PCI Precast/Prestressed Concrete Institute

Acceptability of Appearance

PCI designer's notebook

Acceptability of Appearance

For the acceptability of color, finish, and texture, one person should have final authority. Contract documents must clearly identify who the accepting authority will be: architect, owner, general contractor, or site inspector.

Determining acceptable uniformity of color, finish, and texture is by visual examination, and is generally a matter of subjective, individual judgment and interpretation. Acceptable color and texture variations, surface blemishes, and uniformity should be determined at the time the sample, mockup, or initial production units are approved. Accordingly, it is beyond the scope of this publication to establish precise or definitive rules for product acceptability on the basis of appearance. However, a suitable criteria for acceptability requires that the finished concrete surface should have a pleasing appearance with minimal color and texture variations from the approved samples. The finished surface on the face should show no readily visible imperfections other than minimal color and texture variations from the approved samples or evidence of repairs when viewed in typical daylight illumination with the unaided eye consistent with the viewing distance of the structure but not less than a 20 ft (6.1 m) or greater viewing distance. Appearance of the surface also should not be evaluated when light is illuminating the surface from an angle, as this tends to accentuate minor surface irregularities due to shadowing.

Building facades may be oriented such that sunlight just grazes the surface at a particular time of day. This causes otherwise imperceptible ripples, projections, and misalignments on the surface to cast long shadows and be grossly exaggerated in appearance. The shadows may last briefly. The actual time at which they appear varies with the season for a particular elevation.

Although material and production factors may cause differences in color or texture, lack of uniformity will be minimized if the following recommendations are followed. These include creating pre-bid samples to establish the general color and texture for the project, producing approval samples and a 4 ft. x 4 ft. mockup after the contract award to evaluate the same mixture under production conditions, producing three to five 4 ft. x 4 ft (1.2 m x 1.2 m) sample panels to show the range of anticipated color and texture, and viewing initial production panels to verify the final outcome of the production procedures based on bulk ordering of currently quarried materials, full concrete batches, and actual production methods.

The importance of using small mockups to establish and verify expectations of color, texture, and range cannot be over-emphasized. Their use is especially important when casting difficult mixes, finishes, or shapes.

The following is a list of finish defects and/or problems that are normally unacceptable in high-quality architectural precast concrete. Blemish repairs to meet the acceptability criteria should be permitted provided appearance, structural adequacy and durability are not impaired.

1. **Ragged or irregular edges.** When sharp edges are specified, minor chips and irregular edges are unavoidable and should be acceptable.

   Edge details should be reviewed with the precaster during the design and mockup approval process. It is recommended that all edges be detailed with a chamfer, reasonable radius (eased edge), or quirk. It is impossible to cast concrete into a 45-degree or sharper corner because large aggregate, consolidation, and segregation issues prevent the concrete matrix from completely filling the sharp corner. Further, sharp edges and mitered corners without quirks chip easily and are difficult to manufacture and erect within acceptable dimensional and aesthetic parameters. Mitered corners should have a cutoff or quirk, not less than $^1/_2$ in. (13 mm) with $^3/_4$ in. (20 mm) preferred, nor less than 1.5 times the maximum aggregate size used in the concrete mixtures.

2. **Excessive air voids (commonly called bugholes) evident on the exposed surface.** Products with deep returns and sculptured units may have visible air voids on the returns. Air voids become accentuated when the surface is smooth, acid etched, or lightly sandblasted. If the air holes are of a reasonable size, $^1/_8$ to $^1/_4$ in. (3 to 6 mm) and not clustered into objectionable patterns, it is recommended that they be accepted as part of the texture. Filling and sack-rubbing could be used to eliminate the voids. However, this procedure is costly and may cause color differences. Samples or mockup panels should be used to establish acceptable air void size, frequency, and distribution.

3. **Adjacent flat and return surfaces with greater texture and/or color differences than the approved samples or mockups.** Returns in some finishes will not appear exactly like the front face (down-face) due to a number of factors such as mixture proportions, variable depths, and small differences in consolidation techniques. This is particularly the case with intricate shapes and complex placement requirements. The effect of gravity during consolidation tends to force the large aggregate downward and the smaller aggregate, sand and cement paste, upwards. Consequently, the down-face in the form/mold will generally be more uniform and denser than the returns or upper radius.

   The surface of large panels should be divided into smaller areas by means of rustication or reveals to minimize the perception of textural differences.

