CONCRETE REPAIR
BULLETIN
May/June 2017
Vol. 30, No. 3
A Bimonthly Publication of the International Concrete Repair Institute

BUILDING AND REPAIR CODE UPDATES

INTERNATIONAL CONCRETE REPAIR INSTITUTE

Effective Bearing Area Estimation of Structural Grouts

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Introduction

Machinery grouts, also known as "structural" or "base plate" grouts, provide the vital link between equipment bases and the concrete foundation in order to transfer static and dynamic loads from equipment into the earth. The concrete foundation cannot be made sufficiently smooth and level to accomplish direct load transfer, so a gap is commonly left between the base plate and the foundation. That gap is subsequently filled with machinery grout. To accomplish this filling, the grout must be able to flow into the gap and harden into a strong layer in intimate contact with both the equipment base plate and the foundation.

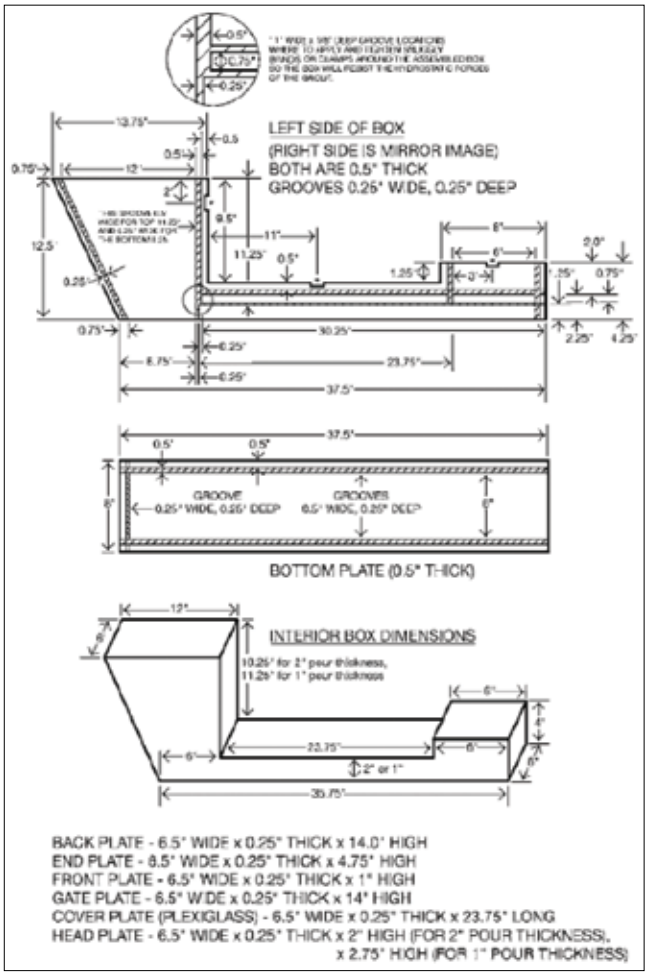

Fig. 1: ASTM C1339 flow box (dimensions are in inches). Reprinted, with permission, from C1339-02(2012) Standard Test Method for Flowability and Bearing Area of Chemical-Resistant Polymer Machinery Grouts, copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428 (a copy of the complete standard may be obtained from ASTM, www.astm.org)

There are two common types of machinery grout based on either cementitious or polymer binders. Standard ASTM test methods may be used to determine the mixed consistency and strength development of either type of grout. Application simulation may be conducted using ASTM C1339, *Standard Test Method for Flowability and Bearing Area of Chemical-Resistant Polymer Machinery Grouts*.

The performance of this type of grout is determined using a measurement known as "effective bearing area" (EBA) that is usually determined visually, comparing to drawings from ASTM C1339[1]. This article describes an improved procedure for more rapidly and accurately estimating the EBA using a photographic technique.

Test Method

ASTM C1339 is written with polymer-based grouts in mind, but can be adapted for cementitious grouts. Essentially a head box hopper is filled with a defined amount of mixed grout. After a resting period of 5 minutes, grout is permitted to flow under hydraulic pressure from the head box into a shallow plastic trough with a clear plastic cover plate. The time it takes for the grout to flow and completely contact the cover plate (fill time) and to contact the end plate of the trough (flow time) is measured. This simulates how grout would be installed under a base plate; the trough represents the area between the foundation, and the cover plate acts as the base plate. A drawing showing the ASTM C1339 test method is shown as Figure 1.

