

It is common knowledge that putting more effort into surface preparation will yield benefits in your floor covering installation. Not only will the floor covering be easier to install, but a truly flat floor will have an aesthetic quality that building occupants will appreciate. While there are many minimal industry standards for achieving a flat floor, the question remains: Do they go far enough? As the flooring industry continues to evolve — and architects and designers become more demanding — construction methods must continue to evolve as well.

Today, there is a growing demand for larger format ceramic and natural stone tiles. This necessitates proper specification and execution of floor surface preparation, particularly in relation to floor flatness, which is critical to any successful floor covering installation. To insure a higher quality appearance and reduced life cycle cost, the ceramic tile industry has responded to large format tile trends with updated reference standards and guidelines that provide more specific definitions for large format tile, as well as tighter tolerances for substrate flatness.

By John D. Gallup, CTC, CSI Architectural Consultatnt Custom Building Products



Technical White Paper

SELF-LEVELING UNDERLAYMENTS



At Custom Building Products, we believe substrate flatness is best achieved through the application of a flowable and cementitious self-leveling underlayment (SLU) and we have developed this paper to address:

- Potential conditions in the floor subsurface and the industry's requirements related to them
- Proper specification and installation of a self-leveling underlayment over some common flooring conditions and substrate types
- The benefits of specifying self-leveling underlayment and cement-based patching and leveling compounds for all hard surface and resilient flooring products
- The performance and cost efficiencies inherent in using self-leveling underlayment materials

ENHANCED DEFINITIONS FOR LARGE FORMAT TILE AND SUBSURFACE FLATNESS REQUIREMENTS

The American National Standards Institute (ANSI) Specification for the Installation of Ceramic Tile stipulates that deviations in sub-floor flatness should be no greater than 1/4" in 10' (Ref. ANSI A108.02 - 4.0 / 4.1.4.3.1). Before the year 2010, the Tile Council of North America (TCNA) described large format tile units as "...generally considered to be 8" x 8" and greater", with no provision for enhanced subsurface tolerances when tiles 8" x 8" or larger had been selected. However, as of 2011, subsurface tolerances for tile installation, based on tile unit size, have been updated in the TCNA Handbook. For tiles with all edges less than 15", the maximum allowable variation is 1/4" in 10' and no more than 1/16" in 12". For large format tiles with one edge greater than 15" and for natural stone tiles, the maximum allowable substrate variation can be no more the 1/8" in 10' and 1/16" in 24". When thin bed epoxy mortars are used, the variation can be no more than 1/16" in 36" with no abrupt irregularities greater than 1/32" (2011 TCNA Handbook). In some instances, the architect/designer will require the more stringent finish tolerance, and the subsurface specification or tile specification should reflect this.

In response to the new subsurface flatness criteria, a number of tile manufacturers specializing in large format tile materials have embraced these updated floor flatness requirements, and now include references to the new guidelines in their product technical data sheets and installation guidelines. It is the responsibility of the architect or design professional to include these enhanced floor flatness requirements in the project specification. It is equally important for the architect or specifications writer to consult with the design/interiors team (and vice versa) to insure that the specific installation requirements and guidelines for the selected tile for the project are reflected in the tiling specification.

To achieve the required flatness tolerances, the industry is increasingly relying on self-leveling underlayments. By virtue of the SLU's working characteristics and performance, a flowable, cementitious self-leveling underlayment will provide flatness tolerances well within 1/8" in 10' maximum plane variation. This provides a finished substrate that can accept most ceramic and natural stone tile, including tile that maintains any edge of 15" or greater, as well as all types of resilient flooring.

TRADITIONAL STRAIGHTEDGE SPECIFICATION VS. F-NUMBERS FOR RATING FLOOR FLATNESS

The American Concrete Institute (ACI) has adopted the so-called "f-number" system, under the ACI 117 specification, as a way of determining the flatness (and levelness as per F/L numbers) of concrete slabs. F-numbers are determined through testing procedures in ASTM E-1155. These testing procedures are also referenced in ASTM F-710 for The Preparation of Concrete Floors to Receive Resilient Flooring. Determining the flatness of a concrete slab using the ASTM E-1155 method provides more accurate and reliable results compared to the conventional "straightedge specification" for 1/4" in 10', and 1/8" in 10' plane variation. Under ASTM E-1155, ACI sets forth guidelines that require specified floor flatness be assessed within 72 hours after concrete installation, to insure accuracy.





