature shall be 54± 3°C (130 ± 5°F). The composition and method of preparation of the test specimens shall be in accordance with Annex I. Pigments shall be tested at both ½ % (7.5) and 6 % levels (based on the cement mass). Half of each specimen shall be masked from light exposure by an aluminum foil covering. The other half of each specimen shall be exposed to light for 500 h after which time its color shall be compared to the unexposed half (3.6).

7.7 *Effects on Concrete*:

7.7.1 *Preparation of Mixtures*—Prepare concrete mixtures both with and without the pigment under test. Refer herein to the concrete mixture without the pigment as the reference or control mixture. The control mixture and the pigmented mixture shall be of the same composition and batched in the same proportions except that the pigmented mixture shall include the pigment addition at the maximum prescribed dosage rate (1.4), and the water content of each mixture shall be adjusted to produce a slump of 100 ± 13 mm (4 ± ½in.), as determined by Test Method C 143. Add the pigment to the first increment of coarse aggregate and water. The mixture shall be proportioned using ACI Practice 211.1. The cement content shall be either the cement content for specific work or 307 ± 3 kg/m^3(517 ± 5 lb/yd^3). If an air-entraining admixture complying with Specification C 260 is used, its dosage rate shall be the same for both the pigmented and the control mixtures.

7.7.2 *Making and Curing*—Specimens made from concrete with and without the pigment under test shall be molded and cured in accordance with Method C 192. Three or more compression specimens shall be prepared for each mixture.

7.7.3 *Time of Setting*—Test Method C 403 shall be used. The temperature of each of the ingredients of the concrete mixtures, just prior to mixing, and the temperature at which the time of setting specimens are stored during the test period shall be 23.0± 2°C (73 ± 3°F).

7.7.4 *Air Content*—Test Methods C 173 or C 231 shall be used.

7.7.5 *Compressive Strength*—Test Method C 39 shall be used. Specimens shall be tested at 28 days and optionally also at 7 days. The 28-day compressive strength of the concrete containing the pigment under test shall be calculated as a percentage of the 28-day compressive strength of the reference concrete as follows: The average 28-day compressive strength of the specimens made from the concrete containing the pigment under test shall be divided by the average 28-day compressive strength of the specimens made from the reference concrete at the same age, and the quotient shall be multiplied by 100.

7.8 *Color Match of Shipment*—Samples of both the shipment of pigment and the standard supplied by the pigment manufacturer shall be prepared in concrete at both the ½ % (7.5) and 6 % levels (based on the cement mass) or at another dosage rate(s) agreed upon between the purchaser and seller. The composition and methods of preparation and color comparison of the specimens should be agreed upon between the purchaser and seller. A suggested method of specimen preparation is given in Annex I. Compare the colors of the concrete specimens. Do not compare the colors of the pigment powders as a test for color control.

8. Report

8.1 The report shall include the following:

8.1.1 The manufacturer, designation, and type of pigment,

8.1.2 Maximum prescribed dosage rate of pigment,

8.1.3 Description of additional admixtures that must be used in the concrete,

8.1.4 Water wettability of pigment,

8.1.5 Resistance to color change when treated with sodium hydroxide,

8.1.6 Percent total sulfates calculated as SO_3,

8.1.7 Percent total water-soluble matter contained in pigment,

8.1.8 Resistance to color change when concrete is cured in a high-relative-humidity atmosphere,

8.1.9 Light resistance of pigment,

8.1.10 Cement content of pigmented and control mixtures,

8.1.11 Water-cement ratios of pigmented and control mixtures and the relative percentage change due to the use of pigment,

8.1.12 Compressive strength (28-day) of pigmented concrete and control and the relative percentage change resulting from the use of pigment,

8.1.13 Initial and final setting times of pigmented and control mixtures and the changes resulting from the use of pigment,

8.1.14 Air contents of pigmented and control mixtures and the change resulting from the use of pigment, and

8.1.15 When individual shipments are tested, a color comparison of each shipment and control.

9. Keywords

9.1 color match; integrally colored concrete; light resistance; pigment

ANNEX

(Mandatory Information)

A1. METHOD FOR PREPARING MORTAR TEST SPECIMENS

A1.1 *Apparatus*:

A1.1.1 *Wooden Mold*, to form specimens approximately 230 mm (9 in.) by 76 mm (3 in.) by 13 mm (½ in.) (Note A1.1). The mold shall be coated with a non-staining coating to prevent water absorption. The mold should be held together with C-clamps for easy removal.