After determining the fill and flow times, the grout is allowed to harden. The hardened grout is then demolded by disassembling the flow box, and the surface under the clear cover plate is wire brushed to expose air bubbles and voids trapped at the grout surface. The percentage of contact area is visually estimated using drawings from ASTM C1339 for

comparison (Fig. 2). ASTM C1339 states, "Because of the limited accuracy of this determination, the suggested classifications are: high—greater than 85%, medium—70 to 85% and low—less than 70%."

It is obvious that a great deal of subjectivity exists in estimation of EBA using the method as described in ASTM C1339. For comparison, a photograph of an actual test specimen from ASTM C1339 is shown in Figure 3. What is your estimate of EBA for this specimen?

There are better methods to estimate the EBA. Gridding off the exposed area and performing a point count could be very precise depending on the fineness of the measurement, however, this is quite time consuming for a 6 in x 24 in (152 mm x 610 mm) area. Alternatively, after completing the wire brushing described in ASTM C1339, the exposed voids may be filled with a contrasting colored powder. This has been done to emphasize the voids in the photograph in Figure 3.

The exposed area can then be photographed. The photograph is opened in any software capable of displaying a histogram, and converted to a pure black and white image. (In this example, Photoshop Elements was used.) A histogram of the specimen from Figure 3 is shown as Figure 4 in the orange box and enlarged in the right hand photo. The histogram divides the range of gray into 256 shades graphed along the x axis, and the y axis shows the number of pixels in each shade.

The image is then adjusted to be pure black and white using the triangles below the histogram output levels or, alternatively, the eyedropper tools as shown in Figure 5. It is important to watch the photograph as these changes are made because shadows, reflections or other information may be interpreted incorrectly if these adjustments are not done with care.

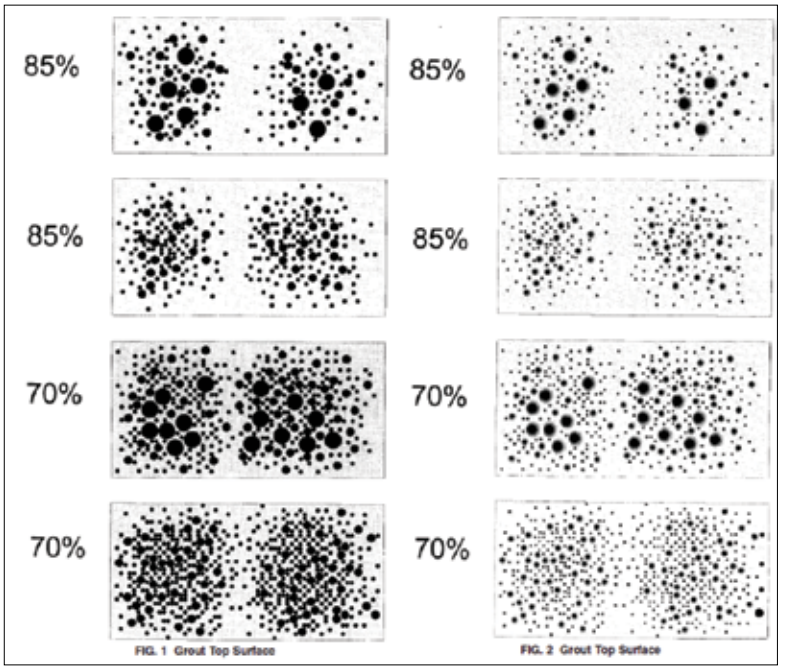

Fig. 2: Visual comparison guides for EBA estimation from ASTM C1339. Reprinted, with permission, from C1339-02 (2012) Standard Test Method for Flowability and Bearing Area of Chemical-Resistant Polymer Machinery Grouts, copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428 (a copy of the complete standard may be obtained from ASTM, www.astm.org)

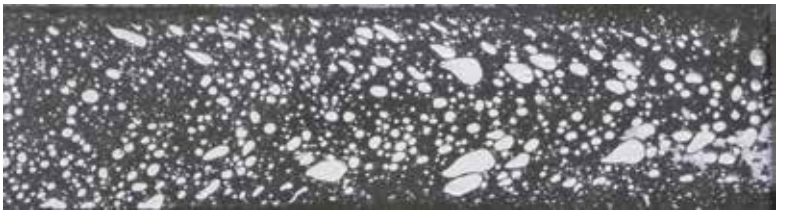

Fig. 3: Photograph of specimen for EBA estimation per ASTM C1339.

