

# Foundation and Anchoring Criteria for Safe Rooms

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*Prefabricated safe rooms provide cost-effective solutions for people seeking protection from tornadoes. Given the extreme forces safe rooms may experience, there are specific foundation and anchoring requirements that, if overlooked, can leave occupants at risk of injury or death during tornadoes.*

Whenever prefabricated safe rooms are installed using Federal Emergency Management Agency (FEMA) grant funds, they are required to be designed, manufactured, and installed in accordance with the criteria in FEMA P-361, *Safe Rooms for Tornadoes and Hurricanes: Guidance for Community and Residential Safe Rooms* (see textbox), which uses the International Code Council® and National Storm Shelter Association® standard ICC 500, *ICC/NSSA Standard for the Design and Construction of Storm Shelters*, as a referenced standard. Safe rooms must be designed to resist the loads specified in the applicable code as well as the loads prescribed in ICC 500 Chapter 3 (Structural Design), which include wind loads, roof live loads, wheel loads (where in-ground units are subject to vehicle loading), hydrostatic loads (see Buoyancy section on page 4), and flood loads where sited in flood hazard areas. Safe rooms must also be capable of resisting impact loads in accordance with ICC 500 Section 305.

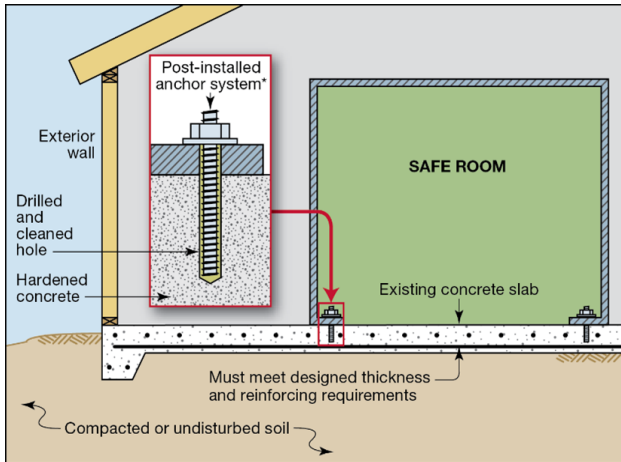
All FEMA-funded residential safe rooms must be designed to resist wind loads and missile impacts for a tornado design wind speed of 250 mph regardless of location or storm type. Refer to FEMA P-361 Table B3-1 for more information.

To provide life-safety protection, the safe room foundation must be able to resist the uplift, overturning, and sliding forces acting on the safe room during an extreme wind event, and then transfer the resulting forces into the supporting soils. According to ICC 500 Section 307.2, slabs-on-ground that are part of the storm shelter's foundation system must be designed in accordance with the American Concrete Institute (ACI) standard ACI 318, *Building Code Requirements for Structural Concrete* (or ACI 332, *Residential Code Requirements for Structural Concrete*, for one- and two-family dwellings), for all loads specified in ICC 500 Chapter 3. The design calculations must also take into account the presence of slab joints (per ICC 500 Section 307.2.1).

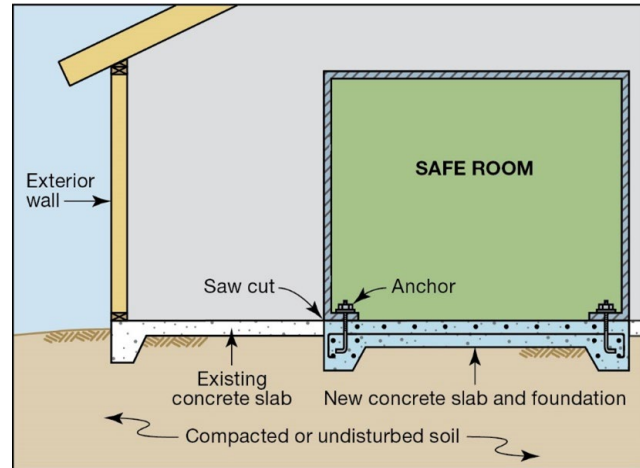
Where existing foundations (including slabs) are used to support storm shelters or safe rooms, they must be evaluated to determine whether they meet ICC 500 foundation requirements. Often, ICC 500 requires greater wind load resistance than typical slabs are capable of providing. In such cases, the evaluation will typically trigger



replacement of the slab.<sup>1</sup> Figure 1 shows a safe room installed on an existing slab-on-ground foundation that has been evaluated to meet or exceed the minimum specifications by the safe room manufacturer (in accordance with ICC 500 foundation requirements). Figure 2 shows a safe room installed on a new foundation because the existing slab-on-ground foundation did not meet the minimum requirements to resist all applicable safe room and storm shelter loads.



**Figure 1: Existing concrete slab foundation that has been evaluated to meet the requirements of FEMA P-361 and ICC 500 Section 307**



**Figure 2: New concrete slab foundation that has been designed to meet the requirements of FEMA P-361 and ICC 500 Section 307**

## POST-INSTALLED ANCHORS

Post-installed anchors are anchors that are installed into hardened concrete. This is typically done by drilling a hole in the concrete, cleaning the hole, applying epoxy, placing the anchor, and allowing it to set. Since post-installed anchors require careful attention during installation to be effective, ICC 500 requires a special inspection.

