Pepper CONSTRUCTION

Quality Technical Bulletin

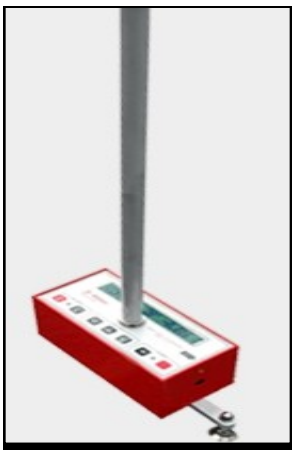
Floor Flatness (F_F) / Floor Levelness (F_L)

Issue 29 | 033000 | February 18, 2014

BUILDING QUALITY AT EVERY LEVEL

FLOOR DIPSTICK

ROLLING PROFILER



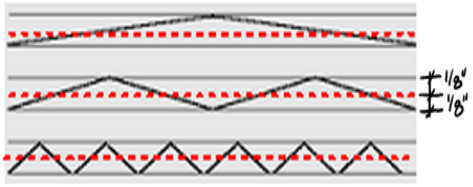
WALKING FLOOR PROFILER

We have been getting F_F25±5 with a hard float finish (fuzzy finish) ...hitting the concrete only once with a power trowel.

There are a lot of items to consider when bidding, pouring, and finishing a concrete floor, we must understand the concrete floor requirements. We must know what the flooring material is going to be installed, as each flooring material has certain requirements when it comes to floor flatness and floor levelness. We should be reviewing these items in the bidding phase or if we have the opportunity to review during pre-construction, we need to discuss these requirements with the architect. The old 1/8" per foot tolerance is no longer valid and has not been valid for about a decade. We must also understand the requirements early so that we make sure that the slab finishing requirements meet those standards ahead of time.

Corey Zussman, AIA, NCARB - Director of Quality Management

- The F-number system is the standard specification and measurement for concrete floors; for flatness and floor levelness. **This system replaces the 1/8" per 10' specification.**
- Floor Flatness (F_F) relates to the bumpiness of the floor…and is always listed first.
- Floor Levelness (F_L) relates to the amount of slope (pitch or tilt) in the slab…F_L = The degree to which the surface of the slab approaches true horizontal perfection.
- Although the 10' straight edge procedure has been used for many years for judging floor irregularities, the procedure has a number of serious deficiencies which include:
  - The difficulty in testing large areas of floors
  - The difficulty of randomly sampling floors
  - The inability to reproduce testing results
  - Failure of the method to predict acceptability of irregularities or roughness in the floor surface
  - The inability to evaluate levelness of the surface
- The old 1/8" per 10' was not clear enough to define….it could mean a total ¼" difference or a 1/16" difference.
- The elevation of roughness for a given amplitude should be based on frequency of the wave forms.
- Straight edge way of determining the floor profile was unable to determine anything but the 1/8"/10'….ie: one ridge at 1/8" or 2 or 10' etc….



- While there is NO direct equivalent between F-numbers and straight edge tolerances:
  - F-numbers measure both the difference and the frequency
  - A rough equivalent is **F_F25± ¼" per 10'** **F_F50 ± 1/8" per 10'** **F_F100±1/16" per 10'**
  - These F-numbers should be used to identify issues with finishing & prevent reoccurring issues

SYSTEM DOES NOT WORK ON ELEVATED DECKS

- A slab on grade usually is specified as both F_F and F_L.
- Elevated slabs are usually specified as F_F only, because of deflection of the elevated deck.
- Section 8.15.3.2 of **ACI 302.1R-04** contains the following statement:
  Levelness of suspended slabs are dependent on accuracy of formwork and strike off, but is further influenced by behavior of the structural frame during and after completion of construction. Each type of structural frame behaves somewhat differently; the contractor should recognize those differences and plan accordingly
- Section 4.5.6.1 of **ACI 117** contains the following statement:
  The F_L levelness tolerance shall not apply to slabs placed on unshored form surfaces and/or shored form surfaces after the removal of shores. F_L levelness tolerances shall not apply to cambered or inclined surfaces and shall be measured within 72 hours after slab concrete placement.
- The F_L tolerance should only be applied to slabs on-ground that are level and suspended slabs that are both level and shored at the time data are taken.
- The F_L levelness tolerance should not apply to slabs placed on unsupported form surfaces. It should not be applied to cambered or inclined slab surfaces.
- Concrete slabs placed over unshored structural steel and metal deck surfaces can exhibit significant deflection in the hardened state.

