

# A21 – Best Practices for Measuring Substrate Flatness for Floor Covering Installations

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Preface:

Straightedge measurement procedures described in this Best Practice can be used on all types of Substrates including concrete slabs-on-grade, suspended concrete slabs, concrete on steel decking, wood framed floors, floors covered with underlayments and toppings, and other types of Substrates.

This Best Practice focusses on Concrete Substrates and was developed to address coordination concerns that commonly occur on project sites as identified by Concrete Finishers and Floor Covering Installers. The coordination issues are initiated by the different methods used by these trades to determine acceptable Flatness Tolerances for their own work. This difference between how tolerances are measured should be aligned within the Design Professionals' project specifications:

- Aligning tolerance differences requires additional Substrate preparation procedures that are not commonly accounted for as a Work Result in the project specifications;
- Disputes can arise during execution of the Work when the Constructor assigns the required Substrate preparation when this work becomes necessary during construction and has not been included as a part of the Concrete Finisher's or Floor Covering Installer's bid price;
- Disputes resulting from assigning additional Substrate preparation procedures to these trades can result in extra costs to the Work.

This Best Practice describes measurement practices supported by the National Floor Covering Association (NFCA), Substrate preparation recommendations provided by Flooring Manufacturers, Concrete Finishers and Floor Covering Installers, integrates required skills described in the Red Seal, Interprovincial Standards Program, and incorporates standard practices described in the various standards referenced in the text.

## A21-1 Introduction

There is currently no floor covering industry-recognized method for taking concrete Substrate Flatness Tolerance measurements that affect installation of Flooring Products and that confirm acceptance with Flooring Manufacturers' stated Flatness Tolerance requirements.

1. The tolerance difference occurs when applying flatness and levelness measurements described in ASTM E1155 Standard Test Method for Determining  $F_F$  Floor Flatness and  $F_L$  Floor Levelness Numbers used by Concrete Finishers to the flatness requirements described by Flooring Manufacturers described in ASTM F710 Standard Practice for Preparing Concrete Floors to Receive Resilient Flooring.
  - a. ASTM F710 describes the standard practice for preparing concrete floors receiving resilient flooring, and states that surface of concrete shall be flat to within 4.7 millimetres in 3 metres (3/16 inch in 10 feet) (as described in ACI 117R, or as measured by the method described in Test Method ASTM E1155 or any industry-recognized method specified).
    - i. Although ASTM F710 describes the 4.7 millimetres in 3 metres (3/16 inch in 10 feet) flatness value, it does not detail a method for taking the concrete substrate Flatness measurements that meets Flooring Manufacturers described tolerances.

- ii. Additionally, the reference to ASTM E1155 is not appropriate because it is a measurement used to assess acceptance for structural concrete tolerance, and may not provide the measurement accuracy required to meet Flooring Manufacturer's flatness tolerance required for installation of Floor Coverings.
  - 1. Concrete measured within 3 days of placement in accordance with ASTM E1155 and meets FF/FL is acceptable for work performed by the Concrete Finishing Trades.
  - 2. Additional work should be accounted for in the project costs to meet the flatness requirements described in ASTM F710 and to attain Flooring Manufacturer's installation Flatness tolerance as a component of remedial measures.
  - 3. Additional confirmation of acceptable Flatness tolerances must be performed before scheduling of installation of Flooring Products.

ASTM F710 states Flatness using imperial dimensions 3/16 inch in 10 feet, and incorrectly converts the metric measurement for 3/16" to 3.9 mm. The correct conversion is 3/16" = 0.1875" multiplied by 25.4 = 4.7625 mm.

Practicality of measurement practice and limitations of the measurement devices demonstrates that decimal points or fractions less than about 1 mm (1/32") cannot be reliably measured; meaning that in application of the Straightedge Procedures in this Best Practice, an observation of between 4.0 mm and 5.0 mm will be accepted as being compliant with the ASTM F710 Flatness requirements.

- b. ASTM E1155 describes methodologies for measuring newly placed concrete made within 72 hours (3 days) of placing and finishing, and that are made along defined and repeatable lines of measurement.
  - i. Using the ASTM E1155 recommendation frequently leads to conflict between Concrete Finishers (Division 03) and Floor Covering Installers (Division 09) because ASTM E1155 test methodology is not intended to measure smoothness, irregularities, roughness, or other defects that could negatively impact installation of Flooring Products.
  - ii. Additionally, the ASTM E1155 excludes measurements at perimeters of slabs and across control joints, where deformations are most likely to occur between the time that concrete was placed and finished and when flooring will be installed.
  - iii. ASTM E1486 Standard Test Method for Determining Floor Tolerances using Waviness, Wheel Path and Levelness Criteria is a different form of measurement that is occasionally used and that has similar limitations as the ASTM E1155 when applied to work associated with floor covering installation.

The National Floor Covering Association (NFCA), Floor Covering Reference Manual lists the standards associated with Flatness testing of Substrates (ASTM E1155 and ASTM E1486) and preparation of Substrates (ASTM F710) in Part A03-2 Codes and Consensus Standards.

- c. The American Concrete Institute (ACI) 117.1R Guide for Tolerance Compatibility in Concrete Construction recognizes that common methods used to measure structural concrete Flatness are problematic for many types of finish Flooring Products.
  - i. ACI 117.1R states that Flatness required by Flooring Manufacturers is difficult to achieve by Plastic (Wet) Concrete Finishers unless additional work such as grinding and levelling is performed.
  - ii. ACI 117.1R states that slab defects affecting installation of Flooring Products will increase and Flatness will decrease as concrete ages throughout the construction period.
  - iii. ACI 117.1R identifies that additional work must be described in the project specifications as an allowance or description of the Work Results.
- d. The American Concrete Institute (ACI) 302.1R Guide to Concrete Floor and Slab Construction describes design and construction coordination requirements that are beneficial to achieving conditions that require minimal subsequent preparation needed before the Substrate is turned over to the Floor Covering Installer.
  - i. ACI 302.1R describes methods and materials that can be used to reduce the amount of deformation of concrete substrates between tolerance measurements made at the time of placement and the more stringent surface tolerances that are made many months afterwards required for installation of Flooring Products.

