

**Correlating Qualitative Surface Profile Assessment Methods
to Quantitative Methodology on Prepared Concrete**

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ABSTRACT

Proper bonding of coatings and linings to concrete surfaces requires proper cleaning and frequently requires the concrete to be roughened to increase the surface area. The roughness, also known as surface profile, can be imparted into concrete by abrasive blast cleaning, acid etching, or various impact/scarifying power tools. The resulting surface profile depth can influence coating/lining adhesion and performance. Coating/lining manufacturers and/or facility owners frequently specify cleaning and roughening of the concrete surface prior to product installation.

The surface profile (roughness) of prepared concrete can be assessed visually using Concrete Surface Profile (CSP) Chips such as those described in Guideline No. 310.2R, *Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair* produced by the International Concrete Repair Institute (ICRI), or by creating a replica of the prepared surface using an epoxy putty as described in ASTM D7682, *Standard Test Method for Replication and Measurement of Concrete Surface Profiles Using Replica Putty* and comparing it to the specified ICRI chip (Method A) or taking depth micrometer measurements from the replica (Method B). ASTM D8271, *Standard Test Method for the Direct Measurement of Surface Profile of Prepared Concrete* describes a procedure for acquiring measurements directly from the prepared concrete using an electronic depth micrometer. Most recently, Technical Applications for Concrete Materials (TACM) has made available concrete samples that are mechanically (or chemically) processed by the actual methods used to obtain the ICRI CSP® profiles on a construction jobsite. AMPP Standard Committee 12 (SC 12) on Concrete Infrastructure is developing a new standard titled *Procedure for Determining Conformance to Concrete Surface Profile Requirements* to address the frequency and acceptability of concrete surface profile measurements using any of these methods (*Note: AMPP SP21513-2021 was approved October 6, 2021*).

The CSP Chips produced by ICRI are arguably the most widely recognized and most frequently specified method to assess concrete roughness; however, this method (as well as the newer TACM concrete samples) is qualitative and requires some judgement. The procedures described in ASTM D7682 (Method B) and ASTM D8271 are quantitative but are not widely specified. There was perceived value in correlating the qualitative and quantitative methods of assessing the surface profile of prepared concrete so that specifiers can specify either, without inadvertently invoking contradictory requirements.

A study was conducted using rigid, epoxy-cast replicas of seven of the ten ICRI CSP Chips (CSP 1-7), seven of the ten concrete samples (CSP 1-7) manufactured by TACM, and the two methods utilizing depth micrometers (ASTM D7682 Method B and ASTM D8271). This paper describes the experimental design and the results of the comparative analysis.

EXECUTIVE SUMMARY

The data produced in this study indicates that there are differences between the ICRI CSP comparator panels and TACM CSP comparator panels. Further, there are differences between taking direct measurements from known surfaces (i.e., the ICRI and TACM CSP panels) and obtaining indirect measurements from an epoxy putty casting of those same known surfaces. Therefore, it is important that the specifier indicate which method is to be used when qualitative or quantitative methods are invoked in the contract documents. Note however that since direct measurement of surface profile from the concrete is now feasible, there is little value in generating replicas of the concrete surface using the epoxy putty (and subsequently measuring it using a micrometer) unless a permanent record of the concrete roughness is desired.

The Look-up Table shown below enables a specifier to easily convert a qualitative assessment (e.g., ICRI or TACM CSP 1-7) to a quantitative range for surface profile on concrete. Ranges are only shown for CSP 1-7 since only those were studied during this research and the values are rounded. Tolerances were established based on the standard deviation data.

Look-up Table (Conversion of ICRI and TACM Panels to mils)

Description	ICRI CSP No.	ASTM D8271 (mils)*	TACM CSP No.	ASTM D8271 (mils)*
Acid-etched	1	6 ± 2	1	2 ± 0.5
Grinding	2	6 ± 2	2	3 ± 0.5
Light Shotblast	3	11 ± 2	3	12 ± 2
Light Scarification	4	15 ± 2	4	30 ± 3
Medium Shotblast	5	16 ± 2	5	29 ± 3
Medium Scarification	6	37 ± 4	6	28 ± 3
Heavy Abrasive Blast	7	48 ± 4	7	38 ± 3
Scabbled/ Surface Retarder	8	Not measured	8	Not measured
Heavy Scarification -	9	Not measured	9	Not measured
Handheld Concrete Breaker/Abrasive Blast Cleaned; or High-Pressure Water Jetting	10	Not measured	10	Not measured

* Average of 15 readings, based on the data generated in this study

EXPERIMENTAL DESIGN

The study design was initially composed of six methodologies that were specifically chosen to enable specifiers to convert from qualitative surface profile assessment techniques to quantitative ranges. However, two of the six procedures were determined not to be feasible due to the inherent properties of the samples that were created. This is further explained below. Accordingly, the actual study design was composed of four methodologies as described below.

