Misunderstandings and Abuses in Flatwork Specifications

Knowing how the F-number system functions can prevent unwelcome surprises and help meet owner expectations

By Terry J. Fricks

The F-number system has gained great popularity in recent years. When used properly, flatwork surface tolerances can be specified and confirmed. If these F-number guidelines are understood and followed, slab surface profiles will meet or exceed owner expectations.

Contractors, however, should be aware of misunderstandings and sometimes outright abuses of the system. Most contractors see F-numbers in the majority of specifications written today and most have read articles and publications on the subject. F-numbers have been around long enough for most contractors to be comfortable with them both in bidding as well as in the construction process. In many cases, however, contractors have become too comfortable or complacent with F-numbers.

Contractors often assume that the people who develop project specifications understand and use the published documents and standards available to them. While this is true in most cases, be aware of the exceptions. Contractors, however, cannot recognize these abuses unless they become familiar with the standards.

Specific information about the F-number system is readily found in documents such as ACI 117 "Tolerances for Concrete Construction and Material," ACI 302 "Guide for Concrete Floors and Slab Construction," and ASTM E-1155 "Test Method for Determining Floor Flatness Using the F-number System." While there is some overlap of material, there seems to be no contradictions when the information is interpreted correctly.

SPECIFICATIONS SHOULD CLEARLY STATE SPECIFIC CORRECTIVE MEASURES TO BE APPLIED.

Sloped Areas

If F-number specifications are written improperly or are incomplete, they can create controversy. For example, specifications for random-traffic floors must include both F_F (flatness) and F_L (levelness) tolerances. However, the levelness tolerance should not apply to slabs placed on unsupported form surfaces or to cambered or inclined slab surfaces. In other words, if a contractor is asked to slope areas of a slab to drains or slope a section of slab to meet an existing slab or other concrete member, then the F_L portion of the specification is automatically invalid for those areas.

SOV and MLV

There also must be Specified Overall Value (SOV) and Minimum Local Value (MLV). One of the worst abuses of the specification is to not include the MLV. When only the SOV is mentioned, many think that the specified F_F and F_L is a minimum tolerance. They also may assume that every survey line in every section of the floor must be at least as good as the specified F-numbers.

Each section of the slab or placement is measured according to ASTM E-1155. The results of all measured slabs are the composite numbers, which must meet or exceed the specified F-numbers. The results of an individual placement are not grounds for rejection—unless they are below a specified MLV.

Every contractor has a bad day

now and then, and the system allows for this. Of course, if the contractor has a bad day, then the tolerances must be exceeded in the days following to keep the average up to specification.

Most contractors do not realize that the F-number calculations give more weight to bad numbers, thus requiring better performance for several days to make up for one bad one. Also, the results of an individual run or survey line mean nothing by themselves; they must be compiled with other runs or survey lines to be meaningful.

When the specification is written with only SOV, MLV can only be assumed. ACI 302 7.15.1.1 states, "Minimum F_F/F_L numbers should also be indicated. They represent the minimum flatness and levelness to be exhibited by any individual floor section. They are not normally set lower than 50% of the F_F/F_L requirement. The minimum F_F/F_L values should never be less than F_F-15/F_L-10, since these values represent the worst local results to be expected." Most specifications establish a realistic MLV of two-thirds of the SOV.

CONTRACTORS SHOULD NOT BE LULLED INTO A FALSE SENSE OF SECURITY THINKING THEY CAN SIMPLY GRIND OUT-OF-TOLERANCE AREAS.

Example: *SOV F_F-30/F_L-27*
MLV F_F-20/F_L-18

When only SOV appears in the specification, contractors should investigate why the MLV is excluded before bidding and certainly before signing contracts. Most of the time, the exclusion of MLV is an oversight or misunderstanding. In some cases, however, deliberate attempts have been made to trick the contractor.

Example 1: *F_F-30/F_L-27*
Note: These tolerances are minimum values when measured by approved methods.

Example 2: All floor slab areas (each individual bay) shall have a minimum flatness of *F_F-30* and a minimum levelness of *F_L-27*
Note: When quickly reading a specification such as this, the contractor assumes he is bidding the SOV when in reality he is bidding the MLV.
The correct specification should read:
Specified Overall Value (SOV)
FF-45/FL-40
Minimum Local Value (MLV)
FF-*30/F_L-27*
Note: It would be easy for anyone to bid *F_F-30/F_L-27* when they should have bid *F_F-45/F_L-40*. Believe me, there is quite a difference.

Also, when contractors are asked to meet minimum numbers in each bay, as in Example 2, they should assume an even higher F-number. F-numbers are based on statistical information and, as ASTM E-1155 states, "As the size of the sample increases, so does the probability that the sample's statistics will accurately represent those of the entire population." This is not to say that a contractor shouldn't meet floor tolerances in each floor section, but when each bay is measured and reported individually, contractors should include a safety factor in bid proposals.

Specifications should be written to ensure that owner requirements are met. If specifiers are unsure of these requirements, they might raise the F-number higher than needed. Experience shows that F_F-35 is more than adequate for most random-traffic floors. Any number greater than this is probably overkill and will waste the end user's money. However, there are unique cases, such as air pallet operations, that require flatness and levelness numbers in the F_F-50/F_L-40 range.