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The typical floor is about ..... ***F_F 20-25 / F_L 15-20***

Offices with fixed partitions ..... ***F_F20 / F_L17***

Offices with movable partitions ..... ***F_F30 / F_L25***

Stores ..... ***F_F20 / F_L17***

School classrooms ..... ***F_F20 / F_L17***

Gymnasiums ..... ***F_F40 / F_L30***

TV studios ..... ***F_F100 / F_L50***

Narrow aisle warehouses ..... ***F_F100 / F_L50***

General warehouse ..... ***F_F50-60 / F_L30-40***

Average industrial floor ..... ***F_F22 / F_L18***

Minimum floor ..... ***F_F15 / F_L13***

To obtain an increase of 5-10 points in FF:

Pan Float

To obtain an increase of 20 or more points in FF:

Long Handle Straight Edge

To obtain FL of 18 or less:

Screed without Rails

To obtain a FL of 19 to 27:

Screed Rails & Vibratory Screed

To obtain a FL of 28 or higher:

Must Use Laser Screed

Localized grinding is not a solution to fix any F number.

By grinding a small spot to flatten down any area might create a dip in another direction.

- When a floor is only specified as F25 this means F_F25.
- F_{MIN} is the minimum that the owner could live with for floor finish or equipment reasons.
- Many times the floor spec will have 2 pairs of F numbers
  1. The specified overall F-numbers, which represents the minimum values allowed for the entire floor, looked at as a whole.
  2. The minimum local F-numbers which defines the minimum quality acceptable to the owner (the lowest results allowed on any one floor section).
- Generally, the difference between the two noted above numbers are 2/3 of the specified numbers, **however, minimum absolute should be F_F15/F_L13.**

WHEN DOES THE MEASUREMENTS NEED TO BE TAKEN

- The floor will be the flattest right after finishing and before any curing compound is installed.
- The F number measurements should be taken ASAP, in order to prevent the next pour issues from arising.
- The ACI mandates that the F number measurements be taken within 72 hours of installation. However, same testing is best (if doable) in order to correct any placing or finishing issues.
- Because F numbers are quantified, they could be reproduced again and again—so an experienced concrete company should have no issue meeting or exceeding many different F numbers based on placement and finishing technique.
- Any test taken after 72 hours will likely show concrete shrinkage, and or deflection, or curling which will affect the results.
- The floor will worsen for 2 years once the moisture loss and shrinkage/curling stops.

HOW ARE THE MEASUREMENTS TAKEN

- Two instruments are used to determine F_FF_L
  1. Profileograph—this produces a continuous measurement for defined traffic floors.
  2. Dipstick floor profiler—produces a point-point graph of the surface and other data to compile the F-number for “Random Traffic Floors.”
- Measurements are not taken within 2’-0” of a construction joint, or other full depth penetration, unless the area excluded exceeds 25% of the total test area.
- F numbers are determined from a statistical analysis of the floors elevation measured at 1’-0” intervals. The elevation difference over 2’-0” are used to determine F_f and the difference over 10’-0” are used to determine F_L. (Rules are per ASTM E1155).
- A minimum number of points must be collected according to the square footage…areas less than 1,600SF the minimum number of 10’-0” elevation difference readings must equal 2x the square root of the area…greater than 1,600SF, the minimum number of elevation difference readings must equal to area/30.

WHY IS THE F NUMBER SO IMPORTANT

- This has a major impact on the installation of door frames, cabinetry, elevator landings, as well as floor finishes.
- In general, a floor to be tiled should be flatter than a floor to receive carpet.
- Always review the flooring finish type to make sure that the F_FF_L are in-line with these requirements or understand the amount of floor fixing that will be required.

HOW TO IMPROVE THE F NUMBER

- Any factor that complicates placing or finishing operations will have an adverse effect upon the F_F/F_L produced.
- How to improve the F numbers:

  F_F — to improve: improve finish techniques.

