

Definitions

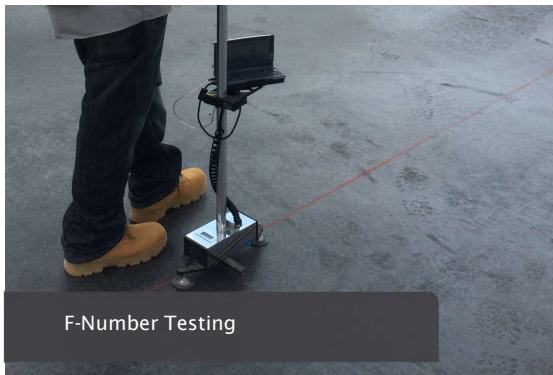
Flatness (F_F)

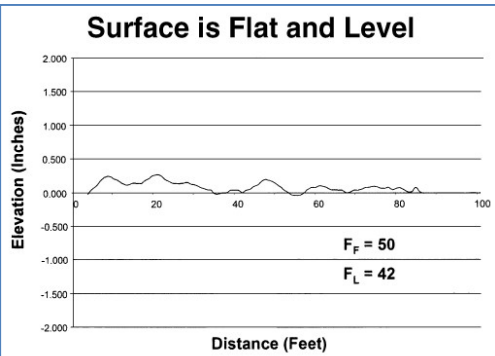
- Waviness or bumpiness of slab surface
- Measure every 2 ft.

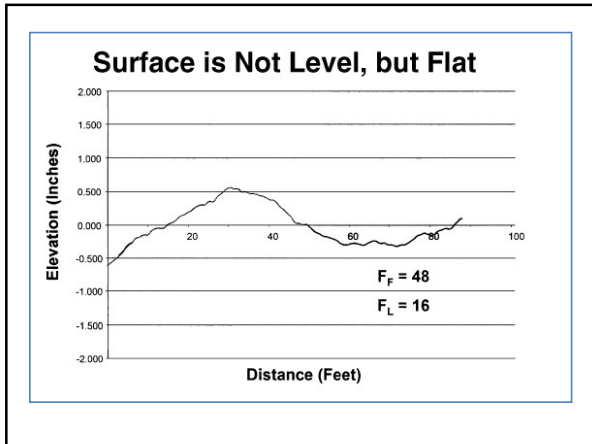
Levelness (F_L)

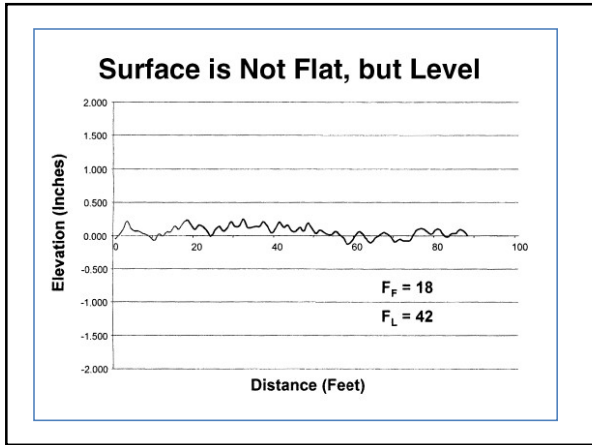
- Tilt or slope of slab surface
- Measure every 10 ft.











What F-Number equals 1/8" in 10'

In rough equivalents:

- A FF 25 = ± 1/4" defect in 10'
- A FF 50 = ± 1/8" defect in 10'
- A FF 100 = ± 1/16" defect in 10'

Floor Flatness and Levelness

Floor Classification	Composite Flatness, F_f	Composite Levelness, FL	Typical Applications
Conventional	20	15	mechanical rooms
Moderately Flat	25	20	carpeted office
Flat	35	25	thin set coverings
Very Flat	45	35	high speed lift trucks/ air pallets
Super Flat	>50	>50	random traffic

Sources: Cheek, M.A. "The Floor Flatness Report", *Concrete International*, January 2011 and ACI 117-10



Minimum Specifications According to ACI 301

301-10 Section 11.3.5.1: Industrial Floor Slab Execution

Unless alternative tolerances are specified, the minimum overall surface flatness shall be F_f35 , levelness shall be F_L25 , and local area minimums shall be F_f23 , F_L17 as determined by ASTM E1155

