PDHonline Course S130 (1 PDH)

Concrete Slabs and the Use of the F-Number System

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EFFECTIVE F-NUMBER SPECIFICATION

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When correctly employed, the F-Number System is the most powerful tool ever devised for controlling finished floor flatness and levelness. Obviously, to realize the full potential of the system, the contract FF/FL specification must be both accurate and complete. Lacking comprehensive guidance from ACI, however, many specifiers continue to produce F-Number specifications that lack one or more of the following essential elements:

Overall Average and Minimum Local F-Numbers
The calculation of overall F-Numbers is inherently an averaging process. If the specification fails to distinguish the worst tolerable local condition from the required overall result, then any sized sub-division of the whole no matter how bad its profile will be deemed entirely acceptable, so long as its F-Numbers are not low enough to cause the floor's overall average to fail.

In order to avoid this "averaging blindness," a two-tiered F-Number specification must be employed. The first specified FF/FL pair, called the "Overall Average F-Numbers," set the minimum values to be exhibited by the completed floor when viewed in its entirety. The second specified FF/FL pair, called the "Minimum Local F-Numbers," set the minimum values to be exhibited by each of the individual minimum local floor sections (i.e. the rectangles defined by the construction and control joints, or the column and half-column lines, whichever is smaller).

Overall Average and Minimum Local F-Numbers have a specific numerical relationship. While ACI sets the ratio of Overall Average to Minimum Local values at 2:1, our firm uses 5:3, since this smaller quotient has proven to be more realistic.

Trouble will routinely develop when only a single FF/FL pair is specified. Lacking clear definition, the owner will invariably interpret the single specified pair as being Minimum Local values, while the contractor will just as naturally view them as Overall Average values. Since there is a huge difference in required profile quality between these two interpretations, conflict between the parties is virtually assured. By convention, a single specified FF/FL pair is now properly interpreted as representing the Overall Average

values. The assertion of this rule, however, rarely proves sufficient to allay the confusion and mistrust engendered in the owner by the dispute.

Exclusions
ASTM E-1155 excludes the use of FF and FL numbers on so-called "Defined Traffic" floors (i.e. floors where the rolling traffic is constrained by fixed rails or embedded guide wires to follow specific paths). Instead, the proprietary "Fmin System," with its vehicle simulation testing procedure, must be employed on these special-use floors.

ASTM E-1155 also excludes the floor area within two (2) feet of any construction joint, any pre-positioned embedment, or any type of full-depth penetration from both FF and FL control, since all such areas are known to be atypical. The FF/FL measurement lines may cross sawcut control joints, however.

ACI-117 prohibits the specification of FL on floors that are to be inclined or cambered. Also, because there is no way for the flatwork contractor either to anticipate or correct the adverse effects of ongoing deflection on FL, ACI prohibits the enforcement of FL on any floor to be installed over a "deflecting base" (i.e. a base structure that sags appreciably when the concrete is deposited).

Testing Responsibilities and Procedures
The specification must clearly set forth who will be performing the tests, who will be paying for the tests, how the tests are to be performed (including the instrument to be used), when the tests are to be performed, when the results are to be made available, who will receive the initial reports, and what will happen if the testing and reporting timeliness provisions are not met. (Generally when the tests are not performed and reported on time the results become void, and the floor area in question is deemed acceptable by definition.)

To avoid the affects of curling (a natural phenomenon not attributable to the contractor), ACI-117 requires the FL tests to be performed within 72 hours after installation. Similarly, to avoid the affects of deflection (a design controlled phenomenon), ACI-117 also prohibits the testing of FL numbers on elevated slabs after the removal of shores.

Specified Remedies
Perhaps the most powerful feature of the F-Number System is its ability to specify an equitable remedy prior to installation for every possible mode of non-compliance. Since there are two basic FF/FL specification categories (i.e. Overall Average and Minimum Local), there are only three possible floor flatness/levelness specification failure modes:

- Mode I: One/both of the measured Overall Average FF and FL values is/are unsatisfactory, but the measured Minimum Local FF and FL values are all satisfactory.
- Mode II: One/both of the measured Overall Average FF and FL values is/are unsatisfactory, and some/all of the measured Minimum Local FF and/or FL values are also unsatisfactory.

- Mode III: The measured Overall Average FF and FL values are both satisfactory, but some of the measured Minimum Local FF and/or FL values are unsatisfactory.

As noted above, the specified Overall Average F-Numbers define the general profile quality to be exhibited by the entire project floor when completed. Specified Overall Average F-Numbers are not, therefore, to be applied to the individual slab placements. It is entirely acceptable, in fact, for any individual placement to test below either or both of the specified Overall Average F-Numbers, provided that the remaining placements measure high enough in combination to compensate.