   For large returns, or situations where it is necessary to minimize variations in appearance, the two-stage or sequential production technique should be used. If feasible, concrete mixtures should be selected where the aggregate gradation can be uniformly controlled and preferably fully graded. Exposures should be medium to deep, and color differences between the ingredients of the mixture should be minimal.

4. **Casting and/or aggregate segregation lines evident from different concrete placement lifts and consolidation.**

5. **Visible form/mold joints, seams, or irregular surfaces in excess of or larger than those acceptable in the approved samples or mockups.**

6. **Rust stains on exposed surface.** Rust stains caused by reactive iron pyrites or other contaminants will occur where such contaminants are found as part of the aggregates. Rust stains may also be caused by particles of steel left by the aggregate crusher, pieces of tie wire from the cage assembly, or particles of steel burned off in welding or drilling. These stains (and steel particles) should be removed from the surface. Rust stains due to corrosion of connection hardware should not occur if the hardware has been protectively coated or where it is entirely behind a weatherproofed joint.

7. **Excessive variation of texture and/or color from the approved samples, within the individual unit or compared with adjacent units.** Some color difference between nominally identical precast concrete units is inevitable. Color variation, between and within panels, should be kept within a range established through range samples. Uniformity in color is primarily related to variations in the water-cement ratio, concrete mix materials, and curing conditions for the concrete.

   Units containing aggregates and matrices of contrasting colors will appear less uniform that materials of similar color. As the size of the coarse aggregate increases, less matrix is seen, which results in a more uniform color. The architect should specify that the matrix's color or tone match that of the coarse aggregate so that variations in the depth of exposure and concentration of aggregate will not be as noticeable.

   Color uniformity is more difficult to achieve on gray, buff and pigmented concrete surfaces. The use of white cement will usually provide better color uniformity than gray cement. Typical color variation in gray cement is sufficient to cause noticeable color differences in precast concrete panels. The slightest change of color is readily apparent on the uninterrupted surfaces of smooth-as-cast concrete, and any variation is likely to be regarded as a surface blemish. As a general rule, a textured surface provides a better aesthetic finish than a smooth surface. The degree of uniformity (different shadings and to some extent, color intensity) between panels and within panels is generally in direct proportion to the depth of exposure. Color variations will normally decrease to some extent with exposure to sunlight and other environmental elements.

It is very difficult and often deceiving to try to assess color variations during cold, damp, and/or freezing conditions. It is also difficult to assess color variations just after the panels have been erected and before they have been cleaned.

8. **Blocking stains evident on exposed surface.** Blocking used to separate production units in the storage yard or during shipment should be made with non-staining materials. Blocking should not trap moisture or prevent air circulation that may disrupt uniform curing conditions. Plastic bubble type pads are well suited for this purpose. Lumber or padding wrapped with plastic should not be used for blocking for extended periods, unless in an area that is not visible in the final structure.

9. **Areas where the backup concrete penetrated through the facing concrete.**

10. **Foreign material embedded in the face of the unit.**

11. **Repairs visible at 20 ft (6m) or greater viewing distance.** A certain amount of product repair is to be expected as a routine procedure. Repair methods should ensure that the repaired area will conform to the balance of the work with respect to applicable requirements for appearance, structural adequacy, serviceability, and durability. Slight color variations may occur between the repaired area and the original surface due to the different age and curing conditions of the repair. The repair will generally become less noticeable over time (at least one month) with exposure to the environment and should blend into adjacent surfaces so it becomes less noticeable. Excessive variation in color and texture of repairs from adjacent surfaces may be cause for rejection until the variation is minimized.

12. **Reinforcement shadow lines.** Reinforcing steel in some finishes may show up as light or dark shadow lines usually directly over the steel depending on the mixture, concrete cover, and vibration of reinforcement. Reinforcement shadow lines may be more prevalent in as-cast or lightly textured finishes.

13. **Cracks visible at a 20 ft (6 m) or greater viewing distance.** The acceptability of cracks should be determined with respect to actual service condition requirements, structural significance, and aesthetics. Every effort should be made to promptly identify the cause of any cracking and to document the pattern, particularly when several units display similar cracking. Such cracking is often the result of a single design, manufacturing, or handling problem, which can then be rectified to prevent any recurrence.

The cement-rich film on smooth concrete may develop a network of fine random hairline cracks (crazing) in an approximate hexagonal or octagonal pattern. A hairline crack is defined as a surface crack of minute width and rarely more than $^1/_8$ in. (3 mm) deep, visible to the naked eye but not measurable by ordinary means.