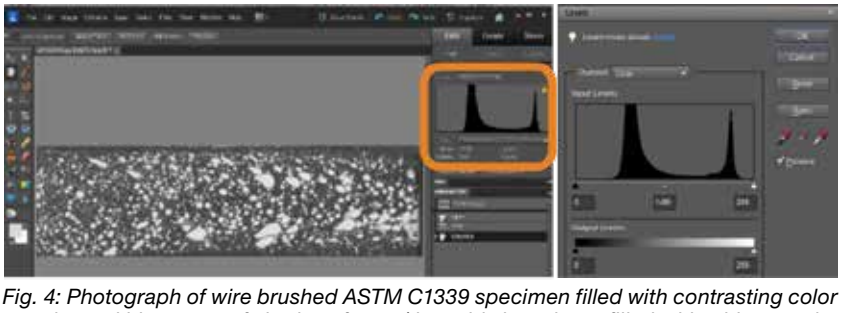

Fig. 4: Photograph of wire brushed ASTM C1339 specimen filled with contrasting color powder and histogram of shades of gray (the voids have been filled with white powder because the grout is dark gray)

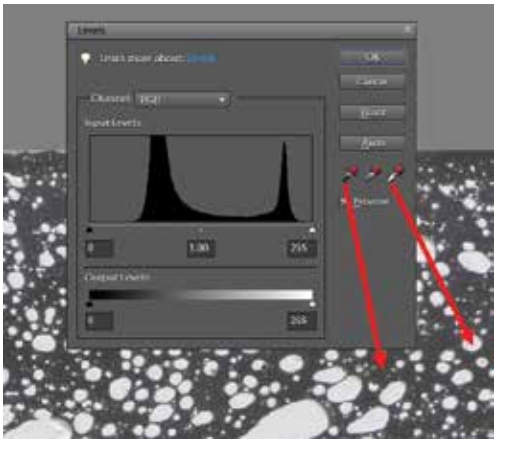

Fig. 5: The input levels or eyedropper icons can be used to select pure black and white areas

After adjusting levels, the peaks on the histogram are now at the far left and right of the graph; however, there are still some gray areas as shown on the left of Figure 6. Using the "Posterize" feature with two levels forces the image into pure black and white. If areas of voids disappear, reselect the black and white endpoints in Figure 5.

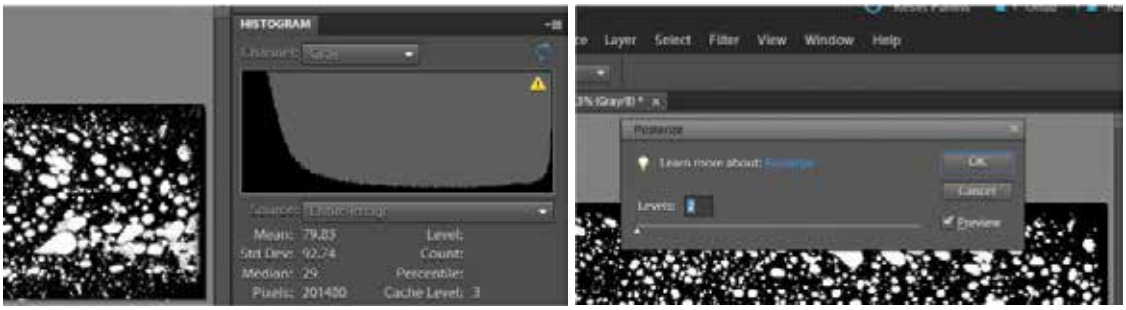

Fig. 6: Histogram after level adjustment (left) and Posterize function (right) with two levels selected

Once this is done, hover the mouse cursor over the leftmost point near pure black. The percentile is the EBA or percentage of black in the image (Fig. 7) where the cursor is about level 16. The percentile in this example is 66.09%, but probably should be rounded between 65% and 70% based on the authors' experience with different operators, repetition of photographs of the same sample, etc.