Methodology 1: Surface Profile Measurements from ICRI Concrete Surface Profile (CSP) 1-7 using a Digital Depth Micrometer (ASTM D8271)

The ICRI CSP Chips are approximately 16 square inches (3.5" x 4.5") and are designed to replicate 10 surface profiles as shown in the Table 1.

Table 1: ICRI CSP Chip Designation and Represented Surface Preparation

ICRI CSP Code	Surface Preparation Represented
CSP 1	Acid-etched
CSP 2	Grinding
CSP 3	Light Shotblast
CSP 4	Light Scarification
CSP 5	Medium Shotblast
CSP 6	Medium Scarification
CSP 7	Heavy Abrasive Blast
CSP 8	Scabbled
CSP 9	Heavy Scarification - rotomilled
CSP 10	Handheld Concrete Breaker/Abrasive Blast Cleaned; or High-Pressure Water Jetting

The ICRI CSP Chips are made from a gray, pliable rubber material that is acceptable for most applications but was problematic for this research. The probe of the digital depth micrometer intended to be used to obtain measurements of surface profile on these CSP Chips contains a stainless steel, spring-loaded 60° cone-shaped point that would penetrate the pliable rubber and generate false high values. Therefore, silicone molds of CSP 1-7 were made and a black epoxy was cast into each mold, effectively creating exact replicas of CSP 1-7 in hardened epoxy that would be unaffected by the micrometer probe and pressure.