- ii. ACI 302.1R states that the Design Professional should correlate slab design criteria with requirements imposed by specified Flooring Products, and describes choices for methods and materials that the Constructor can use to reduce deformation of concrete slabs-on-grade by incorporating the following:
  - 1. Shrinkage compensating concrete mix designs are available that reduce the amount of curling and warping.
  - 2. Curing plans that account for environmental conditions (wind, temperature, humidity, precipitation) at the time of concrete placement, and that curing is left in place throughout the initial and final curing stages.
  - 3. Adjusting spacing and placing of contraction joints, control joints, or saw-cut joints to minimize the height of curl at the edges of Substrates.
  - 4. Installing additional reinforcing to compensate for the upwards movement associated with slab curling.
- iii. ACI 302.1R describes choices that should be made by the Design Professional to account for Deflection of suspended slabs, and describes choices for methods and materials that the Constructor can use to reduce Deflection of suspended slabs by incorporating the following:
  - 1. Increasing slab thickness; which typically adds 10 millimetres (3/8 inch) or more, and requires coordination with formwork design and the Design Professional.
  - 2. Curing plans that account for environmental conditions (wind, temperature, humidity, precipitation) at the time of concrete placement, and that curing is left in place throughout the initial and final curing stages.
  - 3. Placement of underlayments of similar thickness to additional thickness stated above for increasing slab thickness.
  - 4. Installing additional reinforcing to compensate for the downwards movement associated with Deflection.
  - 5. Delaying removal of formwork and shoring until concrete has cured sufficiently to reduce Deflection resulting from lower concrete strength; which typically adds 2 to 3 days or more before starting construction of the next storey.
  - 6. Accepting that Deflection will not be accounted for within the design, and that Deflection will not allow for placement of a flat and level slab.
- e. The Canadian Standards Association (CSA) A23.1/A23.2 Concrete Materials and Methods of Construction/Test Methods and Standard Practices recognizes that construction tolerances for cast-in-place concrete slabs-on-grade and suspended slabs are measured within the time limits described in ASTM E1155, and only apply to Associated Work performed by Plastic (Wet) Concrete Finishers to confirm that slabs meet structural tolerances.
  - i. CSA A23.1/A23.2 recognizes that curling and warping of slabs occurs because of differential drying shrinkage and temperature variation between the top and bottom of slabs-on-grade, and deformation of suspended slabs will increase after removal of formwork and shoring.
  - ii. CSA A23.1/A23.2 notes that tolerance losses of up to 50% are possible after Flatness measurements are made, and are considered a normal part of drying shrinkage of concrete.
  - iii. CSA A23.1/A23.2 references ACI 117 and ACI 302.1R for coordination of tolerances affecting construction of floor slabs to accommodate subsequently applied Flooring Products.
  - iv. CSA A23.1/A23.2 requires correction of floor Flatness by grinding or as otherwise specified to meet specified tolerances, which includes both structural tolerances and architectural finishing tolerances.
- 2. This Best Practice distinguishes between critical performance attributes by naming applicable consensus standards (ASTM, ACI, CSA) associated with the standard of care established for the trades, and less critical practices that are common to:
  - a. Concrete Finishers described in the Red Seal, Occupational Standard for Concrete Finishers, and identifies Related Work is typically performed by either Plastic (Wet) Concrete Finishers or Hardened (Dry) Concrete Finishers.
  - b. Floor Covering Installers described in the Red Seal, National Occupational Analysis for Floor Covering Installers and the NFCA Floor Covering Reference Manual.

3. This Best Practice describes the additional Substrate preparation required to achieve appropriate concrete Substrate Flatness for installation of Flooring Products and suggests methods for including these costs as a part of the bidding and tendering process, and proposes methods for describing the Related Work in the construction documents prepared by the Design Professional.
  - a. This Best Practice describes procedures that are accepted and prescribed as being correct or most effective for Straightedge visualization relating to acceptable concrete Substrate Flatness Tolerance.
  - b. This Best Practice meets the criteria for ASTM F710 industry-recognized methods because it is based on consensus from the members of the National Floor Covering Association.
  - c. This Best Practice includes recommendations for Design Professionals in preparation of appropriate content within their specifications and drawings describing appropriate division of project Work Results and performance to the various trades contributing to successful Flooring Products outcomes.
4. This Best Practice describes effective straightedge visualization practices that identify differences in Surface Geometry that can affect final installation as follows:
  - a. Excessively high ridges and mounds, roughness and other surface irregularities on the Substrate will telegraph through Flooring Products and cause performance and maintenance issues resulting in premature surface wear that diminishes the service life of the installed Flooring Products.
    - i. Height differentials can cause visual tripping hazards for people with low visual acuity or depth perception, particularly when spacing between high and low points are less than 2 metres (6 foot-6 inches) apart.
    - ii. Height differentials can cause runoff and gapping when installing certain Flooring Products.
      1. This can be a significant issue when installing modular (square or rectangular) Flooring Products larger than 200 mm (8 inches) along an edge, rigid Flooring Products, and when installing Flooring Products having pattern repeats.
      2. Correcting runoff and gapping is difficult or impossible, and can cause unacceptable installation appearance.
  - b. Dead spots can occur when height differentials occur within trafficked areas, resulting in pedestrians experiencing a change in footfall.
    - i. Dead spots occur when the foot sole hits the floor sooner than anticipated when the surface is higher, or misses the floor when a depression is deeper than expected.
    - ii. Dead spots can contribute to tripping hazards and result in fall injuries at geriatric or long-term care facilities, or contribute to injuries for professional and recreational athletes in athletic facilities, schools and universities, hospitals and healthcare facilities, shopping centres, office buildings, other buildings that are accessible to the public, and can include privately owned buildings.
      1. Dead spots change the rebound behavior of balls and gymnastic manoeuvres causing consequential outcomes of the sporting activities through loss of control.
      2. Dead spots can also affect the performance of walking aid devices such as canes and walkers.
    - iii. Low spots can cause pooling of liquids from spills and cleaning maintenance solutions resulting in surfaces that are more slippery than intended for foot traffic or other movement activities.
      1. Accumulation of liquid residues can result in increased risk of slip and fall accidents.
      2. Accumulation of liquid residues can lead to premature aging and decreased appearance retention as subsequent soiling is attracted to the wet or dried-out residue.
  - c. Irregular variations across the Substrate can affect performance of rolling traffic items such as moveable equipment, gurneys and carts, or wheelchairs, and cause unanticipated or unwelcome noise or misdirection of the piece of equipment being moved.

