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Brittle Floor Finish Considerations by WTCA Staff

Brittle Floor Finish installations require care in planning and design as well as installation. When designed well and competently installed, they provide a durable floor that performs well.

The installation of Brittle Floor Finishes (BFF) like ceramic tile, slate, natural stone, marble, granite and limestone over wood framed floors have been cause for much discussion and debate over the years. Which structural design criterion to use is often at the center of this debate.

Customer satisfaction with BFF installations is dependent upon the floor substrates staying reasonably level, straight and true, which prevents the BFF or grout from cracking. Framing and/or substrate deflection must be minimized under live, concentrated and total loads. How to ensure a stable surface, regardless of the framing and/or substrate materials, needs to be thoroughly understood by the building designer, the floor structure designer, the framing contractor and the BFF installer.

BFF installations require care in planning and design as well as installation. When designed well and competently installed, they provide a durable floor that performs well. Problems most often arise when BFF is installed under less than optimum circumstances, such as:

1. BFF locations not noted on plans, added as an afterthought or added during remodeling.
2. BFF located but only minimally designed and detailed.

Building code minimums do not account for BFF. Dead load to live load ratios can go from the typical 1.5:4 up to 3:4 or higher. These higher ratios can introduce long-term deflection (creep) into the design equation. A BFF installation using standard loading of 40-10-5 with L/360 LL and L/240 TL deflection criteria is an open invitation to cracked grout, or even worse, cracked tile and the callback consequences of this.

The IBC and the IRC reference BFF installation per ANSI A-108 and A-118/136 standards. These are also specified by the Tile Council of America (TCA) in the 2003-2004 TCA Handbook for Ceramic Tile Installation (41st Edition). As of the 2001 edition, TCA changed its specification to read: “design floor areas over which tile is to be applied to have a deflection not greater than 1/360 of the span when measured under 300 lb. concentrated load (see ASTM C627).” Both the 2001 and the 2003-4 TCA Handbooks list 19.2" and 24" on-center applications in addition to the traditional 16" on-center framing details.

There are two issues
with this specification
(see Figures 1 and 2):

1. The load/deflection requirement—Although it may not be clear from the phrase "floor areas over which tile is to be applied," there are two distinct issues that are being addressed; the deflection of the substrate between supporting members and the deflection of the supporting members themselves.

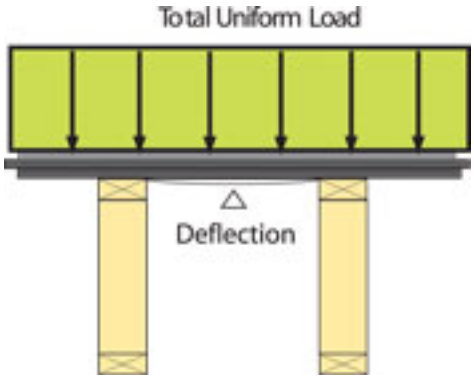

FIGURE 1

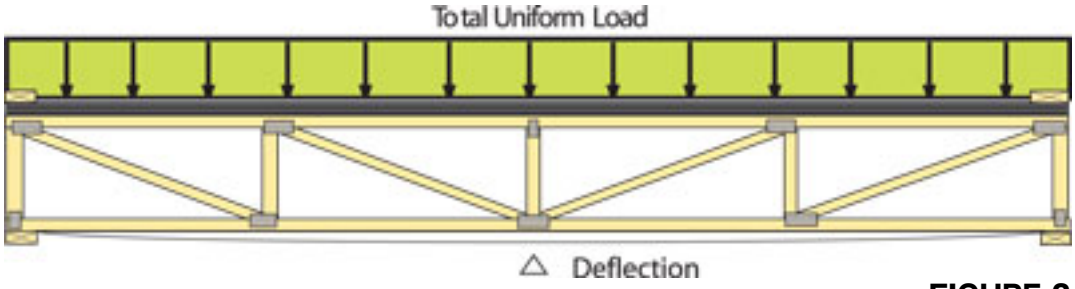

FIGURE 2

2. The spacing maximum—The referenced specifications, ANSI A-108 and ANSI A-118/136, still specify a 16" on-center maximum spacing for framing members (see A-4.8.4.1.3). It is these standards that are referenced by the building codes, not the TCA handbook.