Involving only the specified Overall Average F-Numbers, a Mode I failure in no way threatens the owner's ability to use the floor. Since the sole issue involves a deficiency in the overall delivered value, Mode I failures are equitably resolved simply through the payment of monetary damages. Since the F-Number System provides a final accounting of the square footage in place that is worse than the specified Overall Average values, the exact penalty to be imposed at the end of the project for a Mode I failure may be calculated simply by multiplying this total defective area by the prescribed liquidated damages rate (our firm uses $1.00 per square foot).

The specified Minimum Local F-Numbers define the "minimum usable floor." Since, by definition, any floor section measuring below either of these F-Numbers has no value at all, physical correction of the entire offending area is the only available remedy for a Mode III failure.

A Mode II failure, being the combination of Mode I and Mode III failures, is equitably resolved by first repairing/replacing all of the defective minimum local sections. The corrected areas are then re-measured, and the total square footages measuring below the specified Overall Average F-Numbers are re-calculated, replacing old runs with new where appropriate. Liquidated damages are then recalculated using the revised defective area totals.

Sample F-Number Specification

To address all of the critical issues regarding effective floor profile definition and control, our firm has developed the following standard F-Number specification. To avoid any errors and/or subtle ambiguities, it is strongly recommended that all random traffic floor flatness/levelness specifications be replaced with this language. A specifier can take no more effective step to realize the full power of the F-Number System for his client.

A. Designation: The floor area bounded by column lines (___), (___), (___) , and (___) is designated the Random Traffic Floor . Any floor slab which comprises a portion of the Random Traffic Floor is designated a Random Traffic Slab.
B. Local Flatness/Levelness: Except as set forth in Paragraph D below, the Random Traffic Floor shall conform to the following minimum F-number requirements:
   Specified overall values : OAFF-(___) / OAFL-(___)
   Minimum local values : MLFF-(___) / MLFL-(___)
C. General Conformity to Design Grade: Except as set forth in Paragraph D below, the entire Random Traffic Floor shall fall within +- 3/4" of its specified elevation.
D. Exceptions: Both the overall and minimum local FL levelness tolerances set forth in Paragraph B above shall not apply to any Random Traffic Slab that is to be

inclined or cambered. Likewise, no FL levelness tolerances will be applied to any unshored elevated construction. The general conformity to design grade tolerance set forth in Paragraph C above will apply to unshored elevated slab constructions, but in all such cases, the tolerance will be increased to
+/- 1-1/4".

E. Testing: All floor flatness, levelness, and grade conformity tests shall be made (at the Owner's expense) on each newly installed Random Traffic Slab within 16 hours after completion of the final troweling operation, and in all cases before supporting shores (if any) are removed. FF and FL tests shall be made by a factory certified technician in accordance with ASTM E 1155 (latest revision) using a fully downloading "F-Meter" as manufactured by Allen Face & Company of Wilmington, NC. Grade conformity tests shall be made using an optical or laser level. Results of all floor tolerance tests - including a formal notice of acceptance or rejection of the work - shall be provided to the contractor within 8 hours after testing. Failure to adhere to the testing and reporting requirements set forth in this paragraph shall constitute de facto acceptance of the work.

   NOTE: Weekends and holidays shall be ignored when computing specified testing and reporting deadlines.

F. Remedy for Out-of-Tolerance Work: The entire Random Traffic Floor shall be subdivided into Minimum Local joints, whichever subdivision yields the smaller Floor Sections bounded either by the column and half-column lines, or the construction and control areas.

   All Minimum Local Floor Sections measuring at or above both the specified MLFF and MLFL numbers shall be accepted for F-number compliance as constructed. All Minimum Local Floor Sections which fail to meet or exceed both the specified MLFF and the specified MLFL shall be corrected in their entirety. Such corrective work on elevated slabs may take the form of grinding or depression-and-retopping. Such corrective work on slabs-on-grade may take the form of grinding, depression-and-retopping, or removal-and-replacement. In all cases, the particular method of correction to be employed shall be determined solely by the Owner.

   If the entire Random Traffic Floor, when completed, fails to meet or exceed both the specified OAFF-number and the specified OAFL-number, then liquidated damages shall be paid by the Contractor to the Owner in an amount equal to:

   $(____) x [Total balance of ft2 measuring below Specified OAFF] x [Specified OAFF / Actual OAFF] or
   $(____) x [Total balance of ft2 measuring below Specified OAFL] x [Specified OAFF / Actual OAFL] whichever is the greater amount.

The defective square footages to be used in the above formulae shall be calculated using the "F-Meter Project Management" procedure published by:

G. Additional Information: A complete description of the F-Number System may be found in either the Apr '87 issue of CSI's Construction Specifier or the Jan '89 issue of ACI's Concrete International.

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