5. This Best Practice recognizes that achieving successful concrete Substrate Flatness is dependent on two different trades that measure surface Flatness based on two distinct performance expectations. The affected trades are seldom sitting in the same room when decisions for acceptable project requirements are being finalized, preventing them from coordinating with each others work.
- a. Plastic (Wet) Concrete Finishers' work is described in Division 03, and is governed by structural tolerances that emphasize reasonable safety and usage criteria based on building loads (dead loads) and applied loads (live loads) without causing excessive deformation or collapse, and that maintains occupant safety. Plastic (Wet) Concrete Finishers use test methods stated in ASTM E1155 as follows:
    - i. Point elevations measured at regular 300 millimetre (12 inches) intervals along defined lines across the test area.
    - ii. Requires only a minimum number of readings to confirm compliance with statistical testing regime, and that is appropriate for concrete work.
    - iii. Measurement lines do not cross construction joints, isolation joints, block-outs, penetrations, and other similar discontinuities, and are not made within 600 millimetres (2 feet) of any slab boundaries.
    - iv. Flatness is measured within 72 hours of concrete placement, and provides acceptance for concrete work only.
    - v. Measurements specifically exclude portions of the slab that are outside of the lines of measurements, contains specific allowances for local variability following the lines of measurement, and does not measure localized surface imperfections that occur at intervals less than 300 mm that affect installation of Flooring Products.
  - b. Floor Covering Installers' work is described in Division 09, and is governed by architectural tolerances that describe appearance and functional criteria based on whether the user of the building can experience the space without injury or impediment to movement, while maintaining occupant safety. Floor Covering Installers use the Straightedge Procedure as follows:
    - i. Continuous measurements, recording any gap under the Straightedge and with an indefinite number of measurements across the test area.
    - ii. There are no minimum number of readings. Measurements are made to confirm acceptable Surface Geometry defined by Flooring Manufacturers, and that affects installation of Flooring Products.
    - iii. Measurements cross construction joints, contraction joints, saw-cut joints, isolation joints, block-outs, penetrations, and other similar discontinuities, and include measurements made within 600 millimetres (2 feet) of any slab boundaries.
    - iv. Flatness is measured immediately before installation of Flooring Products, which can be from 4 months to 18 months or more after concrete placement. Floor Flatness changes with time and the initial measurements made by the Plastic (Wet) Concrete Finisher do not predict acceptable Flatness when Flooring Products are installed.
  - c. Successful coordination for the Associated Work of Floor Covering Installers (Division 09) and the Related Work of Concrete Finishers requires:
    - i. Involvement of these trades facilitated by the Constructor during early project start-up meetings and pre-construction meetings.
    - ii. Project specifications prepared by the Design Professional that recognize the different tolerances required by these trades and provides content describing substrate preparation.
    - iii. Owner engagement in decisions that will benefit them by successfully implementing processes that will meet their stated project requirements.

The NFCA website includes a guide specification describing interior floor finishing performance requirements that can aid the Design Professional and Constructor in preparing their respective construction documentation or scopes-of-work statements, and is located at <https://www.nfca.ca/education-calendar/concrete-specification/>.

## A21-2 Scope of the Best Practice

Floor Covering Installers already use a commonly accepted method for making Straightedge measurements that provides satisfactory visualization of concrete Flatness Tolerance consistent with Flooring Manufacturers' installation tolerances. This Best Practice formalizes the Straightedge Procedure so that it becomes an "industry-recognized method" required by ASTM F710 and other related standards and guidelines that may be specified.

The NFCA Floor Covering Reference Manual describes acceptable concrete Flatness Tolerance in Part A10-4 Concrete Substrates and acceptable concrete substrates in Part A10-6 Concrete Substrates.

1. Plastic (Wet) Concrete Finishers use ASTM E1155 and ASTM E1486 to evaluate structural concrete Flatness and are required to meet these measurement standards to meet their specified level of performance; however, the associations that govern the content of these standards state these standards do not provide appropriate guidance for determining acceptable concrete Flatness for installation of Flooring Products.
  - a. ACI 117.1R and the American Society of Concrete Contractors (ASCC PS-6) Position Statement, Division 03 versus Division 09 Floor Flatness Tolerances recognize the need for a defined Best Practice for a Straightedge Procedure for concrete floors receiving Flooring Products.
  - b. Measurements made by Plastic (Wet) Concrete Finishers provide a basis for accepting concrete work at the time that concrete is placed, and does not provide assurance of acceptable Flatness at the time flooring materials are being installed.
  - c. ASTM F710 references ACI 302.1R and suggests that remedial measures for slabs-on-grade might include grinding, planing, surface repair, re-topping, or removal and replacement, and that remediation for suspended slabs is limited to grinding or use of an underlayment or topping material.
  - d. ACI 302.1R also states that contract documents should clearly identify acceptable corrective methods for remedial solutions, and ASCC PS-6 recommends inclusion of a cash allowance where the extent of remedial solutions cannot be accurately determined.

The NFCA Floor Covering Reference Manual describes the Constructor's responsibilities for providing acceptable floor surfaces in the General Requirements described in Part A10, Part A12 and Part A13, which describe Acceptable Conditions, Substrate Preparation, and Patching and Filling Procedures.

2. This Best Practice incorporates the recommendations of ASCC PS-6 by defining the allowable gap under an unlevelled Straightedge that is continuous at any point under the Straightedge, and allows for indefinite numbers of locations on the floor with no maximum or minimum number of readings, includes measurements crossing construction joints, column block-outs and near penetrations, and that are performed before the Floor Covering Installer is called to site.
3. This Best Practice accounts for Flooring Manufacturers' stated tolerances and includes direction for all Project Participants as follows:
  - a. Provides Design Professionals with information they can include in their specifications to reduce potential conflicts between different trades during construction.
  - b. Provides the Constructor with clear and direct language that describes measurement practices commonly used by Floor Covering Installers and that is acceptable to Flooring Manufacturers.
  - c. Provides Floor Covering Installers with an agreed upon Best Practice that is easy to coordinate with Flooring Manufacturers' Flatness Tolerances.
  - d. Provides Plastic (Wet) Concrete Finishers with a Best Practice that does not conflict with their structural concrete performance expectations.
  - e. Provides the Owner with confidence that a Best Practice can help them achieve their stated project requirements and that they are obtaining value for their investment.

4. This Best Practice recommends that measurements should be prepared by a qualified third-party inspection or surveying agency engaged by the Constructor before the Floor Covering Installer is scheduled to arrive on the construction site.

The NFCA Floor Covering Reference Manual describes the Constructor's responsibilities for testing in the General Requirements described in Part A11 Substrate Testing. Providing an acceptable floor surface that is ready for the installation of Floor Products is the responsibility of the Constructor. Measurement and correction of Surface Geometry forms a part of the responsibilities for providing an acceptable floor surface.