For the metal plate connected wood truss industry, these issues are addressed along with general deflection criteria for floor trusses in ANSI/TPI 1-2002. The topic of trusses supporting ceramic tile flooring is addressed in Table 7.5-1, and specified as being equal to L/360 at Total Load (LL+DL). Footnote #4 to Table 7.5-1 further states: "Maximum truss spacing shall be 16" o. c. per ANSI A-108/ANSI A-118/136. Perpendicular blocking installed at 16" o.c. maximum shall be permitted in lieu of the 16" o.c. truss spacing." Deflection is discussed extensively in the Commentary to TPI 1-2002, Section 7.5.1 and 7.5.2. BFF applications with higher than normal dead loads will undoubtedly be controlled by total load deflection as opposed to typical residential floor trusses, which are most often controlled by live load deflection.

ANSI/TPI 1-2002 does not address the issue of the 300 pound concentrated load per ASTM C627. The purpose of this test is to define the BFF installation durability on any floor system by applying 300 pounds of pressure through a rolling caster. This test evaluates the BFF and the substrate performance at various spacing. It doesn't test framing member performance. Therefore, it should not be a consideration when designing the supporting members. (See Figure 3.)

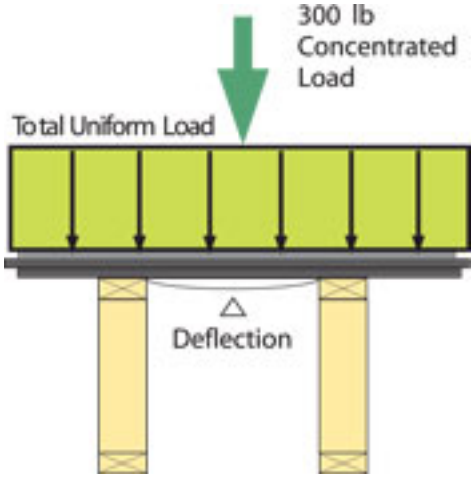

FIGURE 3

That this testing applies only to the substrate is unclear in ANSI A-108 and ANSI A-118/136, the TCA handbook, and a variety of product specifications. Thus, it is important that the parties responsible for the floor system design understand this concept. This must be accounted for in the substrate and BFF system to accordingly specify the proper system. The structure then should be designed to ensure that it has similar stiffness to the

substrate and BFF by limiting deflection.

If the building designer adds this requirement to their specification, the component manufacturer may need to discuss this with them to ensure that this specification is fully understood and that this does not apply to the structural framing. Should the building designer still require this specification, consideration should be given to applying:

• a single 300-lb point load that causes the worst case deflection condition in addition to the other loads.
• a 1.5 or 2.0 multiplier on the actual dead load, depending on its magnitude, to account for long-term creep.

Also, one must also be aware that The Marble Institute of America, Inc. (MIA) specifies that substrates (defined as including the joist and the sub-floor) to receive stone must be designed for L/720 at total load for spans up to 14' and limits the maximum deflection to 7/32" (0.21875") on spans beyond 14'. There are additional requirements for substrate decking.

ARE JOIST DEFLECTION LIMIT SPECIFICATIONS ENOUGH?

Simply holding structural member deflections to a given ratio will not in and of itself prevent BFF serviceability issues. Care should be exercised to:

• assure that the absolute deflections between adjacent trusses of differing spans are also kept within acceptable limits.
• account for the additional dead loads of water beds, appliances, built-in cabinetry, storage and pantry closets and large bath tubs.