  F_L — to improve: improve forming and striking off techniques.

  25%-50% increase of F_F — Use a highway straight edge in lieu of a bull float. Reduce distance edge between forms to below 25’-0” to an F_F above 40.

  25%-50% increase of F_L — The time and accuracy to set forms and strike off to achieve the greatest impact on levelness…typically, the number of laborers generally goes up to achieve a higher F_L.
- Reducing the width of the strips improves the ability to produce a level surface because there is less tendency for the vibrating screen to oscillate or deflect, the controlling edge from in elevation are close together.

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SLAB ON GROUND FLATNESS/LEVELNESS CONSTRUCTION GUIDE

FLATNESS

Typical specification requirements	Typical finishing requirements
Specified overall value - 20 Minimum local value - 15	1. Smooth surface using 4 to 5 ft wide bull float. 2. Wait until bleed water sheen has disappeared. 3. Float surface with one or more passes using a power float (float-shoe blades or pans). 4. Make multiple passes with a power trowel (trowel blades).
Specified overall value - 25 Minimum local value - 17	1. Smooth and restraighten surface using 8 to 10 ft wide bull float. 2. Wait until bleed water sheen has disappeared. 3. Float surface with one or more passes using a power float (float-shoe blades or pans). 4. Restraighten surface following paste-generating float passes using 10 ft wide highway straightedge. 5. Make one pass with a power trowel (trowel blades).
Specified overall value - 35 Minimum local value - 24	1. Smooth and restraighten surface using 8 to 10 ft wide bull float. Apply in two directions at 45 degree angle to strip. 2. Wait until bleed water sheen has disappeared. 3. Float surface with one or more passes using a power float (float-shoe blades or pans). 4. Restraighten surface following paste-generating float passes using 10 ft wide highway straightedge. Use in two directions at 45 degree angle to strip. Use supplementary material to fill low spots. 5. Multiple passes with a power trowel (trowel blades).
Specified overall value – 50 Minimum local value – 35	1. Smooth and restraighten surface using 8 to 10 ft wide bull float or high-way straightedge. Apply in two directions at 45 degree angle to strip. 2. Wait until bleed water sheen has disappeared. 3. Float surface with one or more passes using a power float (float-shoe blades or pans). First float pass should be across width of strip. 4. Restraighten surface following paste-generating float passes using 10 ft wide highway straightedge. Use in two directions at 45 degree angle to strip. Use supplementary material to fill low spots. 5. Multiple passes with a power trowel (trowel blades). 6. Restraighten surface after trowel passes using multiple passes with weighted highway straightedge to scrape the high points. No filing of the low spots is done at this stage.

LEVELNESS

Typical specification requirements	Typical forming and strikeoff requirements
Specified overall value -15 Minimum local value - 10	1. Set perimeter forms (optical or laser instruments). 2. Use block placements of varying dimensions. Use wet screed strikeoff techniques to establish initial grade.
Specified overall value – 20 Minimum local value – 15	1. Set perimeter forms (optical or laser instruments). 2. Use block placements of varying dimensions. Use wet screed strikeoff techniques to establish initial grade. 3. Check grade after strikeoff. Repeat strike off as necessary.
Specified overall value – 25 Minimum local value – 17	1. Set edge forms using optical or laser instruments. Optical instruments provide more accurate elevation control. 2. Use strip placements with maximum widths of 50 ft. Use edge forms to establish initial grade. 3. Use vibratory screed for initial strikeoff.
Specified overall value – 30 Minimum local value – 20	1. Set edge forms using optical or laser instruments. Optical instruments provide more accurate elevation control. 2. Use strip placements with maximum widths of 30 ft. Use edge forms to establish initial grade. 3. Use vibratory screed for initial strikeoff. 4. Check grade after strikeoff. Repeat strikeoff as necessary. 5. Use a laser screed instead of rigid strikeoff guides and vibratory screed to produce this same quality.
Specified overall value – 50 Minimum local value – 35	1. Set edge forms using optical instrument to +/- 1/16 in accuracy. Use straightedge to identify form high spots; place top surface to fit inside 1/16 in. envelope. 2. Use strip placements with maximum widths of 20 ft. Use edge forms to establish initial grade. 3. Use vibratory screed for initial strikeoff. 4. Check grade after strikeoff. Repeat strikeoff as necessary. 5. Follow vibratory screed pass with two or three hand straightedge passes along the axis of the strip.

