ASPHALT ROOFING MANUFACTURERS ASSOCIATION®

TECHNICAL BULLETIN

ASCE 7 Tornado Load Requirements and Asphalt Shingles

March 2026

The 2022 edition of ASCE 7 was updated to include a new Chapter 32 for tornado loads. Chapter 32 of ASCE 7-2022 was subsequently referenced in new Section 1609.5 of the 2024 edition of the International Building Code (IBC), making consideration of tornado loads necessary in jurisdictions which have adopted the 2024 IBC where the following two conditions apply (see Appendix for more information):

(1) Risk Category III or IV buildings[1], and

(2) located in the "tornado prone" region[2].

However, for asphalt shingles the new tornado load provisions do not apply for reasons that follow, even where tornado loads must be considered for a building and its roof deck.

How does this affect residential construction?

There are no tornado load requirements for Risk Category I and II buildings of residential and commercial occupancy groups. Thus, for typical residential buildings (Group R) constructed in accordance with the IBC and assigned a Risk Category II, there are no tornado load requirements. Similarly, the International Residential Code (IRC) for one- and two-family dwellings has no tornado load requirements.

What is the effect on roof coverings for Category III and IV buildings?

Section 1609.6 of the 2024 IBC requires that "Roof systems shall be designed and constructed in accordance with Sections 1609.6.1 through 1609.6.3, as applicable."

Section 1609.6.1 requires that the roof deck "shall be designed to withstand the greater of wind pressures or tornado pressures" determined in accordance with ASCE 7.

Section 1609.6.2 states that roof coverings "shall comply with Section 1609.6.1." Thus, a general requirement to design roof coverings for tornado loads (where required to be considered) is established. But there are two important deviations from this general requirement for roof coverings that are (1) air-permeable and (2) have special design procedures or testing standards that account for pressure equalization effects. These deviations apply to asphalt shingles (Section 1609.6.2.1) and rigid tile roof coverings (Section 1609.6.3).

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[1] Building risk categories (RC) are defined in Chapter 1 of ASCE 7-22 and are roughly described as follows: RC I (low risk to life, such as agricultural, temporary, and minor storage buildings), RC II (buildings such as homes, offices, retail), RC III (buildings with substantial life or economic risk potential, such as larger public assembly, educational, and institutional facilities), and RC IV (essential facilities having substantial community impact, such as care facilities, fire, rescue, ambulance, and police stations, designated emergency shelters, and public utilities).

[2] The tornado prone region is mapped in Figure 1609.5 of the 2024 IBC (Figure 32.1-1 of ASCE 7-22) and encompasses almost the eastern 2/3rds of the U.S.

How does this change affect asphalt shingles?
For asphalt shingles, Section 1609.6.2.1 requires that they be "installed over a roof deck complying with Section 1609.6.1" which necessitates consideration of tornado loads (where determined applicable) for the roof deck design. However, for the asphalt shingles, it requires that they separately "comply with the wind-resistance requirements of Section 1504.2." Section 1504.2 requires testing in accordance with ASTM D7158, and satisfaction of the basic wind speed requirements associated with the building on which the shingles are installed. Similarly, asphalt shingles not within the scope of ASTM D7158 are evaluated and classified in accordance with ASTM D3161. Thus, consideration of tornado loads (or tornado wind speed) is not required for asphalt shingles but must be considered for the roof deck onto which shingles are installed where tornado loads are applicable.

See Appendix for more information on the applicability and determination of tornado loads.

APPENDIX – Supplemental Information on Tornado Loads

The 2022 edition of ASCE 7 introduced a new Chapter 32 for tornado loads. According to the proponents of a code change introducing those tornado loads to the 2024 edition of the International Building Code: [3]

> *"The tornado loads specified in the new Chapter 32 provide reasonable consistency with the reliability delivered by the existing criteria in ASCE 7 Chapters 26 and 27 for the Main Wind Force Resisting System (MWFRS), using the same return periods as the basic wind speed maps in Chapter 26 for Risk Category III and IV facilities (1,700 and 3,000 years, respectively). At return periods of 300 and 700 years (used for wind speeds with Risk Category I and II structures), tornado speeds are generally so low that tornado loads will not control over Chapter 26 wind loads. Therefore, design for tornadoes is not required for Risk Category I and II buildings and other structures."*

Because the tornado wind speeds are probabilistic wind speeds (not based on a deterministic tornado magnitude or "Fujita scale"), the provisions of Chapter 32 are not intended to provide life safety protection or prevent major damage in the event of a "direct hit" by a violent tornado. Consequently,

> *"ASCE 7-22 tornado design speeds for Risk Category III and IV structures range from 60 to 138 mph, depending on geographic location, Risk Category, and effective plan area (which is a function of the building footprint size and shape)."* [3]

And,

> *"The mapped tornado speeds represent the maximum 3-s gust produced by the translating tornado at a height of 33 ft anywhere within the plan area of the target building. The design tornado speeds for Risk Category III and IV buildings (for 1,700- and 3,000-year return periods, respectively) typically range from EF0-EF2 intensity, depending on geographic location, Risk Category, and plan size and shape."*[3]

When is design for tornado loads required?