- a. The Constructor should correct out-of-tolerance Flatness before scheduling Floor Covering Installers to the construction site, and re-surveys the Substrate to confirm that remedial measures and corrective actions attain Flatness Tolerances required by Flooring Manufacturers.
- b. The Floor Covering Installer reviews Constructors survey records and corrective actions and verifies that floor surface is acceptable for installation of specified Flooring Products. The Floor Covering Installer will notify the Constructor in writing of any conditions that are detrimental to installation of Flooring Products, and will require additional remedial measures (if any).
- c. Survey results should be witnessed by the Constructor, the Design Professional, and the Owner to build a consensus of acceptable Substrate conditions:
  - i. Experienced Plastic (Wet) Concrete Finishers can place and finish concrete to meet a high degree of Flatness that may meet Flatness Tolerance with minimal remedial measures; provided that concrete is:
    1. Cured under controlled conditions;
    2. Maintained under controlled heat and humidity;
    3. Protected from weather; and
    4. Construction loads are not applied before it reaches design strength.
  - ii. Remedial measures by the Constructor to correct Substrates can be addressed using cash allowances specific to acceptable corrective methods to achieve acceptable Flatness Tolerances. Cash allowances should not be used to repair defective or deficient concrete work that is out-of-tolerance.
- d. The Owner should be the entity accepting the final Substrate condition after consideration of recommendations by the Design Professional, the Floor Covering Installer, and the Constructor.
  - i. Owner may not understand the need to control and correct Flatness Tolerances, but they must be informed because they are paying for the Work associated with cash allowance expenditures.
  - ii. Costs associated with controlling and correcting Flatness Tolerances can be substantial if Associated Work and Related Work are not clearly communicated by the Design Professional, or included in the price of construction by the Constructor.

## A21-3 Definitions

Definitions are provided to avoid misunderstanding of descriptions of Associated Work for trades involved with achieving concrete Flatness, and clarifies procedures that may use similar words as those used in Related Work described in this Best Practice. The following definitions provide the word or phrase being defined, the concept of the term, and any differentiating characteristics that distinguish it from similar terms that may be used by the different trades involved in the Work.

**The Work:** The Work applies to the total construction and related services required to complete construction, is described by the contract between the Constructor and the Trades, and is consistent with the specifications and drawings prepared by the Design Professional:

- **Associated Work:** In the case of this Best Practice, Associated Work includes generic descriptions of the finishes, Work Results and specified requirements associated with performance of the Floor Covering Installer.

- **Related Work:** In the case of this Best Practice, Related Work includes descriptions related to, or that are dependent on the finishes, Work Results and specified requirements associated with the performance of the Concrete Finisher or the Constructor.
- **Work Results:** In the case of this Best Practice, Work Results are the permanent or temporary aspects of construction that are achieved by the application of skills associated with the trades performing the Work as described in the specifications.

**Surface Geometry (NFCA):** Surface geometry describes the acceptable characteristics of a concrete or other Substrate, and includes properties that describe overall Flatness, levelness and smoothness, and other surface irregularities that have potential to telegraph through and affect performance of installed Flooring Products:

- **Datum:** A datum is a theoretical exact plane, axis (line), or point location that dimensional tolerances are referenced to, and that will be used to assess Straightedge Procedure and determination of acceptable concrete or other Substrate Flatness.
- **Deflection:** The displacement or deformation of a material from its original position due to the effects of an applied load. The concept is similar to a trampoline's surface that deforms due to the weight of the fabric (dead load) or increases (live load) when someone stands on or jumps on it. For example:
  - Dead loads in a hospital project could include the weight of the concrete floor slab, wall assemblies installed on top of the floor slab, and non-moveable fixtures such as permanent casework.
  - Live loads in a hospital could include people walking on the concrete floor slab, gurneys and supplies rolling over the floor, and other non-permanent loads such as moveable furniture.
- **Deviation:** The gap space between the underside of the Straightedge and the top of the Substrate for new installations, or from the top of Flooring Products for existing installations.
- **Dimensional Tolerance:** This refers to the defined length or distance that Flatness deviations must be evaluated within, typically in defined increments between 1.8 metres (6 foot) to 3 metres (10 foot).
- **Flatness (Surface Flatness):** Refers to how uniformly flat a Substrate surface is in relation to any undulations, waviness, or bumpiness in comparison to an agreed upon Datum that represents a straight line or flat plane, and that is also smooth and free from roughness or other defects that could telegraph through installed Flooring Products.
  - Flatness describes an ideal Substrate that is considered to be flat and smooth, without any changes in level that affects Flatness, and that does not contain any irregularities, roughness or other defects that affect installation of Flooring Products.
  - The Design Professional is responsible for correctly specifying Flatness required by the project based on the material used and the occupancy type.
    - Flatness is partially based on Flooring Manufacturers' stated Flatness Tolerance and ranges from a minimum of 4.7 millimetres in 3 metres (3/16 inch in 10 feet) for products such as Luxury Vinyl Plank and as much as 6 millimetres in 3 metres (1/4 inch in 10 feet) for Broadloom Carpet (Roll Carpet or Sheet Carpet), and must be coordinated with the maximum overall Flatness Tolerance described by ASTM F710.
    - Flatness is also based on Owners stated Flatness Tolerance and ranges from 3 millimetres in 3 metres (1/8 inch in 10 feet) such as hospitals and television studios to 8 millimetres in 3 metres (5/16 inch in 10 feet) for some commercial and industrial facilities.
    - The degree of Flatness can be further described using ASTM E1155  $F_F/F_L$  Numbers describing a 3 mm straightedge gap measurement as  $F_F35/F_L20$  for a standard Flatness office occupancy,  $F_F50/F_L35$  for a super flat hospital operating room occupancy,  $F_F100/F_L75$  for a television studio, or  $F_F200/F_L150$  for a high lift warehouse.
  - ASTM F710 describes 4.7 mm in 3 m (3/16" in 10') Flatness and is specific to resilient flooring, but recognizes that the standard practice for preparing concrete floors can be applied to other types of floor finishes. Manufacturers of other floor finishes can have different Flatness requirements than described in ASTM F710, and that must be coordinated with the project documents and appropriately communicated to the Constructor, Hardened (Dry) Concrete Finisher and Floor Covering Installer.

**Flatness Tolerance:** The Flatness Tolerance references the Straightedge which is placed parallel to the Substrate surface and provides the maximum deviation (gap space) that is acceptable between the Straightedge and Substrate where Flooring Products are being installed or measured, and that include the following critical dimensions described in ASTM F710:

- Maximum overall Flatness Tolerance for concrete floors shall be no greater than 4.7 millimetres in 3 metres (3/16 inch in 10 feet). Maximum overall Flatness Tolerance for the project may be less than described in ASTM F710 based on the materials used and occupancy type.



- Maximum local deviation from Flatness Tolerance shall be no greater than 0.8 millimetres in 305 millimetres (1/32 inch in 12 inches).
- Flatness Tolerance is achieved by preparing concrete Substrates to align with the difference between the measured Flatness required by ASTM E1155 performed within 3 days of concrete placement and wet concrete Finishing, and the starting measured Flatness required by ASTM F710 before scheduling installation of any Flooring Products.
- Achieving the hardened concrete Flatness Tolerance may involve an experienced Hardened (Dry) Concrete Finisher that has equipment for grinding and filling concrete Substrates, but could also include a Floor Covering Installer that has similar equipment and experience.