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SAFETY

SUSPENDED SLAB FLATNESS/LEVELNESS CONSTRUCTION GUIDE

FLATNESS

Typical specification requirements	Typical finishing requirements
Level and shored until after testing: Specified overall value – 20 Minimum local value – 15 Unshored: Specified overall value – 20 Minimum local value – 15	1. Smooth surface using 4 to 5 ft wide bull float. 2. Wait until bleed water sheen has disappeared. 3. Float surface with one or more passes using a power float (float-shine blades or pans). 4. Make multiple passes with a power trowel (trowel blades).
Level and shored until after testing: Specified overall value – 25 Minimum local value – 17 Unshored: Specified overall value – 25 Minimum local value - 17	1. Smooth and restraighten surface using 8 to 10 ft wide bull float. 2. Wait until bleed water sheen has disappeared. 3. Float surface with one or more passes using a power float (float-shoe blades or pans). 4. Restraighten surface following paste-generating float passes using 10 ft wide highway straightedge. 5. Make multiple passes with a power trowel (trowel blades).
Level and shored until after testing: Specified overall value – 30 Minimum local value – 24 Unshored: Specified overall value – 30 Minimum local value - 24	1. Smooth and restraighten surface using 8 to 10 ft wide bull float. Apply in two directions at 45 degree angle to strip. 2. Wait until bleed water sheen has disappeared. 3. Float surface with one or more passes using a power float (float-shoe blades or pans). 4. Restraighten surface following paste-generating float passes using 10 ft wide highway straightedge. Use in two directions at 45 degree angle to strip. Use supplementary material to fill low spots. 5. Make multiple passes with a power trowel (trowel blades are preferable).
Level and shored until after testing: Specified overall value – 50 Minimum local value – 35 Unshored: Specified overall value – 50 Minimum local value - 35	1. Smooth and restraighten surface using 8 to 10 ft wide bull float or high-way straightedge. Apply in two directions at 45 degree angle to strip. 2. Wait until bleed water sheen has disappeared. 3. Float surface with one or more (float-shoe blades or pans). First float pass should be across width of strip. 4. Restraighten surface following paste-generating float passes using 10 ft wide highway straightedge. Use in two directions at 45 degree angle to strip. Use supplementary material to fill low spots. 5. Make multiple passes with a power trowel (trowel blades are preferable). 6. Restraighten surface after trowel passes using multiple passes with weighted highway straightedge to scrape the high spots. No filing of the low spots is done at this stage.

LEVELNESS

Typical specification requirements	Typical forming and strikeoff requirements
Level and shored until after testing: Specified overall value – 15 Minimum local value – 10 Unshored: Specified overall value – N/A Minimum local value – N/A	1. Set perimeter forms (optical or laser instruments). 2. Use block placements of varying dimensions. Use wet screed strikeoff techniques to establish initial grade.
Level and shored until after testing: Specified overall value – 20 Minimum local value – 15 Unshored: Specified overall value – N/A Minimum local value – N/A	1. Set perimeter forms (optical or laser instruments). 2. Use block placements of varying dimensions. Use wet screed strikeoff techniques to establish initial grade. 3. Check grade after strikeoff. Repeat strike off as necessary.
Level and shored until after testing: Specified overall value – N/A Minimum local value – N/A Unshored: Specified overall value – 50 Minimum local value – 30	1. Use a two-course placement to achieve this levelness quality. Topping slab must be placed using slab on grade techniques after shoring has been removed. 2. Set edge forms using optical instrument to +/- 1/16 in. accuracy. Use straightedge to identify form high spots; place top surface to fit inside 1/16 in. in envelope. 3. Use strip placements with maximum widths of 20 ft. Use edge forms to establish initial grade. 4. Use vibratory screed for initial strikeoff. 5. Check grade after strikeoff. Repeat strikeoff as necessary. 6. Follow vibratory screed pass with two or three hand straightedge passes along the axis of the strip.

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