Floor Flatness and Levelness

Floor flatness and levelness are described by Face Floor Profile Numbers, also called F-numbers. Two separate numbers, one each for flatness and levelness, are used to define a constructed floor surface. This document provides a brief explanation of these numbers and typical construction requirements and techniques to achieve a desired flatness and levelness. The reader is directed to ACI 117 and ASTM E 1155 for more information.

The *flatness* F-number (F_F) limits localized surface bumpiness by limiting the magnitude of successive 1 ft. (300 mm) slope changes (along a line defined by ASTM E 1155). A number of factors at the jobsite are of particular concern when flatness is an important consideration. These include:

- Workability, finishability, and setting times of concrete to be used;
- The window of finishability;
- Sun, wind, rain, temperature, and other exposure conditions;
- Amount and angle of light;
- Timeliness of concrete delivery;
- Consistency of delivered slump; and
- Site accessibility.

The *levelness* F-number (F_L) controls local conformance to the design grade by limiting departures over distances of 10 ft. (3 m) (along a line defined by ASTM E 1155). The levelness of a surface is primarily determined by the accuracy and rigidity of the formwork and the initial strikeoff technique. The behavior of the structural frame during and after completion is also a significant factor contributing to the levelness of suspended slabs.

These F-numbers can each range from zero to infinity and are written together as a pair in the order F_F/F_L. In practice, these numbers typically range from 12 to 45 although there is still much to be learned about which tolerances can be expected from a given construction method. For projects where floor flatness/levelness constitutes a potential issue, the following precautions are suggested:

- The exact meaning of the flatness/levelness requirement, and the exact method and time of measurement to determine compliance should be determined prior to construction;
- The contractor should confirm an ability to satisfy the floor tolerance requirement by profiling previous installations;
- Tests slabs should be considered to verify the effectiveness of the proposed installation procedures; and

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- Exact remedies should be determined to handle floor tolerance deficiencies should they occur.

On random-traffic floors with varied and unpredictable traffic patterns, two F_F/F_L sets should be specified. One set for the composite value and the other for the minimum quality level that will be accepted without repair. Minimum levels are typically set at 67% of the composite value and rarely set below 50% of the overall F_F/F_L requirements. Local values should never be set below F_F13/F_L10.

The following two tables provide a guide for the flatness and levelness numbers that can be expected from various construction techniques for slabs on grade and suspended slabs.

FLATNESS

Typical Specification Requirements			**Typical Finishing Requirements**
Slabs on Grade	Suspended Slabs		
	Level and Shored Until after Testing	Unshored	
Composite: 25 Minimum: 15	Composite: 20 Minimum: 15	Composite: 20 Minimum: 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. 4. Make multiple passes with a power trowel.
Composite: 25 Minimum: 17	Composite: 25 Minimum: 17	Composite: 25 Minimum: 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. 4. Restraighten surface following paste-generating float passes using 10 ft. wide highway straightedge. 5. Make multiple passes with a power trowel.
Composite: 35 Minimum: 24	Composite: 30 Minimum: 24	Composite: 30 Minimum: 24	1. Smooth and restraighten surface using 8 to 10 ft. wide bull float. Apply in two directions at 45 degrees angle to strip. 2. Wait until bleed water sheen has disappeared. 3. Float surface with one or more passes using a power float. 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.
Composite: 50 Minimum: 35	Composite: 50 Minimum: 35	Composite: 50 Minimum: 35	1. Smooth and restraighten surface using 8 to 10 ft. wide bull float. Apply in two directions at 45 degrees angle to strip. 2. Wait until bleed water sheen has disappeared. 3. Float surface with one or more passes using a power float. 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. 6. Restraighten surface after trowel passes using multiple passes with weighted highway straightedge to scrape the high points. No filling of the low spots is done at this stage.

LEVELNESS

Typical Specification Requirements			Typical Finishing Requirements
Slabs on Grade	Suspended Slabs		
	Level and Shored Until after Testing	Unshored	
Composite: 15 Minimum: 10	Composite: 15 Minimum: 10	--	1. Set perimeter forms (optical or laser equipment). 2. Use block placements of varying dimensions. Use wet screed strikeoff techniques to establish initial grade.
Composite: 20 Minimum: 15	Composite: 20 Minimum: 15	--	1. Set perimeter forms (optical or laser equipment). 2. Use block placements of varying dimensions. Use wet screed strikeoff techniques to establish initial grade. 3. Check grade after strikeoff. Repeat as necessary.
Composite: 25 Minimum: 17	Composite: 30 Minimum: 24	Composite: 30 Minimum: 24	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.
Composite: 30 Minimum: 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 as necessary. 5. Use a laser screed instead of rigid strikeoff guides and vibratory screed to produce this same quality.
--	--	Composite: 50 Minimum: 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 instruments to 1/16 in. accuracy. Use straightedge to identify form high spots; place top surface to fit inside 1/16 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 as necessary. 6. Follow vibratory screed pass with two or three hand straightedge passes along the axis of the strip.
Composite: 50 Minimum: 35	--	--	1. Set edge forms using optical instruments 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 as necessary. 5. Follow vibratory screed pass with two or three hand straightedge passes along the axis of the strip.

The preceding information was taken with permission from the ACI Craftsman Workbook Publication CP-11(08).