**Levelness (Level):** Absence of deviation from a theoretical horizontal plane, with the horizontal plane having no tilt or slope, and can be compared to a datum established by a line parallel to the horizon similar to a tabletop or the surface of calm water in a lake or swimming pool.

- Levelness is a measurement of the tilt or slope of the Substrate, and seldom forms a part of the evaluation of acceptable concrete Substrates for installation of Flooring Products, except where slopes affect concrete Flatness Tolerances.
- Most concrete Substrates that have intentional tilt or slope and meet the specified Flatness Tolerances are acceptable.
- Concrete Substrates that have tilt or slope that affects installation of Flooring Products must be corrected before installation of Flooring Products.

**Smoothness:** Refers to texture of the Substrate surface, having an even and regular surface or consistency without projections, bumps, indentations, or other irregularities, and is free of defects in the surface that could telegraph through or affect the bond, performance, or appearance of specified Flooring Products.

**Straightedge:** A rigid and flat, lightweight metal rectangular bar of fixed length that ranges from 1.8 metres (6 foot) to 2.4 metres (8 foot) to 3 metres (10 foot), and that is designed for measuring Flatness of Substrates prior to installation of new Flooring Products or measuring Flatness of existing installed Flooring Products, using a height (ruler) or angular gauge (graduated tapered wedge) to measure gaps under the Straightedge.

**Flooring Products (Flooring, Floor Covering or Floorcovering):** The words flooring, floor covering, and floorcovering are used interchangeably in this Best Practice to describe various Flooring Products and apply generically to any finish material applied over a floor Substrate that provides a finished walking surface.

Floor covering types influenced by this Best Practice include resilient and static control flooring, broadloom carpet, carpet tile flooring, hardwood flooring, laminate flooring, bamboo flooring and cork flooring described in the NFCA Floor Covering Reference Manual, Part A16-2 Specification Guides.

Additional floor covering types that are also influenced by this Best Practice includes resinous coatings, liquid applied flooring, tile and stone flooring, and other applied floor finishes such as mechanically polished concrete or terrazzo flooring, which are governed by their own trade associations.

**Substrate Preparation:** Substrate Preparation is described in the NFCA Floor Covering Reference Manual, Part A12 – Substrate Preparation. Manufacturers’ product literature and installation instructions should be closely coordinated with the Design Professionals’ specifications to establish appropriate quality of products and determine execution requirements necessary for the Work of individual projects.

- **Skim Coating:** The process of trowelling a cementitious material over a Substrate creating a smooth and adherable surface that Flooring Products can properly bond to.
  - Skim Coating materials form a thin layer that follows the Substrate Surface Geometry without flattening or levelling the floor surface.
  - Skim Coating materials typically have an unsanded composition and usually applied from a feather edge (0 mm/0 inch) profile to a thickness of about 1 millimetre (1/32 inch) to smooth the Substrate receiving Flooring Products.
  - Skim Coating materials are applied after Floor Covering Installer verifies that Substrates are compliant with Flooring Manufacturer’s requirements.
  - Skim Coating materials are supplied and installed by the Floor Covering Installer.

- **Self-Levelling Underlayments:** Flowable hydraulic cement material designed for use in smoothing, flattening, and levelling horizontal substrates in preparation for installation of Flooring Products.
  - Self-Levelling Underlayments are typically installed at a minimum thickness of 3 millimetres (1/8 inch) over the highest point in the floor surface, and typically results in an average thickness of 6 millimetres (1/4 inch) or more over the entire floor area.
  - Some Self-Levelling Underlayments have high flow characteristics and can be installed at a minimum thickness of 1.5 millimetres (1/16 inch) over the highest point in the floor surface, and typically results in an average thickness of 3 millimetres (1/8 inch).
  - Self-Levelling Underlayments can be tapered to meet floor elevation, can also be applied to a feathered edge, and are typically applied flush to perimeter enclosing walls.
  - Self-Levelling Underlayments do not form a part of the Associated Work of the Floor Covering Installer, and are typically supplied and installed by the Hardened (Dry) Concrete Finisher.
    - Floor Covering Installers that have appropriate equipment and experienced workers may be asked to include for Self-Levelling Underlayments as an additional cost to The Work when specifically requested by the Constructor.
    - Self-Levelling Underlayments must be specified as a defined Work Result with costs for supply and installation included as a component of the bid price from the Hardened (Dry) Concrete Finisher or Floor Covering Installer, or a cash allowance managed by the Constructor.
    - Self-Levelling Underlayments do not form a part of The Work when they are not described in the Design Professional's project documents.
- **Patching:** The process of trowelling cementitious material to an area of the Substrate to fill or smooth minor depressions, irregularities, and deficient Surface Geometry before installation of Flooring Products.
  - Patching materials do not level the Substrate and may require Skim Coating materials to smooth the surface before installation of Flooring Products.
  - Patching materials can be tapered to the minimum thickness of the aggregate filler in the product, and can be built-up to thicknesses of 25 millimetres (1 inch) or more.
  - Patching materials that apply to whole floor areas do not form a part of the Associated Work of the Floor Covering Installer, and are typically supplied and installed by the Hardened (Dry) Concrete Finisher.
    - Floor Covering Installer includes supply and installation of Patching materials for minor surface corrections forming a part of their Associated Work concurrent with application of Skim Coating described above.
    - Hardened (Dry) Concrete Finisher includes patching when remedial measures are required and forms a part of Related Work described in ASTM F710.
      - Patching for remedial measures must be specified as a defined Work Result with costs for supply and installation included as a component of the bid price from the Hardened (Dry) Concrete Finisher, or a cash allowance managed by the Constructor.
      - Patching for remedial measures do not form a part of The Work when they are not described in the Design Professionals project documents.

Terminology associated with Patching materials can cause confusion between the two Trades involved with this work when responsibilities for their individual work is not clearly delineated.

Patching over entire floor areas to address height deviations greater than 4.7 millimetres in 3 metres (3/16 inch in 10 feet) is typically performed within the Hardened (Dry) Concrete Finisher's Related Work, and includes correction to abrupt height variations over shorter lengths of any height. Floor levelling can also be completed by the Hardened (Dry) Concrete Finisher using Patching materials to fill low-laying areas (birdbaths) followed by grinding to make the Substrate smooth and even to the surrounding surfaces.