Crazing is merely a surface phenomenon (penetrates only as deep as the thin layer of cement paste at the surface of the panel) and has no structural or durability significance but it may become visually accentuated when the surface is wetted or dirt settles in these minute cracks. Crazing is more predominant in as-cast or lightly textured finishes. Such crazing cracks are of little structural importance and should not constitute a cause for rejection.

It should be recognized that a certain amount of crazing or cracking may occur without having any detrimental effect on the structural capacity of the member. It is impractical to impose specifications that prohibit cracking.

A key point is cracks do not always result in corrosion of reinforcement. Corrosion depends not only on the width of the crack and whether it reaches the reinforcing steel, but also on the presence of chlorides or low pH in combination with oxygen and moisture. For surfaces exposed to the weather, cracks up to 0.005 in. (0.13 mm) wide have no influence on the corrosion of reinforcement and should be acceptable from an aesthetic viewpoint as shown in viewer's reactions, **Figure 1**.

If the crack width is narrow, not over 0.012 in. (0.30 mm), the structural adequacy of the casting will remain unimpaired and the crack will have little influence on the potential for corrosion of the reinforcement. The limitation on crack-size specified is for structural reasons. The aesthetic limitation will depend on the surface texture and the required appearance. On coarse textured surfaces, such as exposed-aggregate concrete, and on smooth surfaces comparable to the best cast-in-place structural concrete, the structural limitation would be aesthetically acceptable. In addition, it should be noted that cracks may become more pronounced on surfaces receiving a sandblasted or acid-etch finish.

If crack repair is required for the restoration of structural integrity, cracks may be filled or pressure-injected with a low-viscosity epoxy. The acceptability of the crack repairs should be governed by the importance and function of the panel. The decision regarding acceptability must be made on an engineering basis as well as on visual appearance.

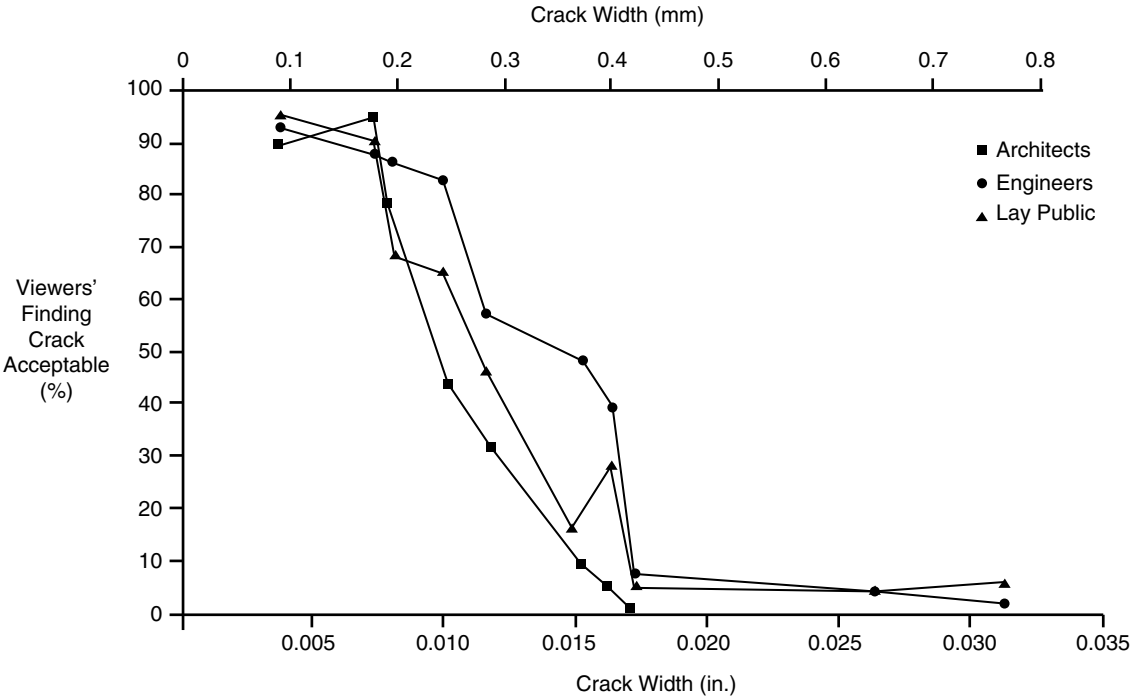

Figure 1 Viewer reaction to cracks of different widths.

designer's**notebook**

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