NCSEA
National Council of Structural Engineers Associations

Structural Engineering for Tornados FAQ

What tornado design resources exist for Structural Engineers?

ICC/ NSSA 500 *Standard for the Design and Construction of Storm Shelters*

Safe Rooms for Tornadoes and Hurricanes: Guidance for Community and Residential Safe Rooms, FEMA P-361, April 2021, Fourth Edition

ASCE/SEI 7-22: Minimum Design Loads and Associated Criteria for Buildings and Other Structures

Are buildings currently designed to withstand tornadoes?

Historically, there has not been a requirement for structures to be designed for tornadoes. This was due to perception that the probability of any individual building or structure being impacted by a tornado was small given their infrequency of occurrence and very limited spatial extent. However, in recent years, several tornadoes have caused damage that has resulted in extensive life and property loss. This has led to a re-examination of approaches to structural design for tornadoes.

The National Institute of Standards and Technology (NIST) started working toward its goal of a wind load standard for tornado-resistant design after a tornado devastated Joplin, Missouri on May 22, 2011. In December 2021, ASCE/SEI 7-22 was published, and it contains the first code chapter on tornado resistance.

Will all buildings designed under the new ASCE 7-22 provisions be required to be designed for tornadoes?

No. To balance construction costs and adoption of the proposed provisions, these initial provisions were limited in scope. The provisions use the same probability of structural failure as the standard uses as the basis for structural failure from non-tornadic winds. The standard also only applies to structures classified as Risk Category (RC) III or IV that are located in the tornado-prone region of the United States. This area is generally considered to be the contiguous states east of the Continental Divide.

Why are Risk Category I and II structures not required to be designed for tornado loads?

RC III and IV buildings and structures represent a substantial hazard to human life in the event of failure. These buildings and structures should have shorter recovery times following a tornadic event to support the community recovery. Among these are occupancies for public assembly or large groups, schools, and certain infrastructure. RC IV buildings are those designated as essential structures, such as hospitals and police & fire stations.

The provisions do not apply to RC I buildings, which represent a low hazard to human life in the event of failure, such as agricultural facilities, certain temporary facilities, and minor storage facilities. And it does not apply to most RC II buildings, including residential and office buildings, except those that include places of public assembly.

Why do the new provision scoping guidelines depend on building size?

Buildings with larger footprints are more vulnerable to tornado damage because they are larger targets. Under the ASCE 7-22 provisions, engineers must first calculate the effective area of the building, which often goes beyond its actual footprint if it is not a rectilinear shape or has supporting elements (e.g., generator) outside the building footprint.

Where will engineers find the tornado design wind speeds?

The tornado speeds to use in structural calculations are provided in the standard and will be provided on the ASCE Hazard Tool (free of charge).

If the tornado maps show a lower wind speed than the basic wind speeds, can an engineer (by inspection) eliminate the tornado wind calculations?

No. It is important to perform two independent sets of calculations: tornado and wind. There are many variables that affect the wind pressure for tornadoes differently than wind, including significant vertical components, rapid atmospheric pressure changes, internal pressures assumptions, and load combinations.

Would this new standard have prevented the damage caused by the December 11, 2021, tornadoes?

The ASCE 7-22 Standard is the beginning of development of tornado loads. The provisions contained within this new standard are based upon the more "typical" level of tornadoes that occur which are in the range of EF0 to EF2. The largest of the December 11, 2021, tornadoes are estimated to have been of the EF4 and EF5 size.

Also, as noted, the provisions are currently limited to Category III and IV structures. For example, the fire station in Mayfield would have been required to be designed for elevated loading, while the homes and warehouses would not have been required.

What is NCSEA or my local SEA doing to ensure practicing engineers are equipped to design structures for tornado loads?

NCSEA, with input from local SEAs and practicing engineers, has advocated at the ASCE 7-22 code development hearings. In addition, NCSEA Wind Engineering Committee continues to educate practicing engineers on the implementation of the new tornado provisions, including sessions at the 2020 and 2021 NCSEA Structural Engineering Summit, and forthcoming webinar series and development of example problems.