Minor patching performed by the Floor Covering Installer is limited to small areas of correction such as shallow recesses, chips or holes that are 4.7 millimetres or less in depth, and that can typically be trowelled into the surface as a part of the Skim Coating process described above. Minor patching does not include correction to deviations greater than 4.7 millimetres nor any corrections to abrupt elevation changes of any height within the area that Flooring Products are being installed.

- **Concrete Toppings:** Cementitious toppings applied in thicknesses from about 40 mm (1½ inches) and greater using traditional concrete placement methods. Concrete Toppings may be bonded or unbonded to the Substrate and in some applications used to repair or strengthen deficient Surface Geometry and Substrate conditions.
  - Concrete Toppings can be used to smooth surfaces and make Substrates flat and level.
  - Concrete Toppings may require Skim Coating materials as described above.
  - Concrete Toppings are formulated to repair existing concrete surfaces and may provide ultra-flat Surface Geometry when required by the project specification.

- Concrete Toppings are supplied and installed by the Hardened (Dry) Concrete Finisher when specified as a defined Work Result.

The NFCA Floor Covering Reference Manual, A12 Substrate Preparation and A13 Patching and Filling describe detailed procedures for use of these materials, and Part A Appendices provides specification guides for hydraulic cement underlayment (AA1-03 54 15) and gypsum underlayment (AA2-03 54 12).

**The Floor:** The surface of a room or area that typically consists of a structural supporting layer in the form of a subfloor or Substrate that supports application of Flooring Products, and that must be safe for building occupants and support design loads in accordance with Building Codes:

- **Substrate:** Based on ASTM F141, the Substrate is the underlying support surface upon which Flooring Products are installed, that must also be rigid and structurally sound, and meet the Flooring Manufacturer’s suitability requirements for installation of their Flooring Products.
- **Subfloor:** Based on ASTM F141, the subfloor is the structural layer that provides support for design loading based on building occupancy and usage, and that can have Flooring Products directly applied to the surface or indirectly applied on top of an underlayment where the surface of the subfloor is not suitable for installation of Flooring Products.
  - A Substrate may refer to the subfloor with another material layer or layers applied over it before installation of Flooring Products.
  - An underlayment is a material layer that is installed between the subfloor and underneath the Flooring Products.
  - Flooring or Floor may also refer to the bare subfloor; a subfloor with an underlayment or the Flooring Products.
  - Floorcoverings refers only to the final finished material layer that is applied directly over the subfloor or Substrate.

**Project Participants:** The people who contribute to the Work Results associated with achieving acceptable concrete Substrate Flatness, and that can include the following:

The NFCA Floor Covering Reference Manual includes recommendations for construction sequencing and coordination of Project Participants in Part A Appendices, AA5 Construction Sequence and Trade Coordination.

- **Owner:** The Owner is the entity defined by the contract, who establishes the performance of The Work and engages with a Design Professional for preparation of the project documents that define The Work, and forms an agreement with a Constructor for delivery of The Work.
- **Design Professional:** The Registered Architect, Professional Engineer or Licensed Interior Designer who is responsible for describing the Owner’s project performance requirements in the project documents (the specifications, schedules, and drawings) associated with The Work.
- **Constructor:** The General Contractor, Design-Builder or Construction Manager described within the various forms of contract selected by the Owner, and who has general control over the means and methods of construction associated with delivery of The Work.
- **Concrete Finishers:** The Concrete Finisher is responsible for placing and finishing concrete to meet specific performance requirements identified in the project documents. Specialization within this trade is common, and this Best Practice recognizes that different trades may be responsible for the following contributions to Acceptable Concrete Substrate Flatness:
  - Plastic (Wet) Concrete Finishers: Concrete Finishers that specialize in placing, finishing, curing and protection of concrete delivered to the construction site, as described in the Red Seal, Occupational Standard for Concrete Finishers.
  - Hardened (Dry) Concrete Finishers: Concrete Finishers that specialize in application of toppings and underlayments, surface grinding and repairing of cured concrete, as described in the Red Seal, Occupational Standard for Concrete Finishers.
  - Specialized Concrete Finishers: Concrete Finishers that specialize in a variety of other common concrete finishes that includes mechanically polished surfaces, application of resinous coatings, textured and stamped concrete surfaces, as well as coloured and stained finishes as described in the Red Seal, Occupational Standard for Concrete Finishers.

- **Floor Covering Installers:** The Floor Covering Installer is responsible for minor surface preparation to an acceptable concrete Substrate, is commonly certified in the installation of a variety of Flooring Products described above, and is recognized as Trade Qualified or Product Qualified when they have successfully completed any NFCA recognized installation training program.

Qualifications and certifications for Floor Covering Installers are described in the NFCA Floor Covering Reference Manual, Part A05-1 Qualification of Installers, which also recognizes specialty product qualified programs provided by Flooring Manufacturers.

- **Flooring Manufacturer:** Flooring Manufacturers produce Flooring Products that include the diverse types of Flooring Products and accessories described in the NFCA Floor Covering Reference Manual, and includes floor preparation materials, hydraulic cement underlayment products, adhesives, tools, and maintenance materials.
  - Flooring Manufacturers also provide installation instructions that establish Flatness Tolerances, installation environmental conditions, surface preparation and moisture limitations, as well as compatibility requirements that are essential to the successful installation and longevity of Flooring Products.

## A21-4 Measuring Substrate Flatness using a Straightedge

1. This Best Practice describes the NFCA accepted procedure for measuring Substrate Flatness using a straightedge (Straightedge Procedure) used to determine overall Substrate Flatness acceptable to Flooring Manufacturers. Project Participants can use this procedure to evaluate the quality of the Surface Geometry, and determine whether a concrete substrate is acceptable for installation of Flooring Products, or whether any remediation is required before installation begins.
  - a. The Straightedge Procedure shows conditions that can affect installation of Flooring Products, and that may affect final use of the spaces being finished. Some of these problematic conditions could include:
    - i. Substrates that are Level but Not Flat, or that are Flat but not Level.
    - ii. Substrates that are Flat but Not Smooth, or that are Smooth but Not Flat.
    - iii. Substrates that are Level but Not Smooth, or that are Smooth but Not Level.
    - iv. Substrates that have Multiple, Short, Bumpy Surfaces, or that contain a Long Extended Bump or that are generally Flat and then have a sharp or abrupt Declination.
  - b. The Straightedge Procedure provides identification of areas that cannot be corrected with the use of Skim Coat materials typically used by Floor Covering Installers.
  - c. The Straightedge Procedure is easy to perform, and efficiently identifies areas that may pose a concern for installation of Flooring Products.
  - d. The Straightedge measurement can also be compared to a similar existing Substrate that had a satisfactory installation result, in the case of disagreement about acceptability of the Substrate being evaluated.
2. Straightedge measurements form the basis for most surface Flatness tests regardless of the building component, and can also be used to determine changes in surface levels (tilt). The National Floor Covering Association strongly discourages measurement procedures that do not consider The Floor conditions required by the Flooring Manufacturer.