The above method, although believed to be more precise than the visual comparison of the images in ASTM C1339, is still subject to photograph quality and careful selection of the software parameters. Some examples of poor quality photographs are shown in Figure 8.

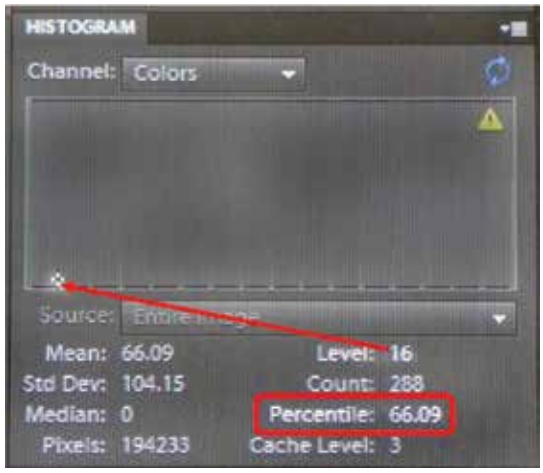

Fig. 7: Hover the cursor over the histogram near pure black (about level 16 in this example). Read the EBA in Percentile as shown in the red box

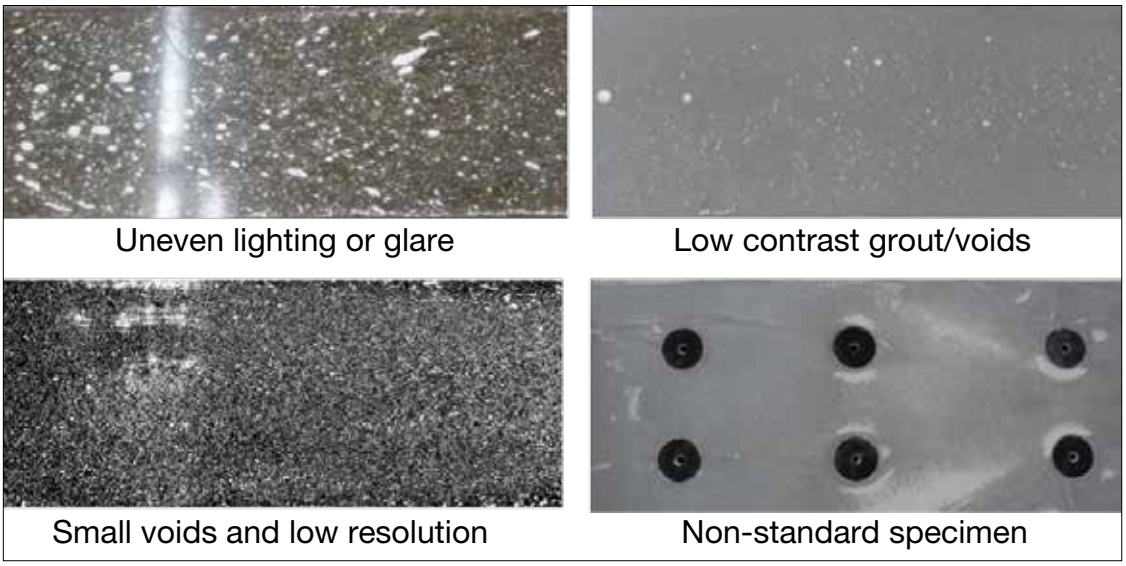

Fig. 8: Examples of poor quality photographs—Glare (upper left) will be counted as void area as it is lighter than the grout; Low contrast between the grout color and voids (upper right) will make it difficult to discern the difference between voids and grout; Low resolution photographs of small voids (lower left) create similar problems to low contrast; and Non-standard specimens (lower right) cannot be properly evaluated in their entirety

Conclusion

In summary, this method for estimation of effective bearing area of machinery grouts seems to produce more objective results as well as provide a documented record of the results from the estimation in the form of a photograph. The equipment and software are in common usage and the techniques to manipulate the images are not difficult. This procedure will be described in detail in a document being developed by ICRI 320 Materials and Methods Committee, *Guideline for Structural Grouts Material Data Sheet Protocol*.

References

1. ASTM C1339, *Standard Test Method for Flowability and Bearing Area of Chemical-Resistant Polymer Machinery Grouts*, ASTM International, West Conshohocken, PA, 2012, 5 pp.

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