Photo Courtesy ABW Construction - Woodinville, WA

Where a typical straightedge method for plane variation indicates only where gaps occur between a 10' straightedge and finished floor, floor flatness testing procedures under ASTM E-1155 provide a more quantitative method for determining the flatness and levelness of the entire concrete substrate. While a number of various techniques exist for measuring concrete to determine f-numbers, perhaps the most common is the "dipstick floor profiler" method, in which assessments are taken at a frequency of 1 ff., in both north/south and east/west directions. Measurement lines must maintain a minimum of 11 ff., and a minimum of 34 readings per 1000 sq. ff. of floor is required. The "dipstick" testing apparatus is broadcast along a line, which measures the variation in surface elevation at 1 ff. intervals. A reading is recorded at a point when the dipstick is pivoted, and the alternate "foot" of the apparatus is placed on the slab.

PROJECT SPECIFICATIONS SHALL INDICATE THE CORRECTIVE MEASURES FOR CONCRETE SLABS THAT ARE NOT IN COMPLIANCE WITH PROJECT AND CONDITION REQUIREMENTS.

Appropriate floor flatness requirements for the slab, based on conditions, intended usage, and service requirements, can be found in ACI 302 section - Guide for Concrete Floor and Slab Construction. Although there is no exact method of comparing f-numbers to conventional straightedge testing results, the following chart can be used as a guideline to approximate values between the two:

F-Number Result (FF)	Straightedge Specification Result (Plane Variation in 10')
25	1/4"
50	1/8"
100	1/16"

F-Number Results of Self-Leveling Applications

Installing a self-leveling underlayment makes it easy to exceed the requirements of the floor covering. Using the testing procedures outlined in ASTM E-1155, floor surfaces covered with a cementitious SLU have rendered f-numbers in the mid to upper 80's. The following is one example of field test results for a floor covered with CUSTOM's high performance SLU:

Minimum Required Flatness/Levelness	30 Day Result using SLU
35 / 25	86.6 / 46.2

Lippage, Facial Variation of Tile Units and Craftsmanship

Lippage is an unsightly and potentially hazardous defect in a ceramic and natural stone tile installation. It is a condition in which one edge of a tile is higher than the adjacent tile, which gives the finished surface an uneven appearance. When tile is selected as a flooring finish, accessibility is a key consideration, and design professionals should understand that any plane variation in the subsurface would be reflected in the finished installation. In short, a true and flat subsurface, within the flatness tolerances set forth in ANSI sections A108.01 and A108.02, will only minimize lippage conditions and any potential subsequent liability issues caused by unexpected changes in the plane of the finished floor.

Facial variation of the tile units that are being considered for the installation will also present some challenges. A tile installation with tile units maintaining any facial variation will be made even more challenging over a subsurface that maintains a change of plane outside of the ANSI and TCNA flatness guidelines. ANSI A108.02 – Section 4.3.8 stipulates that the grout joint width shall be at least three times the actual facial variation of the tile. Proper surface preparation with regard to subsurface flatness tolerances will allow for a much more efficient and less challenging tile installation, particularly when you are dealing with non-rectified tile units which maintain a facial variation, as described in ANSI A108.02 4.3.8. It is important to note that thin-set bond coats are intended solely to bond the tile to the substrate. They are not formulated for use as leveling agents.



WOOD AND RESILIENT FLOORING ALSO NEED FLAT UNDERLAYMENTS

Just like ceramic tile, wood and resilient flooring require a high degree of flatness that can easily be achieved using a cementitious SLU. Many manufacturers of wood flooring require that the variation in floor flatness be no more than 3/16" in 10' and 1/8" in 6'. The installation of wood flooring also requires that the floor be dry. Because of the rapid curing of cementitious SLU, it is possible to achieve a dry floor that meets the industry requirements in less than 24 hours. Many of the adhesives used to bond wood and resilient flooring are sensitive to moisture and extreme pH readings, CUSTOM's SLU is formulated to balance the finished pH to accommodate most common adhesives.