The NFCA Floor Covering Reference Manual describes some of the aspects associated with other forms of Flatness measurements in Part A Appendices, AA4 Floor Flatness and Levelness.

3. The National Floor Covering Association recommends using the Straightedge methodology described below, but recognizes that other methods can demonstrate acceptability of concrete substrate surfaces depending on intended usage of the floor area, size, and complexity of the project, as well as the types of Flooring Products being installed.
  - a. **Straightedge Measurements for New Floors:** Measurements are made using an unlevelled 1.8 metre (6 foot), 2.4 metre (8 foot) or 3 metre (10 foot) long Straightedge to visualize the amount of unevenness of the Substrate and determine whether there are any imperfections that negatively affect long-term performance of Flooring Products:
    - i. Length of Straightedge is determined by size of space being measured. A longer Straightedge may not be usable within smaller areas or within areas that have potential to damage or break adjacent finishes and equipment.
    - ii. Gap is measured under the Straightedge or at the tip where the Straightedge rests across a mound or ridge, using a height gauge or angular gauge to measure the gap under the Straightedge.
      1. The Straightedge is placed and repositioned, or slid continuously across the floor to make as many measurement readings as necessary to confirm acceptability of Flatness conditions.
        - a. Both methods of placing and repositioning, or sliding the Straightedge can be used as appropriate to the floor area being measured.
        - b. Placing and repositioning of the Straightedge is preferred over sliding of the Straightedge to prevent abnormal wear of the tool, or where sliding the Straightedge has the potential to scratch or damage exposed Substrates.
        - c. Wear along the Straightedge could result in errors showing an acceptable gap measurement. The Straightedge should be replaced when wear becomes excessive.
      2. Measurements will cross construction joints, contraction joints, saw-cut joints, isolation joints, block-outs, penetrations, and other similar discontinuities, and include measurements made within 600 millimetres (2 feet) of any slab boundaries.
      3. The Straightedge must be free-resting and placed in a stable position with no pressure applied, and without teetering over high points.
        - a. Adjust placement of the Straightedge when placement occurs over the centre of only one high point to equally distribute the Straightedge to span two points of contact and establish a stable position.
        - b. Measurements that occur when half of the Straightedge is self-resting on the Substrate while the other half remains suspended will be based on the total deviation over the length of the Straightedge.
      4. Gap measurement is based on the specified Flooring Manufacturers' product requirements, typically ranging between 3 millimetres in 3 metres (1/8 inch in 10 feet) and 8 millimetres in 3 metres (5/16 inch in 10 feet) depending on Flooring Manufacturers' stated tolerances.
        - a. Gap measurement range is reduced to 2.5 mm to 6 mm (3/32" to 1/4") when using a 2.4 m long Straightedge.
        - b. Gap measurement range is reduced to 2 mm to 5 mm (5/64" to 3/16") when using a 1.8 m long Straightedge.
      5. The height gauge or angular gauge is graduated in increments of 1 millimetre (1/32 inch) over the first 25 millimetres (1 inch) of the gauge being used.
      6. Measurement is made on the maximum gap observed, no matter how many undulations there are under the Straightedge. The accuracy of the deviations being measured is approximately 1 millimetre (1/32 inch) per reading.
      7. Finding one deficient measurement within a measurement area being evaluated is sufficient for establishing an unacceptable tolerance within that area.

8. Once one measurement area of the floor area is evaluated and accepted or rejected, the Straightedge is then moved to the next measurement area for evaluation until the entire floor area has been assessed.
- iii. The Straightedge provides visualization of high and low points, and identifies local deviations that may affect installation of Flooring Products across the entire floor area.
    1. Length of the straightedge is not critical to visualization, the length will vary depending on Flooring Manufacturers' stated methodology, or the size of the floor area being measured.
      - a. It may not be practical to measure a small floor area, or a floor area encumbered by furniture or equipment with a longer straightedge.
      - b. Some manufacturers will adjust the length of the straightedge measurements based on the modular size of the Floor Products they fabricate.
    2. Floor area should be free from equipment, piles of materials, furniture and other objects that interfere with the ability to conduct the Straightedge Procedure.
    3. There is no limit to the number of Flatness measurements performed. The goal of the Straightedge Procedure is to find deviations that exceed Flooring Manufacturers' stated Flatness Tolerances.
    4. The intent of the Straightedge Procedure is to actively identify areas that will affect installation of Flooring Products, and not simply perform a limited number of measurements to simply pass the test.
  - b. **Straightedge Measurements for Existing Floors:** Measurements are made similarly to new floors as described above, except that they are commonly made using an unlevelled 1.8 metre (6 foot) long Straightedge to accommodate limited space and accidental damage or breakage of adjacent finishes and equipment.
    - i. Measurements are made from the surface of Finishing Products rather than from the Substrate.
    - ii. Measurements are made by placing and repositioning the Straightedge to prevent scratching of existing Flooring Products that may be susceptible to damage, or by sliding straightedge along existing durable Flooring Products.
    - iii. Measurements are unlimited within each measurement area in open areas only. The Owner is responsible for moving furniture and equipment, and other objects out of the measurement area to accommodate the Straightedge Procedure, the third-party inspection agency engaged by the Constructor will not move these items, but will note the estimated percentage of area that was obstructed in the flatness report.
    - iv. Measurements are affected by installation conditions of existing Flooring Products:
      1. Non-rigid, direct-glued resilient Flooring Products will telegraph the actual undulations and deviations of the Substrates to the surface of installed Flooring Products.
      2. Rigid-direct-glued, or nailed-glued-assisted plank-like Flooring Products such as engineered hardwood may reduce the amount of measured undulations and deviations of Substrates because they will rest on the upper portions of undulations, and may only be observable as movement or noise when walking across installed Flooring Products.
      3. Floating or loose-laid Flooring Products installed over compressible underlayments may reduce the amount of measured undulations and deviations of Substrates by masking the deformation within the cushioning material.

## A21-5 Other Technologies – Alternatives to Straightedge Visualization

Larger floor areas may make the Straightedge Procedure inefficient such as when measuring high tolerance Substrates at healthcare facilities and athletic facilities where alternative methods may become more useful.