As noted at the beginning of this Technical Bulletin, consideration of tornado loads is only required for Risk Category III and IV buildings that fall within the "tornado prone" region of the eastern two-thirds of the U.S. (see ASCE 7-22, Figure 32.1-1 or 2024 IBC Figure 1609.5). If the building is Risk Category I or II, these provisions do not apply and have no effect on building design.

Even if a building is Risk Category III or IV and is located within the tornado prone region, the

[3] International Code Council 2021/2022 Code Development, Group B Committee Action Hearings, Proposal S63-22.

applicability of the tornado design provisions depends on several conditions (see ASCE 7-22, Figure 32.1-2). Determining the applicability of these tornado load provisions is a critical first step. Where tornado loads do apply, they must be checked in addition to the ASCE 7 wind loads and the more stringent will control the design for a building.
Design for tornado loads is not required where any of the following conditions exist (ASCE 7-22, Section 32.5.2):

- V_T < 60 mph for any site,
- V_T < 0.5 V for Exposure B sites,
- V_T < 0.6 V for Exposure C sites, or
- V_T < 0.67 V for Exposure D sites

The first condition above is addressed by determining the appropriate tornado wind speed, V_T, from maps found in Section 32.5 of ASCE 7, which vary based on the building size (effective plan area, A_e) and the building Risk Category (III or IV). The greater the effective plan area of a building and higher the risk category, the greater the probabilistic tornado wind speed. If V_T is less than 60 mph, design for tornado loads is not required. The remaining conditions listed above require comparing the same V_T to the basic design wind speed (V) for the site. If V_T is less than the indicated fraction of V for the building site's indicated wind exposure condition, design for tornado loads is not required.

If it is found that design for tornado loads is required, a detailed analysis of tornado loads for the building and building components in accordance with Chapter 32 of ASCE 7 is necessary. Some important general considerations are addressed in the following section.

Determining Tornado Loads

In comparison to the wind design procedure of ASCE 7 (Chapters 26-30), the tornado loads of Chapter 32 have very different values for the following key wind load parameters:

- Velocity pressure exposure coefficient (K_{zTor}) – see ASCE 7-22, Section 32.10,
- Internal pressure (GC_{piT}) – see ASCE 7-22, Section 32.13,
- Tornado pressure coefficient adjustment factor (K_{vT}) – see ASCE 7-22, Section 32.14,
- Directionality Factor (K_{dT}) – see ASCE 7-22, Section 32.6,
- Wind exposure classifications do not apply – see ASCE 7-22, Section 32.7, and
- Topographic factor does not apply – see ASCE 7-22, Section 32.8.

These parametric differences in analyzing tornado loads in comparison to "normal" wind loads are explained as follows:[3]

> *"Tornado Velocity Pressure. While the effects of terrain and topography on tornado wind speed profiles are not yet well understood, a review of near-surface tornadic wind measurements from*

mobile research radar platforms plus numerical and experimental simulations consistently showed wind speed profiles with greater horizontal wind speeds closer to the ground than aloft. The tornado velocity pressure profile (K) used has a uniform value of 1.0 from the ground up to a height of 200 ft, with a slightly smaller value at greater heights. In comparison, wind loads are based on an assumed boundary layer profile, where wind speeds are slower near the ground due to the effects of surface roughness.

Tornado Design Pressures. Atmospheric pressure change (APC) was found to have significant contributions to the tornado loads, particularly for large buildings with low permeability. The internal pressure coefficient was modified to also include the effects of APC. Since APC-related loads are not directionally dependent, the directionality factor was removed from the velocity pressure equation and added to the external pressure term (only) in the design pressure/load equations. The directionality factor K_d was modified through analysis of tornado load simulations on building MWFRS and components and cladding (C&C) systems. The resulting tornado directionality factor K_{dT} has values slightly less than the corresponding wind K_d values, with the exception of roof zone 1' (in the field of the roof), which increased. External pressure and force coefficients for both the MWFRS and C&C remain unchanged, but a modifier (K_{vT}) was added to account for experimentally determined increases to uplift loads on roofs caused by updrafts in the core of the tornado."

Consequently, tornado loads can control building or component design even when the mapped probability-based tornado wind speed, V_T, is less than the mapped basic wind speed, V, normally used for wind design.

WARNING: Because it is dangerous to walk, climb or work on a roof, ARMA recommends that only trained professionals engage in such activity. If you choose to do so, exercise extreme care, comply with all government safety regulations, and follow all safety work practices, precautions and procedures, including but not limited to manufacturer's instructions, labels, and warnings.