



VISUAL SHOTCRETE CORE QUALITY EVALUATION

Keywords: cores; encapsulation; visual evaluation; reinforcing bars; voids.

During shotcrete construction, owners, architects, engineers, and contractors want to verify the quality of shotcrete being placed. Shotcrete cores are normally extracted from shotcrete sample panels or when needed from as-placed shotcrete for evaluation of shotcrete quality (ACI 506.4R). In addition to the routine tests such as compressive strength or other material quality tests required by project specification, visual examination of shotcrete cores by an experienced licensed design professional (LDP) is an important tool for evaluation of shotcrete quality.

The contractor should demonstrate that shotcrete material can be placed in a manner that accomplishes intimate contact between the shotcrete and the reinforcing steel to accomplish the design requirements of the project. Visual examination can reveal imperfections, including voids, sand lenses, delaminations, and degree of reinforcing steel encapsulation. Visual evaluation of core quality will be dependent on the LDP's experience and knowledge. Visual evaluation is intended to detect quality issues on the surface of the core and should be conducted on a group of no less than three cores—not dependent on a single core that may not be representative of the entire area sampled (ACI 506.4R).

To provide guidance for visual evaluation of cores, Table 1 lists quantitative criteria for each category of core quality an LDP can refer to during the core evaluation. This TechNote should be considered a reference document by the LDP to provide a reasonable evaluation of shotcrete quality. These are intended to be general guidelines, and the LDP's professional judgment should be used to ascertain the demonstrated quality of the cores. Whether the demonstrated quality is adequate for the intended purpose of the in-place shotcrete is the subject of ACI 506.4R.

Visual core evaluation is not an exact science; it requires professional judgment from the LDP. This visual evaluation process should employ Table 1 and a written description in this document to provide guidance. When needed, other aspects linked to the placement of shotcrete may be helpful for evaluating overall quality of shotcrete placement (for example, the inspection of the back of the shotcrete panel for rebound or overspray entrapment or other visible imperfections not necessarily found on the surface of the cores).

There are four categories of visual evaluation of core quality. Each category of quality is clearly discussed and quantified in Table 1 based on two criteria. It is important to understand that each category is not only a function of the imperfections found, but also intimately linked to the complexity of the reinforcement layout. Factors including size of the reinforcement, spacing, laps, layers, reinforcement location within a cross section, and other types of placement obstacles may affect the performance of shotcrete placement.

Categories are as follows:

a) **Very Good**—In a lightly reinforced structure, cores show few local imperfections and complete encapsulation of the reinforcement. As reinforcement complexity increases, localized imperfections (which are not repeated in the same core) behind the reinforcement may be found with void areas not more than 25 percent of the area of the largest-diameter reinforcement considered or with bonded encapsulation exceeding 90 percent of the circumference of the reinforcement. There should not be any sand lenses or delamination. Scattered voids up to 1/4 in. (6.4 mm) diameter should be ignored.

b) **Good**—In a lightly reinforced structure, cores show small local imperfections. As reinforcement complexity increases, localized imperfections (which are not repeated in the same core) behind the reinforcement may be found with void areas not more than 30 percent of area of the largest-diameter reinforcement considered or with bonded encapsulation exceeding 80 percent of the circumference of the reinforcement.

The longest linear dimension of exposed voids created by sand lenses and delamination (excluding any voids touching the reinforcing bar) should be less than 10 percent of the longest dimension of the observed specimen. Scattered voids up to 3/8 in. (9.5 mm) diameter should be ignored.

c) **Satisfactory**—Imperfections appear on a regular basis in the samples with large localized imperfections present. As reinforcement complexity increases, localized imperfections without repetition behind the reinforcement may be found with void areas not more than 35 percent of area of the largest-diameter reinforcement considered or with bonded encapsulation exceeding 70 percent of the circumference of the reinforcement. The longest linear dimension of exposed voids created by sand lenses and delamination (excluding any voids touching the reinforcing bar) should be less than 20 percent of the longest dimension of the observed specimen. Scattered voids up to 3/8 in. (9.5 mm) diameter should be ignored.

d) **Poor**—Imperfections are found throughout the samples or areas of the sample and show a high complexity of imperfections. As reinforcement complexity increases, localized imperfections without repetition behind the reinforcement may be found with void areas more than 35 percent of area of the largest-diameter reinforcement considered or with bonded encapsulation of less than 70 percent of the circumference of the reinforcement. The longest linear dimension of exposed voids created by sand lenses and delamination (excluding any voids touching the reinforcing bar) represents more than 20 percent of the longest dimension of the observed.

Shotcrete core quality evaluation table

Table 1 is primarily based on the degree of encapsulation of the reinforcing steel, and secondarily on the size and location of voids. Cores are categorized as outlined in Table 1. The intent is that for a specific core evaluation, both Criteria a and b should be satisfied. The LDP may modify quality assurance procedures or criteria as needed based on project-specific needs. Sketches combining both Criteria a and b in Table 1 are presented in Fig. 1.

Table 1—Core evaluation category

	Criteria	Very good	Good	Satisfactory	Poor
a	Encapsulation of reinforcing steel as a percentage of the circumference of the reinforcement (any individual reinforcement cross section or total of all reinforcements in the core)*	Greater than 90 percent	Greater than 80 percent	Greater than 70 percent	Less than or equal to 70 percent
b	Maximum size [†] of any void touching the reinforcement, as a percentage of the cross section of that reinforcement	Less than 25 percent	Less than 30 percent	Less than 35 percent	Greater or equal to 35 percent

*When reinforcements are not centered in the core, an attempt should be made to determine the approximate length of the reinforcement's edge contact with shotcrete.

[†]Measured as approximate area of any voids touching the reinforcing steel on the cylindrical surface of the core.

Notes: Sand lenses should be measured as voids. Occasional scattered voids up to 1/4 in. (6.4 mm) diameter should be ignored.

References

ACI Committee 506, 1994, "Guide for the Evaluation of Shotcrete (ACI 506.4R-94)," American Concrete Institute, Farmington Hills, MI, 12 pp.