Designing structural members that carry additional dead load with the same deflection criteria as the adjacent structural members without the additional dead loads will induce differential deflections which could show up as tile or grout cracks. The stiffness of the sheathing substrate assumes that the relative stiffness of the supporting structural member is reasonably constant. Additional strongbacks may prove beneficial in reducing the magnitude of differential deflections. Undertaking additional planning up front by looking closely at each truss design and comparing it to its adjacent truss is a valuable serviceability check. The time spent doing this check during the design phase is small compared to what would be involved in a call-back/repair condition.

SUBFLOOR/UNDERLAYMENT SPECIFICATIONS

Subfloor and underlayment design is as critical as the structural member design. To the tile or stone, deflection is deflection. A bend in one direction is no better than a bend in another direction. BFF performance depends on both the structural component and the sheathing substrate to meet the performance specifications.

The 2003-2004 edition of the Handbook
for Ceramic Tile Installation includes

specifications for six assemblies with joist (structural member) spacing greater than 16" on-center. (See Table 1.)

The Engineered Wood Association, APA, in cooperation with TCA, has tested a number of floor systems with joists spaced 24" on-center with both plywood and OSB (see APA Technical Topic TT-006, Ceramic Tile Over Wood Structural Panel Floors, October 2000). (See Table 2.)

Although the TCA and APA include minimum substrate specifications for structural members spaced greater than 24" on-center, it might be advisable to increase the suggested minimum substrate thickness of subfloor and/or underlayment to increase floor stiffness and to check the actual expected deflection for the substrate.

TCA No.	Joist Spacing (structural member spacing) (in. o.c.)	Service Class	Subfloor	Underlayment	Other Considerations
F147-03	24	Residential	23/32"	3/8"	Flange requirements
F148-03	19.2	Residential	23/32"	None	Single layer floor
F149-03	24	Residential	23/32"	19/32"	
F151-03	24	Lt. Comm.	7/8" T& G	None	Coated glass mat
F152-03	24	Residential	23/32"	3/8"	
F155-03	24	Residential	23/32"	19/32"	

Table 1. ASTM C627 Tested assemblies -Listed by TCA

TCA No.	Joist Spacing (in. o.c.)	Service Class	Subfloor	Underlayment	Other Considerations
Unlisted	24	Lt. Comm.	23/32"	19/32"	
Unlisted	24	Lt. Comm.	23/32"	19/32"	OSB Subfloor
Unlisted	24	Lt. Comm.	1-1/8" T&G	None	Single floor
Unlisted	24	Residential	23/32"	19/32"	OSB UL & subfloor

Table 2. ASTM C627 Tested assemblies - Not listed by TCA, but listed by APA

TABLES 1 & 2

CONCLUSIONS

The current provisions of ANSI/TPI 1-2002, Table 7.5-1, address only ceramic tile and truss deflection. Component manufacturers are advised that this specification is not the only way that a Building Designer and component manufacturer can or shall comply with the TCA and/or MIA requirements for floor framing performance under BFF. Trusses under non-tile BFF may need to be designed for even stricter deflection limits per MIA.

The 300 lb. concentrated load test in ASTM C627 is not related to structural members; however, it might be interpreted this way. ASTM C627 is not clear how or if this load would be applied to the structural building component member. If it is applied, this could easily become the controlling case in some designs. If the Building Designer adds this requirement to their specification, it is important to discuss this so that all involved in the project thoroughly understand the specification and how to appropriately design for the applied loads.

It is advisable that the component manufacturer get the floor performance specifications in writing, and then set about meeting or exceeding those specifications in both the design and manufacturing/supplying of the floor framing products. The recommendations and guidelines provided above are merely minimum performance standards. Customer expectations and satisfaction is often not accomplished through meeting minimum standards. Should you feel uncomfortable with the provided floor performance specifications, it is wise to communicate those concerns with the responsible Building Designer in writing. Should a floor performance complaint arise, you'll be glad you did.

Our industry has been and will continue to work with the Tile Council of America to continue to foster improvements in engineering design and installation procedures to assure trouble free BFF applications.

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