F-number System Specs and Tests

- Required by ACI 301-10 Section 5.3.4.3 for areas greater than 10,000 ft²
- Measures floor flatness and levelness (Section 4.8 of ACI 117-10 *Specification for Tolerances for Concrete Construction and Materials*)
- ACI 302.1R-04 *Guide for Concrete Floor and Slab Construction*, Section 8.15
- Measurements in accordance with ASTM E 1155 *Standard Test Method for Determining F_f Floor Flatness and F_L Floor Levelness Numbers*



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Contractor Responsibility

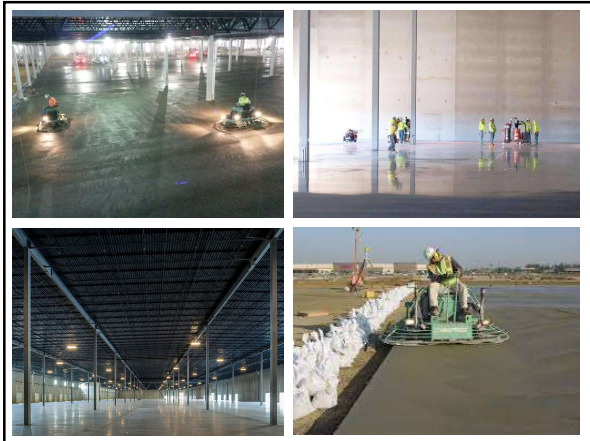
What the Contractor Can Do

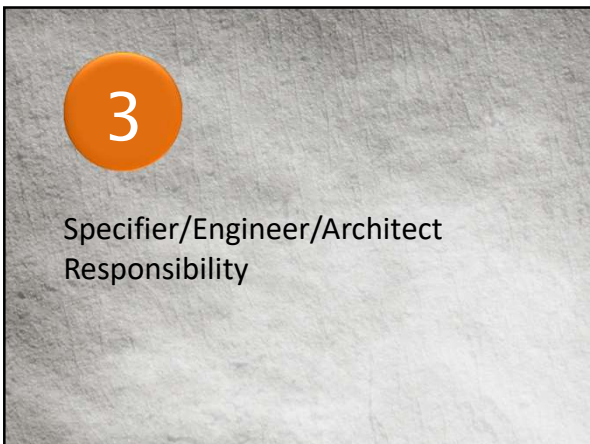
1. Subgrade preparation (soft, cold)
2. Formwork setting
3. Lighting
4. Craftmanship











What the Specifier Can Do

1. Specify F_f/F_t numbers!
2. F-Numbers tailored to the needs of the space/polishing expectations
3. What F_f/F_t numbers are achievable?
 - Equipment access
 - Load restrictions
 - Elevated Slabs



General Concerns

- ▶ There are at least two situations for which higher specified F-numbers are not feasible
 - floors with multiple obstructions to finishing operations
 - floors with small cover over the top reinforcing bars (i.e. 3/4 in.)
 - The bars closest to the top surface can create waves in the fresh concrete during strikeoff and finishing, thus decreasing F-numbers.



General Concerns

- ▶ Allow contractor to specify slump—depends on size of job, equipment used.
- ▶ Consistent concrete delivery--slump by itself doesn't matter, just as long as it is consistent from load to load



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Floor Flatness After 72 Hours



Floor Flatness/Levelness Beyond 72 hours

- ▶ FF and FL numbers should be measured ASAP and before 72 hours after placing floor.
- ▶ Warping, curling, cracking, shrinking does not stop at 72 hours.



Floor Flatness/Levelness Beyond 72 hours

- ▶ Vapor barrier directly below slab causes curling—drop at least 18" below bottom of slab
- ▶ Consider internal curing with lightweight aggregate
- ▶ Specify maximum shrinkage of 0.04%
- ▶ Consider using macro poly fibers to keep cracks tight
- ▶ Consider using macro steel fibers and eliminate reinforcing steel to ensure proper position of flexural reinforcement and hold cracks together
- ▶ Limit equipment loads until concrete has gained full strength
- ▶ Wet curing for minimum 7 days (longer is better)

Floor Flatness/Levelness Beyond 72 hours

- Aggregate gradation to limit shrinkage and cement content
 - Uniform gradation (0.45 Power Curve)
 - Use maximum top aggregate size possible
 - Use a higher percentage of intermediate aggregate (3/8 in) than sand
- Limit total cementitious content by specified strength requirements
- Substitute a portion of Portland cement with fly ash or slag
- Specify maximum water content of 250 lbs/cy (not w/c)