Technical Q & A

Natural Stone Floors & Deflection

The differences between L/360 and L/720 for deflection criteria.

by Ryan J. Dexter, P.E.

There are two basic objectives with respect to the design of all structural building components, including trusses. First, they must be strong enough to safely carry the loads they are designed to support. Second, they must be stiff enough to limit deflections, vibrations and any other deformations to comply with building codes and to satisfy the end user. Making sure a truss is designed for adequate strength is extremely important since any mistakes in this area could potentially result in structural collapse, injury, and even death. But stiffness and deflection concerns are often not given the same level of scrutiny because they tend not to have an impact on life/safety issues. Instead, serviceability and quality of performance issues are the most common and time-consuming problems encountered when components are not designed to account for the specific application and loading conditions. This article provides a basic review of deflection criteria to consider when designing floor trusses to be covered with natural stone flooring.

Question

We recently worked on a large residential job in which marble tile was to be installed on portions of the floor. The construction documents did not indicate any special deflection requirements. We designed the floor trusses in these areas for a total load deflection of L/360 based on our previous experience with ceramic tile floors. However, we have recently become aware that the Marble Institute of America requires a deflection limitation of L/720. Since this information is not in the building code is there another source (besides the specific material supplier) that has this information?

Answer

Floor deflection issues are not unique to trusses or wood construction. However, because of the structural nature of wood and the longer spans and depths made possible with metal plate connected wood trusses, deflection, vibration and camber can become noticeable. When one of these conditions occur, customer satisfaction can become an issue even though structural performance meets the building code and adequately transfers all the applied loads.

Chuck Muehlbauer, Technical Director of the Marble Institute of America (MIA), answers questions in the association's newsletter. He addressed this very topic just recently:

Q: In the MIA's Dimension Stone Design Manual it calls for floor deflections of L/720 in some places, but in other places it lists L/360. Why are these not consistent? Is this just a typo? Which one is correct?

A: It is not a typo. Both are correct, but they are specific to particular substrate types. **Deflections not exceeding L/720 are recommended when installing stone flooring over wood frame construction.** Deflections not exceeding L/360 are recommended when installing stone flooring over concrete substrates. While this seems illogical, there are two reasons for the difference in requirements. Concrete floors tend to have a different behavior under load, in that they don't have the linear pattern to their deformation as is found in wood framing members. It is not necessarily the total deflection in wood frames that causes a problem. Oftentimes it is the differential deflection between adjacent members or the "hinge effect" at regions of subfloor discontinuity. Secondly, concrete floors tend to have longer spans. A given deflection in a short span actually creates a sharper curvature in the floor than the same deflection in a longer span.

at a glance

- ❑ Conditions like deflection and vibration can occur in metal plate connected wood trusses even if they meet the building code and adequately transfer loads.
- ❑ When stone flooring is installed over wood frame construction, deflections not exceeding L/720 are recommended.
- ❑ The Building Designer is responsible for providing the deflection criteria and on-center spacing requirements to limit deflections.
- ❑ If no building design information is given, truss technicians should not assume deflection criteria of L/360.

Although the L/720 total load deflection is not referenced in the building code it *is* referenced in the *TPI 1* Commentary. ANSI/TPI 1 -2007 Table 7.6-1 outlines the deflection limits for non-cantilevered portions of trusses.

The following text is from the *TPI 1* Commentary:

> The deflection limits in **Table 7.6-1** are consistent with typical minimum building code requirements where specified. In addition, certain floor coverings require more restrictive deflection criteria than the typical limit on floor trusses of L/360 in order to prevent cracking of the flooring materials. While **Table 7.6-1** includes one common floor covering requiring more restrictive deflection criteria, namely ceramic tile, the Truss Designer should be aware of possible other deflection criteria associated with specific floor coverings (e.g., L/720 total load deflection for marble tile). Maximum on-center spacing of floor joists supporting certain floor materials may also be required by some material standards.

TPI 1-2002 explicitly referenced a 16-inch on center spacing limit for some floor coverings. *TPI 1-2007* now just references *ANSI A108/A118/A136* for truss spacing since there are a number of available systems that allow 19.2- and 24-inch on center spacing of supporting joists. More restrictive deflection requirements for increased stiffness and improved serviceability, particularly of floor trusses, may be desired and may be specified as such by the Building Designer for any particular building. If floor vibration is a concern (and since the probability of vibration problems increases as floor spans increase in size), using a more restrictive deflection limit like L/480 or even L/600 will help to prevent floor vibration. It may also be desirable to limit the truss deflection to a finite amount (e.g., maximum number of inches) depending on the truss span or load, or building usage. But remember that establishing the deflection limits is not the responsibility of the Truss Manufacturer, Truss Technician or Truss Designer.

The Building Designer should establish what deflection and on center spacing requirements apply to any particular floor covering at the time of design. All parties in the design process should keep in mind that as truss spans and material weight increase (i.e., marble or stone tile), the greater the risk for serviceability and performance issues. If no building design information is given, truss technicians should not assume deflection criteria of L/360. Rather, get the information from the Building Designer in writing so the trusses are designed stiff enough to limit deflections, vibrations and any other deformations to acceptable levels. SBC

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Member	Deflection due to LL only	Deflection due to total load (LL + DL)
Roof truss supporting plaster[1]	360	240
Roof truss supporting drywall[1]	240	180
Roof truss not supporting ceilings[1]	180	120
Floor trusses[2,4] (See footnotes for trusses supporting ceramic tile)	360 or 480[3]	240
Top chord panel[5]	180	120 (600[6])
Habitable spaces in trusses[7]	360	

Table 7.6-1. Deflection limits for non-cantilevered portions of trusses.[4]
Values given in the table are divisors that are applied to the clear span length, L_s, to establish a deflection limit (limit = L_s/specified value).

[1] Roofs not having sufficient slope or camber to assure adequate drainage shall be investigated for ponding.
[2] Certain floor coverings require more restrictive deflection criteria. For ceramic tile, truss spacing and appropriate dead load for the installation method, and other aspects of design per *ANSI A108 / A118 / A136* shall be such that the system passes the requirements of the Building Designer per Chapter 2 of this Standard.
[3] Floor trusses with ceilings attached that meet L/480 criteria shall not require strongbacks to meet deflection criteria.
[4] Cantilevered and overhang portions of trusses are subject to deflection limits using the values shown above applied to twice the length of the cantilever, Lk.
[5] Span length for top chord panel limits shall be the panel length.
[6] Where required by *ACI530 / ASCE5 / TMS402* for trusses used as a beam or lintel providing support of vertical masonry veneer.
[7] Limit is for panel deflection of the loaded panel when loaded with 30 psf (14.4 KPa) or greater of live load.

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Truss Publications, Inc.

6300 Enterprise Lane • Suite 200 • Madison, WI 53719
608/310-6706 phone • 608/271-7006 fax
www.sbcmag.info • admgr@sbcmag.info