<sup>1</sup> ICC 500 Section 307.3 provides conditions where replacing or strengthening the existing slab is not required for concrete or masonry storm shelters and safe rooms.

## Construction Documents

Safe room construction documents (e.g., plans, specifications, installation requirements) should be prepared by a registered design professional. For prefabricated residential safe rooms, the minimum foundation capacity specifications and anchor installation requirements should be provided to the installer and homeowner by the unit's manufacturer. The safe room installer should follow the installation requirements precisely, and if any site conditions differ from the plan assumptions, then the installer should contact the manufacturer to resolve the conflict. The information should also be submitted with the application for permit, so the building official is able to verify compliance as needed.

### DESIGN INFORMATION

ICC 500 Section 106.2 provides design information required within storm shelter or safe room construction documents and includes the following foundation-specific items:

- Minimum foundation capacity requirements, including foundation thickness, steel reinforcement, and concrete cover
- Installation requirements, including anchor locations, minimum edge and end distances, and minimum required capacity for all post-installed anchors

## Post-Installed Anchors and Special Inspections

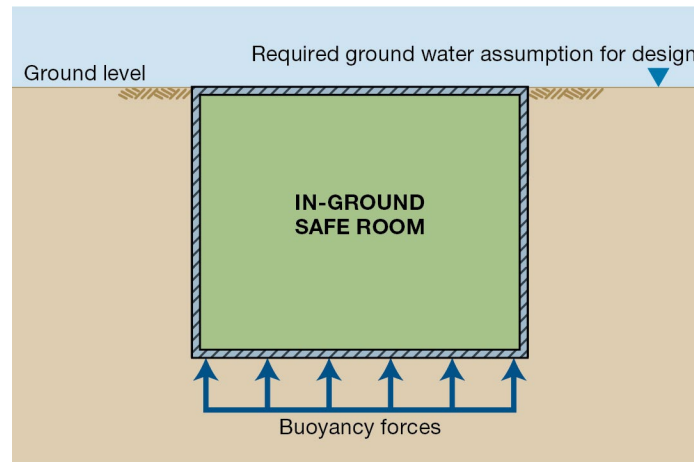
Whenever storm shelter or safe room foundation anchors are installed into hardened concrete (i.e., post-installed anchors), ICC 500 requires a special inspection (per Section 111.1.2.1 of ICC 500) to verify that the anchor installation and foundation capacity are in accordance with the information submitted in the construction documents.

Post-installed anchors depend on adhesive bonding or friction for pull-out resistance, making the performance of the connection highly dependent on its proper installation, including meeting the required thickness for the anchor manufacturer's specified embedment depth. Post-installed anchors must be appropriately selected by the designer and installed in accordance with the manufacturer's installation instructions as required in Chapter 17 of ACI 318-19.

As a best practice, any installer of post-installed epoxy anchors should be certified as an ACI-CRSI Adhesive Anchor Installer. ACI and CRSI (Concrete Reinforcing Steel Institute) operate a program to train and certify Adhesive Anchor Installers. See <http://www.concrete.org/certification/certificationprograms.aspx>.

## Buoyancy

In-ground safe rooms must be designed to resist buoyancy. Section 303.4 of ICC 500 requires that any underground portions of storm shelters (and safe rooms, by reference) be designed to resist buoyancy and hydrostatic loads, assuming the ground water level is at the surface of the ground at the entrance to the storm shelter (see Figure 3), unless adequate drainage is available to justify designing for a lower ground water level. If an in-ground safe room is not properly anchored, heavy rainfalls and an increase in the water table (even temporarily) can push the safe room out of the ground.



**Figure 3: Ground water level that should be used for in-ground safe room anchorage design**

This means that all in-ground storm shelters and safe rooms need to be designed to resist buoyancy forces, regardless of whether they are within a host building or are separate, detached structures. Consumers should be sure to receive confirmation from the manufacturer that buoyancy forces have been considered during design and that the safe room they are purchasing will be anchored to resist movement or displacement due to buoyancy forces.

## Resources

ACI (American Concrete Institute). 2019. *Building Code Requirements for Structural Concrete*, ACI 318.

<https://www.concrete.org/store/productdetail.aspx?ItemID=318U19&Language=English>.

ACI. 2020. *Residential Code Requirements for Structural Concrete*, ACI 332,

[https://www.concrete.org/store/productdetail.aspx?ItemID=33220&Language=English&Units=US\\_Units](https://www.concrete.org/store/productdetail.aspx?ItemID=33220&Language=English&Units=US_Units).

FEMA (Federal Emergency Management Agency). 2024. *Safe Rooms for Tornadoes and Hurricanes: Guidance for Community and Residential Safe Rooms*, FEMA P-361, Fifth Edition. Download a free copy from

<https://www.fema.gov/emergency-managers/risk-management/safe-rooms/resources>.

FEMA. 2024. *Taking Shelter from the Storm: Building a Safe Room for Your Home*, FEMA P-320, Sixth Edition.

Download a free copy from <https://www.fema.gov/emergency-managers/risk-management/safe-rooms/resources>.

ICC/NSSA (International Code Council / National Storm Shelter Association). 2023. *ICC/NSSA Standard for the Design and Construction of Storm Shelters*, ANSI/ICC 500-2023,

<https://codes.iccsafe.org/content/ICC5002023P1>.