1. The goal of any alternative to the Straightedge Procedure is that it assesses the overall quality of the Surface Geometry and allows for localized confirmation that Flatness Tolerances have been met. Some alternative methods that have been used successfully are as follows:
  - a. **Stringline and Plumb Bob:** Stringline is suspended over the Substrate, and moved across the measurement area in 1.0 metre (3 foot) or 1.2 metres (4 foot) increments.
    - i. The stringline is set at a fixed Datum point above the Floor and the plumb bob is used to measure the distance between the Floor and the stringline to identify variations in the Surface Geometry.
    - ii. The stringline must account for Deflection of suspended Floors which is considered a normal consequence of construction and does not form a part of the evaluation of acceptable Substrates for installation of Flooring Products.
  - b. **Laser Level and Rod:** Can be used similarly to the stringline and plumb bob, and allows for placement of the surveying rod off a pre-determined grid to more easily identify localized Flatness irregularities that do not meet Flooring Manufacturers' required Flatness Tolerance.
  - c. **Total Station and Receiver:** Can be used similarly to the stringline and plumb bob, and as with the laser level and rod can be used to identify localized Flatness irregularities, but offers the advantage of storing data using a receiver on the rod ready for download and analysis off site.
  - d. **Laser Scanner:** Laser scanners are high precision instruments that survey thousands of points independent of a grid that can accurately map the Substrate and provide a visual reference of Surface Geometry of the entire floor area, based on pre-established fixed Datum points such as a column or elevator shaft that support concrete floors.
2. Results from straightedge and alternative visualization methods can be displayed in a number of ways to identify areas that need correction by grinding, filling or a combination of grinding and filling as follows:
  - a. Results from grid measurements can be represented as chalk marks drawn on the Substrate highlighting the extent of high points that require correction by the Constructor.
  - b. Results from grid measurements can be presented as a floor plan indicating a grid of 2-dimensional plus (+) and minus (-) data-point measurements highlighting areas of concern that require correction by the Constructor.
  - c. Results from grid measurements can be entered into a software program that translates the 2-dimensional data into a 3-dimensional topographical map showing contour lines that present a visual aid showing areas of concern that require correction by the Constructor.
  - d. Results from a laser scanner collect data in the form of a point-cloud that can present information in a variety of outputs that includes the 2-dimensional data-points, 3-dimensional topographical map or as a 3-dimensional heat map that identifies areas of concern that require correction by the Constructor.
3. Regardless of the choice of straightedge or one of the described alternative methods to visualize concrete Substrate Flatness Tolerance, the procedure must follow the same Best Practice guidance as demonstrated by the Straightedge Measurement Procedure, and be acceptable to the Floor Covering Installer.

## A21-6 Conclusion

The approach to measuring tolerances used by Plastic (Wet) Concrete Finishers and Floor Covering Installers are different and are designed to achieve distinct outcomes to determine acceptable construction. Using the measurement tests or methods for one trade and applying to the other is misleading and may cause disputes.

The NFCA website includes a guide specification describing interior floor finishing performance requirements that can aid the Design Professional and Constructor in preparing their respective construction documentation or scopes-of-work statements, and is located at <https://www.nfca.ca/education-calendar/concrete-specification/>.

1. To avoid any misunderstandings of tolerance requirements, the Design Professional, the Constructor, the Concrete Finisher, and the Floor Covering Installer should establish a clear protocol for coordination of measurements and acceptance of Substrate features being measured. This is particularly important when multiple tolerances exist for the same measured features. For example:
  - a. The method used to measure and accept the Plastic (Wet) Concrete Finisher's Related Work is different than the method used to measure the Floor Covering Installer's Associated Work.
  - b. Both methods are legitimate and clearly define the level of acceptance for the different trades involved with the Work.
  - c. The extent of Work required to address the difference between trade tolerances cannot be accurately predicted and could range from minimal additional work to extensive rework depending on how well the concrete Substrate was cured and protected during construction.
2. Due to the uncertainty of the amount of corrective work required to address the differences in trade tolerances, both ACI 117.1R and ASCC PS#6 recommends providing a cash allowance for control and correction of Flatness Tolerances.
3. The Design Professional must clearly identify the potential for addressing tolerance issues in the specifications and identify methods to address compatibility of Flatness Tolerances and align the different Work described in Concrete Work (Division 03) and Flooring Work (Division 09).
4. The Constructor should anticipate that remedial measures may be required to achieve an acceptable Flatness Tolerance and coordinate the different trades involved with this Work.
  - a. Remedial measures should be tendered or bid as an identifiable component of The Work.
    - i. Remedial measures are described in ASTM F710, Paragraph X1.7.5 and suggests methods that can be used to perform corrections to Surface Geometry.
    - ii. ASTM F710 also states that acceptable corrective methods must be clearly identified in the Design Professionals' project documents.
  - b. Trades should have experience and equipment to perform remedial measures for maintaining Flatness.
  - c. Remedial measures may be performed by any of the following:
    - i. A Hardened (Dry) Concrete Finisher.
    - ii. Either the Hardened (Dry) Concrete Finisher or Floor Covering Installer (Already Retained for the Work).
    - iii. The Constructor (Self-Performed).

Differences should not be a challenge when they are recognized as a necessary component of the construction process to distinguish individual contributions from trades contributing to the Work. Disputes may arise when Project Participants focus too much on making decisions based on familiarity with one part of the Work, while discounting the characteristics of a different part of the Work. Allowing opportunities for all Project Participants to ask questions and reference their conceptions of each component of the Work leads to better coordination, and leads to a better understanding of project complexity, which can foster stronger relationships between Project Participants and should lower the risk of disputes and cost escalation.



## A21-7 WAIVER OF LIABILITY

The National Flooring Covering Association assumes no responsibility and accepts no liability for any disputes, errors, corrective work, or repairs arising from the use of the document published by NFCA, entitled **Best Practice for Measuring Substrate Flatness for Floor Covering Installations**. These guidelines and methods describing the execution of a 10' (8' or 6') straightedge flatness test have been developed by the NFCA Straightedge Committee, together with leading industry authorities, through review of longstanding installation principles and practices, along with research and data regarding the provision of acceptably flat subfloors and or substrates. These guidelines and methods address a variety of methods for determining acceptable flatness related to the installation of floorcoverings but are not intended to address issues arising to or from these guidelines. Individual construction contracts may and can affect the application of these guidelines. They are not enforceable standards in any other way than by individual project specifications. This document is offered no charge, the user assumes all responsibility for any disputes resulting from following the provided information.

The principles and practices described in this publication are not universal requirements and may change. The recommendations in these guidelines and methods are directed at the North American market in general, and therefore may not reflect the most-accepted industry practices in other geographic areas. Some test methods and materials may not be suitable in some geographic areas because of local trade practices, or construction methods. All subfloor and substrate surfaces must remain in compliance with local building codes, ordinances, and trade practices when applying these guidelines.

In addition, manufacturers' recommendations for floor flatness of specific products should always supersede the recommendations contained in these guidelines.

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