NOTE A1.1—The dimensions may be modified, as long as finished specimen strength is maintained, to suit the individual weatherometer used for the light resistance test.

A1.1.2 *Wooden Tamping Block*, with a working surface area of approximately 50 mm (2 in.) by 100 mm (4 in.)

A1.1.3 *Metal or Ceramic Mixing Vessel*.

A1.1.4 *Stirring Device*, such as a large spoon or spatula.

A1.1.5 *Heated Drying Cabinet*.

A1.2 *Material*:

A1.2.1 *Clean Silica Sand*,

A1.2.2 *White Cement* (Note A1.2), and

A1.2.3 *Pigment to be Tested*.

NOTE A1.2—White cement is suggested to give maximum color discrimination in judging the pigment, but other cement may be used that is representative of the intended use.

A1.3 *Formulation*:

A1.3.1 Prepare the mortar mixtures at both ½ % (7.5) and 6 % pigment levels (based on the cement mass) in accordance with formulas below:

	Control[A]	½ %	6 %
Silica sand	480.0 g	480.0 g	480.0 g
White cement	160.0 g	159.2 g	151.0 g
Pigment	0.0 g	0.8 g	9.0 g
Water[B]	72 mL	72 mL	72 mL

[A] Control specimens are required for the atmospheric curing stability test but not for the light resistance test.

[B] In order to eliminate fluctuations in the moisture content (water/cement ratio) of the fresh and cured mortar specimens, it is advisable to dry the sand at 105 ± 3°C (221 ± 5°F) in an oven to constant weight. The amount of water should be adjusted such that a fairly dry, non-bleeding, mortar mix is obtained. However, the water content for all batches of the same mortar mix shall be identical.

A1.4 *Procedure*:

A1.4.1 In sequence, add the sand, cement, and pigment to the mixing vessel and mix thoroughly with the stirring device until the blend is uniform. Add the water and continue to mix until all the ingredients are thoroughly wetted.

A1.4.2 Place the mold on a glass slab, a steel plate, or any other flat, waterproof surface. Slightly overfill the mold with the mortar mixture. Using the wooden block, tamp the mixture firmly and evenly and with a screed, level it to the top of the mold.

A1.4.3 As soon as the mortar has set, loosen the C-clamps and carefully remove the sides of the mold.

A1.4.4 Place the mortar specimen on a table using spacers to permit ambient air to circulate around it, and let it dry in the air at room temperature for 12–24 h.

A1.4.5 Continue the curing process as follows: Transfer each specimen for the light resistance test and each control specimen for the atmospheric curing test to the heated cabinet, and finish curing at 49± 3°C (120 ± 5°F) for 24 h at 20 ± 10 % relative humidity. Transfer each test specimen for the atmospheric curing stability test to a 100 % relative humidity atmosphere at room temperature (Note A1.3) for at least 20 days, and then dry in the heated cabinet at 49 ± 3°C (120 ± 5°F) for 24 h at 20 ± 10 % relative humidity.

NOTE A1.3—A sealed plastic bag can be used for this purpose. Small amounts of water may be injected periodically into the bag to maintain a saturated atmosphere.

APPENDIX

(Nonmandatory Information)

X1. TYPICAL PIGMENT TYPES MANUFACTURED FOR COLORING CONCRETE

X1.1 Typical pigment types manufactured for coloring concrete are as follows:

X1.1.1 Synthetic iron oxides, yellows, red, browns, and black,

X1.1.2 Some natural iron oxides,

X1.1.3 Chromium oxide,

X1.1.4 Cobalt blue,

X1.1.5 Titanium dioxide, and

X1.1.6 Carbon black (concrete grade).