CONDITION REQUIREMENTS PRIOR TO APPLICATION OF SELF-LEVELING UNDERLAYMENT

It is typically recommended that SLU be applied in conditions where ambient temperature is above 50° F, and not more than 90° F. To ensure the integrity of the primer, the moisture vapor transmissions rate (MVTR) from the substrate should not be in excess of 5 lbs. of water/day/1000 sq. ft., based on a standard ASTM F-1869 (Calcium Chloride) test, or 80% rh, based on ASTM F-2170. A moisture content that is too high will also slow the cure of the SLU and can affect the subsequent floor finish. Most floor covering manufacturers will have acceptable limits for MVTR and their recommendations must be followed. Consult with Custom's technical representatives for specific recommendations regarding CUSTOM's SLU and your particular installation.

DEFINITION, FORMULATION, AND PERFORMANCE VALUES OF SELF-LEVELING UNDERLAYMENT

Self-leveling underlayment (SLU) for flooring consists of a blend of Portland and/or calcium aluminate cements, inorganic aggregates, co-polymers, and chemical modifiers, which form a flowable, self-leveling compound for leveling interior subfloors. These components form a high compressive strength and flowable cementitious compound, resulting in a flat-level surface that accepts all ceramic and natural stone tile floor finishes. Many SLU manufacturers state that select self-leveling materials also provide proper surface prep and acceptability under alternative floor finishes, such as carpet, vinyl, linoleum, resilient, and hardwood flooring. Refer to the manufacturers' published data sheets for compatibility with alternative floor finishes. Virtually all the cementitious SLU sold today is mixed with water only; no liquid acrylic-latex additive is required. The dry re-dispersible co-polymers in the manufacturer's formulas provide improved bond strength and flexibility. SLU is formulated with proprietary copolymers and cements, which provide ultra high compressive values, in some materials in excess of 4000 psi. The high compressive value of SLU materials results in a floor assembly that consistently passes all 14 cycles on an ASTM C627 Robinson Floor Test for most applications. This 'Extra Heavy Duty' rating for the finished floor is crucial for floors that are subject to heavy foot traffic and large equipment such as scissor lifts and pallet jacks. Alternative self-leveling applications, such as those over hydronic tubing or electric radiant heat systems, will provide a moderate service rating. Installations over wood joist / plywood subfloor installations can provide anywhere from a light commercial to a standard residential service rating, depending on the specific assembly detail.

The versatility of cement based self-levelers allows for SLU pours that can be applied from 1/8", all the way up to 1 1/2", or in some cases, up to 2" in total thickness. SLU materials can also be feather-edged to transition to other floor finishes. Allowable thicknesses will vary depending upon the manufacturer and the specific formula. Certain proprietary formulas are available that provide an extended set for pumping. These are designed for use in high ambient temperature conditions, or over large spans when more time to float the material is required.

Cure rates of SLU materials provide for a fast setting underlayment that can accept ceramic or natural stone tile set with modified thin set in as little as 4 hours and 12 to 14 hours for resilient flooring after the SLU is poured in place. This helps to minimize project downtime and allows the work schedule to proceed more expeditiously.





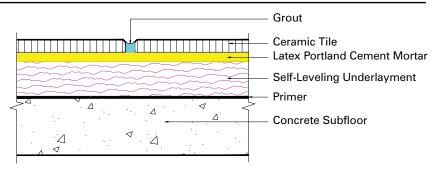
DETAILS AND GUIDELINES FOR SELF-LEVELING UNDERLAYMENTS

Details and installation guidelines for floor systems that include an SLU are outlined in the Tile Council of North America Handbook for Ceramic, Glass, and Stone Tile Installation. The handbook recommends crack-isolation membranes, such as RedGard®, Custom 9240®, or CrackBuster Pro® from Custom Building Products over concrete substrates including SLU in order to isolate existing and new cracks in the substrate. Floor systems over SLU need to conform to IBC, IRC, and local building codes. Maximum allowable substrate deflection (prior to the application of self-leveling agent) is not to exceed I/360 under live load. For stone installations, maximum allowable deflection in the substrate is I/720.