Superflat Floors

Defined traffic, such as that found in narrow-isle warehouses,

requires superflat floors. Many designers and contractors know that lift trucks travel the same path day after day in these facilities, but many people misunderstand the specification and how it is measured. The specification does not include F_F/F_L, nor does it include SOV and MLV. Superflat specifications should be written as a minimum.

Example: F-min 100
F-min 70

F-min 100 is not the same as F_F-100. F_F/F_L specifications are intended for random-traffic applications and measured according to ASTM E-1155. Different calculations are used when computing tolerances for F-min floors. Tolerances also are measured differently. Instead of a random sampling, each of the traffic paths is measured directly, using a continuous-recording floor profilometer configured to run exactly in the traffic wheel tracks. The results of the measurements do not produce F-numbers, but simply confirm compliance with the minimum requirements.

A tape is printed by the profilometer that tells the contractor if the work is "in tolerance" or not. The tape identifies the exact locations of any defects so the contractor can grind these areas to meet the tolerance.

Measuring

When F-number specifications are not measured and compliance is not confirmed, the system is abused along with the unsuccessful contractors who bid the job with the intent of meeting the specifications. If measurements are not taken, contractors are no better off

than they were with the gap-under-a-straightedge specification.

The standards for measuring random-traffic floors are found in ASTM E-1155. The information in this document is straightforward and includes types of test equipment, minimum number of measurements, location of survey lines, and methods for calculating results.

The timing of these measurements always seems to create controversy. Although time limits are not mentioned in ASTM E-1155, numerous references do appear in ACI 117 and ACI 302. After reviewing these documents, it is understandable why there is confusion.

The bottom line is that F_L values must be measured within 72 hours of placement, with no time limit made for the measurement of F_F values. It would be advantageous for both contractor and owner if the specifications were confirmed within 24 hours of placement. With timely information, the contractor is able to change procedures, when necessary, to provide the intended results. If there is a problem, it is much better to be informed with only one day's work in place instead of three.

A few specifications are appearing with requirements to measure across construction joints. According to ASTM E-1155, "No portion of any sample measurement line shall fall within 2 feet of any test section, boundary, wall, penetration, or similar discontinuity." Special circumstances, such as air pallet operation and television studios, dictate that measurements continue across slab joints.

The danger is that the proper F-number requirement may not be specified. Most of the historical data contractors use to establish costs to produce specific F-numbers is based on slabs measured according to ASTM E-1155. The area of the slab adjacent to its joints is never as flat as the rest of the slab.

When including the joints, the resulting F-numbers are lowered as much as 20% to 50%, depending, of course, on the spacing of the joints. An F_F-100 placed in 15-foot-wide strips could easily become F_F-50 or less when joints are included. If contractors are not careful when interpreting the specifications, they could bid F_F-50 and have to build to F_F-100.

Corrective Measures

Specifications should clearly state the specific corrective measures to be applied in the event of an "out of tolerance" result. However, deciding which corrective measures to use is not always easy.

ACI 302 offers the most comprehensive explanation and states "Remedial measures might include grinding, planing, surface repair, retopping, or removal and replacement. Specifications should clearly identify the acceptable correction methods to be used."

MISUNDERSTANDINGS CAN BE AVOIDED IF SPECIFICATIONS ARE WRITTEN AND INTERPRETED PROPERLY.

If the composite values of the entire floor installation (when complete) are less than the specified overall value, a monetary penalty should be considered. The F-number system provides a method for calculating the exact percentage compliance between the specified and estimated F-numbers. It is possible to produce this number with daily as well as composite results. The penalty should be based on the percentage of or the square footage of slab that is out of tolerance, not the entire slab.

If the values of an individual section or placement are less than the MLV, then the areas causing the problem must be repaired or removed, not the entire section—unless the entire section of placement is out of tolerance. Problem areas or bays should be identified and sectional boundaries established at the column or half-column lines, or at the construction and control joints and should not be smaller than one-half bay.

Grinding, planing, or other surface repair is probably the least desirable of the options given. Contractors should not be lulled into a false sense of security thinking they can simply grind the out-of-tolerance areas. Because of the way random-traffic floors are measured, it is difficult, if not impossible to identify the exact areas to grind. Topping is a viable option if accomplished by an experienced contractor and care is taken not to damage the integrity of the slab. Slab removal and replacement is, of course, the most costly option, but often is the only one that makes sense.

Misunderstandings can be avoided if specifications are written and interpreted properly. Both specifier and contractor should be familiar with applicable standards and procedures.

There is nothing wrong with changing or tailoring specifications to meet special circumstances or individual needs. Contractors should read the material carefully and understand its impact on the cost of complying with the specification. Specifiers should be concise in their explanations when they deviate from normal practice. The number one goal should always be to meet or exceed owner expectations. Communication is essential in achieving this goal.

Terry J. Fricks is president of Fricks Floor Systems, a Forth Worth, Texas, firm specializing in designing and constructing industrial floor slabs nationwide. He is a member of ACI committees 223, 302, and 360.