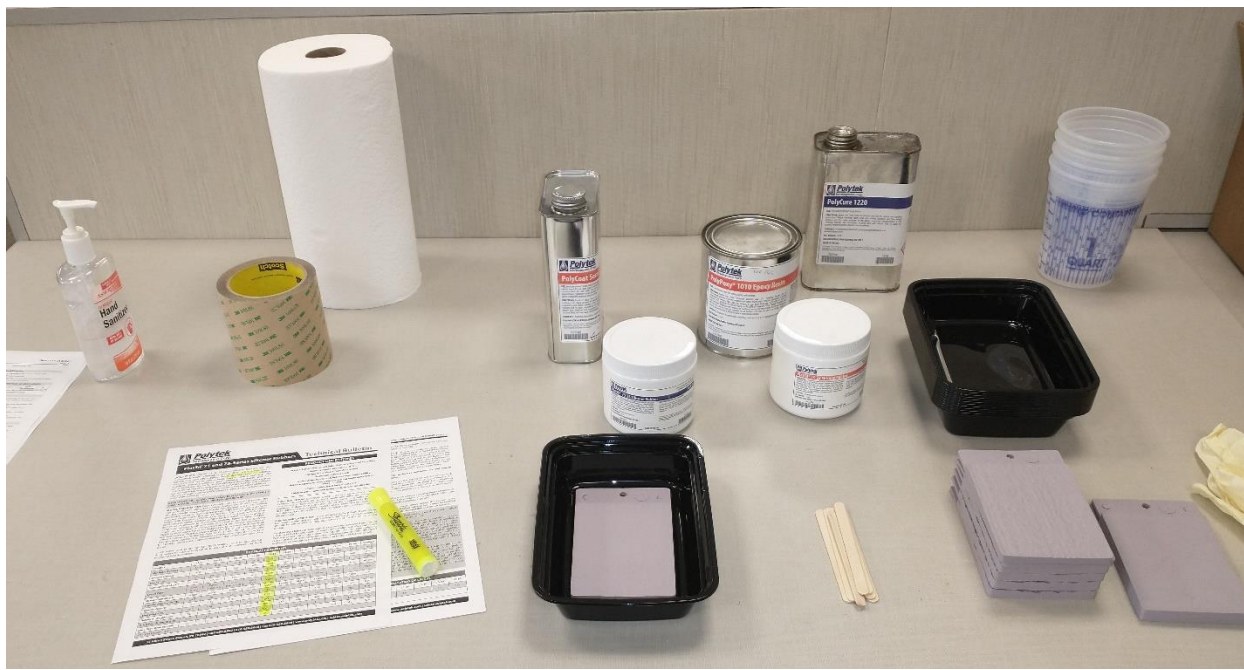


Figure 1: ICRI CSP Chip Casting Apparatus & Materials

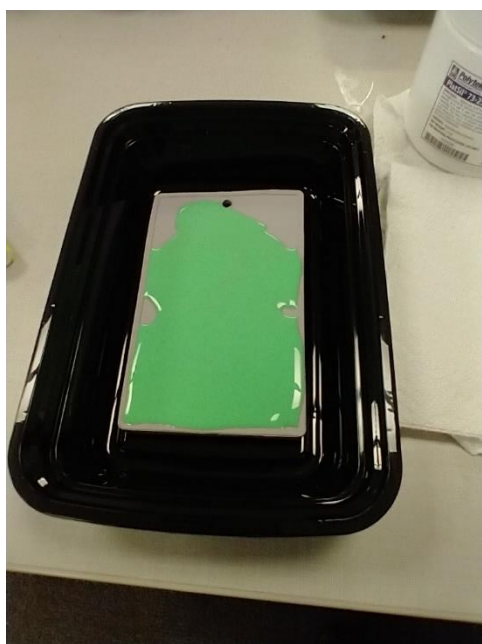


Figure 3: Beginning to add silicone molding compound to an ICRI CSP Chip



Figure 2: The silicone mold of ICRI CSP Chip 3

Once the epoxy was fully cured, removed from the mold, and visually inspected for defects, three sub-batches of 15 readings/each were obtained on CSP 1-7 replicas by 6 technicians (independently) using a digital depth micrometer (gage; Figure 6) with a range up to 250 mils and stored in the gage memory for subsequent analysis. ICRI CSP 8, 9, and 10 contain a surface topography that inhibits the gage probe from sitting flush on the surface to obtain accurate measurements, and therefore were not cast.

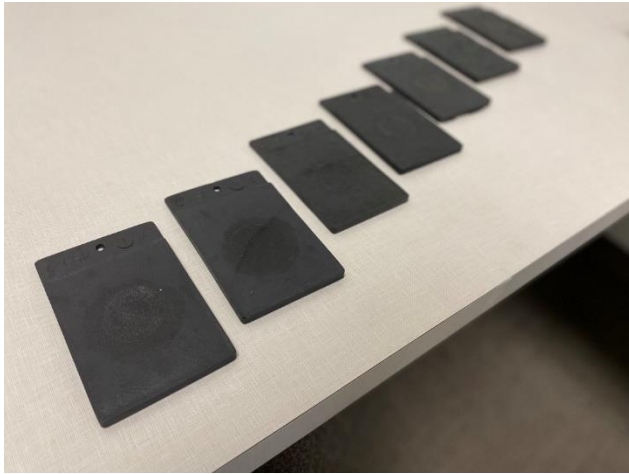


Figure 4: The epoxy cast ICRI CSP Chips 1-7

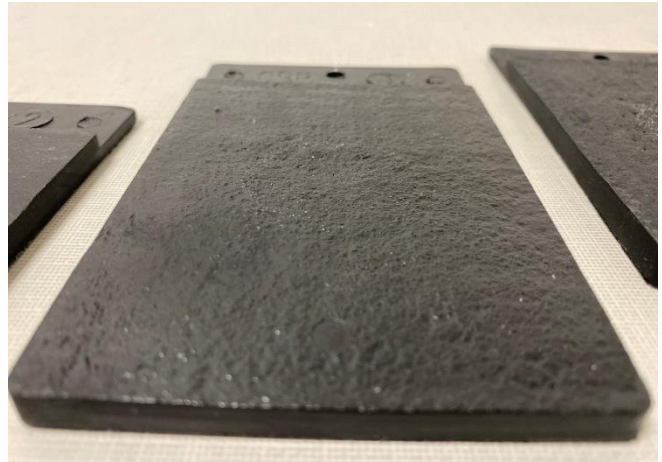


Figure 5: Close-up of the cast ICRI CSP chip 3



Figure 6: Digital Concrete Surface Profile Depth Micrometer