COMMON TILE ASSEMBLY INCLUDING SELF-LEVELING UNDERLAYMENT: TCNA F205-11 – SELF-LEVELING UNDERLAYMENT OVER ON GRADE CONCRETE

Plywood subfloor engineered truss joist (TJI) systems can be encapsulated with a self-leveling agent. When installing an SLU over any wood framed plywood floor system, application of metal or plastic lath mechanically anchored to the plywood sheathing is essential to insure the integrity of the self-leveling installation, with the most common reinforcement being a 2.5 lb. expanded metal lath. All plywood surfaces that are to receive self-leveling should be coated with a latex primer that is formulated for use with the self-leveling material. SLU over plywood sheathing truss joist floors must conform to IBC, IRC, and local building codes. Maximum allowable substrate deflection (prior to the application of self-leveling agent) should not exceed I/360 under live load. For stone installations, maximum allowable deflection in the substrate is I/720. CUSTOM's XP-1, LevelQuik RS and LevelLite SLU can be applied to TJI or dimension lumber joist systems can maintain up to 24" o.c. spans in the joist assembly.

CF205
Floors, Interior
Concrete Subfloor
Self-Leveling Underlayment, Bonded



COMPATIBILITY OF SELF-LEVELING APPLICATIONS AS PART OF A COMPLETE SYSTEM ASSEMBLY.

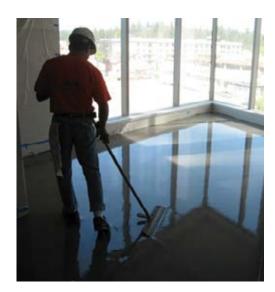
Generally a cement-based self-leveling underlayment is a suitable surface for most bonding mortars and adhesives. To assure compatibility, all installation products should come from the same manufacturer. All Custom Building Products cement- or epoxybased thin-set mortar and grouting material are 100% compatible with CUSTOM SLU products. So are CUSTOM's waterproofing and crack isolation membranes, such as RedGard®, Custom9240®, CrackBuster Pro®, or SpiderWeb Mat™. CUSTOM's ability to provide a complete system inclusive of SLU (LevelQuik or LevelLite), crack isolation and waterproofing, uncoupling membrane (RedGard, Custom 9240, CrackBuster Pro or SpiderWeb Mat), setting mortar (ProLite® or MegaLite®) and grout (Prism® SureColor® or CEGLite® Commercial Epoxy Grout) makes single sourcing from one manufacturer a simple process.

EXECUTION AND COST COMPARISONS OF SELF-LEVELING VS. STANDARD MORTAR BED INSTALLATIONS

Perhaps the biggest benefit of a cementitious self-leveling floor prep assembly is the inherent cost and labor savings it provides, particularly when compared to traditional

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cement mortar bed assemblies (ref. TCNA methods F111 & F112). In researching cost comparison information for this paper, flooring contractors who specialize in both traditional mortar bed and self-leveling applications indicate that self-leveling installations cost an average of 25% to 35% less than a traditional mortar bed installation, including materials and labor costs. A two-man crew can manually pour a self-leveling application in a fraction of the time required to gauge, screed and tamp a traditional 4:1 mortar bed, as described in TCNA details F111 and F112, and ANSI A108.1. Furthermore, compared to mortar bed assembles, the efficiency of a self-leveling application insures that the finished product will meet much higher tolerances in regards to floor flatness, with far less labor and tooling of the material required. The cost savings noted above are indicative of this enhanced efficiency.

In consulting with floor / surface prep sub contractors, many indicate that projects involving floors in excess of 10,000 sq. ff., self-leveling is normally broadcast with automated pumping equipment, operated by a two- or four-man crew. As the self-leveling material can be applied to specific areas of the floor using a mechanical pumping method, far less tooling of the SLU is required. Floor floats are used to broadcast the material over the floor span and required to achieve the intended floor flatness. Some manufacturers provide materials with extended set/cure times, allowing for a larger timeframe in which to heal and smooth the material. This extended set is most beneficial when applying self-leveling over large floor spans in one pour. Consult with the manufacturer prior to selecting a job specific self-leveling product. Pumping of flowable self-leveling material can be executed on high-rise projects, including buildings in excess of 20 floors.

For surfaces of less than 10,000 sq. ft., self-leveling is often manually mixed on site and "bucket poured" onto the properly prepared floor finish.

Estimated per square foot weights of self-leveling installations are approximately 11 lbs. for ceramic tile, and 13 lbs. for stone installations (9 and 11 lbs. per sq. ft. for CUSTOM's LevelLite), with a self-leveling underlayment at $\frac{1}{2}$ " in thickness, in standard applications over plywood or concrete. Mortar bed installations are typically between 19 and 21 lbs. per square foot. With today's lightweight building construction, this weight differential can accommodate designer-preferred ceramic and stone tile flooring.

Self-Leveling Underlayment is ready for flooring in as few as 4 hours. This provides a much faster cure rate compared to a mortar bed application, which requires a minimum of 20 hours, and can be as much as 10 days, depending upon jobsite conditions (ref. ANSI A108.02 - 4.2.2.1).

In many cases a concrete floor specification (section 03450) will not provide the flatness required for the concrete substrate to be finished with a tile or stone installation. This being the case, and given the efficiencies of the SLU method, the concrete contractor and general contractor can pay less attention to subsurface tolerances when a self-leveling underlayment is included in the tiling spec section, as the SLU method provides the most efficient method for remedying concrete that is out of flatness tolerances for floor finishes.

If you want to be assured of a flat surface for installation of all floor coverings, a self-leveling underlayment and cementitious patching materials provide:

- A cost effective floor finish compared to traditional floor prep methods such as traditional mortar beds
- Finished floors that provide flatness and levelness characteristics far greater than the requirements of TCNA and ACI 117
- Reduction in potential lippage conditions in the tile assembly
- The availability of self-leveling products formulated with post consumer recycled content, which provide a floor with a lighter per square foot weight and contribute to LEED® certification for the project
- A subsurface finish that provides for a faster, more efficient, and higher quality tile installation







CUSTOM BUILDING PRODUCTS ANSWERS THE CHALLENGES OF THE ENHANCED FLOOR FLATNESS STANDARDS WITH LEVELQUIK® AND CUSTOMTECH™

LevelQuik and CustomTech products are engineered to meet a wide range of job requirements and address a variety of existing floor conditions.

Formulated with Controlled Cure Technology (CCTTM), LevelQuik RS Rapid Setting Self-Leveling Underlayment seeks its own level within minutes, and provides a high early compressive strength that can accept thin-set bonded tile applications in 4 hours or less after application. LevelQuik RS will maintain a compressive value of 4400 psi after a complete 28-day cure, and can be applied up to 1" in thickness in a single pour. LevelQuik can also be feather-edged for smooth transitions to adjacent floor conditions and finishes

With a 30-minute working time, LevelQuik® ES Extended Set Self-Leveling Underlayment is ideal for large applications that require longer cure rates to allow for additional tooling and working after pour. As a result, LevelQuik ES is ideal for large single or multi floor projects that require the self-leveler to be pumped with mechanical pumping equipment. LevelQuik ES is formulated for application in conditions that require as much as a 2" thick leveling agent and that can be tooled down to a feather edge. This provides for smooth transitions to other floor finishes and project conditions.

LevelQuik Latex Primer is recommended as a preparation for all surfaces prior to treatment with any LevelQuik cementitious self-leveling material. LevelQuik Latex Primer dries within 30 to 60 minutes, depending upon the project conditions (including temperature and humidity), and it dramatically improves the adhesion of the SLU to the substrate while controlling subsurface porosity.

CONTRIBUTIONS OF SLUS TO LEED® AND GREEN BUILDING

One recent trend in the formulation of self-leveling underlayments is the addition of post consumer recycled aggregates to enhance the materials' contribution to LEED certification and green building. CUSTOM has also identified the benefits of using post-consumer recycled aggregates to achieve a lighter weight formula. In some cases, the selection of a so-called "lightweight" SLU can reduce the per square foot (psf) weight of the floor by as much as two pounds per square foot. Exactly how much an SLU can contribute to minimizing floor psf weights will depend on the thickness requirements of the self-leveling agent as a floor leveler. The thickness of the SLU will vary based on the existing conditions and thickness of the substrate, as well as transitions to other floor finishes.

Custom Building Products Responds to LEED and Green Building Requirements with LevelLite® Lightweight SLU.

Engineered with over 20% Post-Consumer recycled content, LevelLite from Custom Building Products provides the highest level of Green contribution under LEED 4.1 compared to any other material in the cementitious self-leveling product category. Formulated with a unique blend of high quality cements and aggregates, LevelLite provides a subsurface that is up to 2 lbs. per square foot lighter than standard mortar bed installations.

LevelLite can accept a thin-set / tile application in as few as 4 hours after pour, and can be applied up to 2" in thickness in a single pour, down to a feather-edge for smooth transitions to other floor surfaces. In addition, Calcium aluminate-based patching and self-leveling materials provide high compressive value and performance, resulting in a versatile surface preparation solution for a host of selected floor finishes.

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CUSTOM BUILDING PRODUCTS LAUNCHES CUSTOMTECH™

To address the needs of all floor coverings, CUSTOM recently introduced three new products designed for leveling the floor prior to the installation of wood and vinyl flooring as well as ceramic and stone tile. These products incorporate state-of-the-art aluminate cements to achieve the performance the industry expects. They have been designed for easy application and allow immediate installation of the floor covering.

A High Compressive Strength SLU

CustomTech™ TechLevel™ XP-1

Premium Calcium Aluminum Based Self-Leveling Underlayment
For challenging floor leveling installations, Custom Building Products has developed
TechLevel XP-1, a premium high-performance calcium aluminate based self-leveling
underlayment. With a compressive value in excess of 5,000 psi, TechLevel XP-1 is
ideal for floors that are subject to heavy foot traffic and large equipment, such as scissor
lifts and pallet jacks. TechLevel XP-1 is an abrasion-resistant formula that requires less
surface preparation. TechLevel XP-1 can level floors from featheredge up to 2" in
thickness. It is the preferred choice for preparing concrete floors to receive alternative
finishes, such as resilient flooring. (Refer to ASTM section F710 for concrete floor prep
and flatness requirements for resilient floor finish.)

New Generation General Purpose Patching Compound

CustomTech GenPatch™ General Purpose Calcium Aluminate Based Patch For general purpose trowel-applied patching of interior or exterior concrete substrates, specify CUSTOM's GenPatch Calcium Aluminate Cement Based Patching Compound. GenPatch can accept floor finish and adhesive bond coat in 60-90 minutes, and can be feather-edged, or applied up to 1" thick.

Provides an Easy-to-Apply High-Strength

CustomTech Silk™ Patching and Finishing Compound

As a calcium aluminate-based cementitious compound, CustomTech Silk provides the best solution for challenging applications, such as ramping between floor finishes which maintain a variation in plane, in a smooth, easy to apply, high-strength formula. CustomTech Silk has a rapid cure compound that can accept a host of different floor finishes, including tile, stone, and resilient flooring.

References:

Tile Council of North America (TCNA) – Handbook for Ceramic Tile Installation 2011 48th Edition

American National Standards Institute (ANSI) Specification for the Installation of Ceramic Tile – 2011

American Concrete Institute (ACI) 117

American Concrete Institute (ACI)

"Guide for Concrete Floor and Slab Construction"

TTL News Volume 10 - Issue 1 - February 2009

"The Floor Flatness Report" – Concrete International – www.AClelearning.org January 2011

ABW Construction - Woodinville, WA

Custom Building Products – www.custombuildingproducts.com

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John Gallup is an Architectural Consultant for Custom Building Products, based in the Seattle area, and is responsible for the Northwest Region. In his 20+ years in the ceramic tile and flooring industry, John has been responsible for specification consultation and development , project pre-construction meetings, and job installation inspections. John is an 8 year member of the Puget Sound Chapter of the Construction Specifications Institute.



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