FEMA Fact Sheet

Foundation and Anchoring Criteria for Safe Rooms

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

Prefabricated safe rooms are required to be designed and manufactured in accordance with the criteria in Federal Emergency Management Agency (FEMA) publication P-361 (see textbox), which uses International Code Council® publication ICC 500, *Standard for the Design and Construction of Storm Shelters,* as a referenced standard. Specifically, residential tornado 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, hydrostatic loads (see Buoyancy section on page 3) 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.

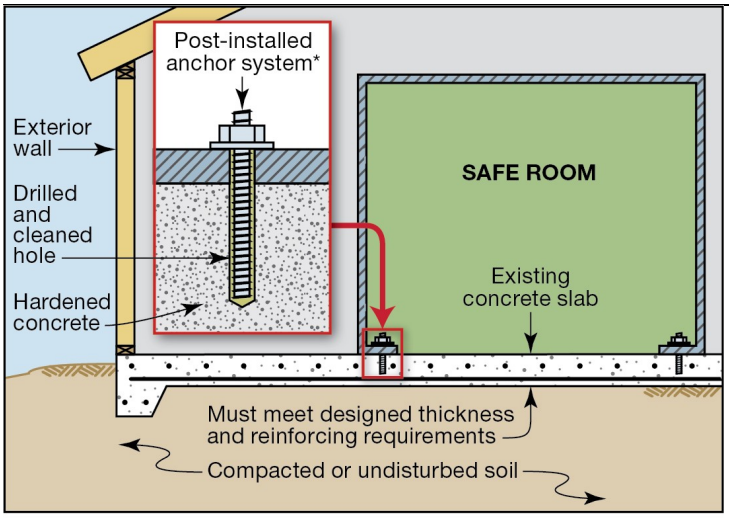
All FEMA-funded residential safe rooms must be designed to resist wind loads and missile impacts for a tornado design wind speed of 250 mph regardless of location or storm type. Refer to FEMA P-361 Table B3-1 for more information.

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 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 if they meet ICC 500 foundation requirements. Oftentimes, ICC 500 requires greater wind load resistance than typical slabs are capable of providing. In such cases, the evaluation will trigger replacement or strengthening the slab.[1] Figure 1 shows a safe room installed on an existing slab-on-ground foundation that has

[1] 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.

been evaluated to meet ICC 500 foundation requirements, while Figure 2 shows a safe room installed on a new foundation because the existing slab-on-ground foundation did not meet the requirement to resist all applicable safe room and storm shelter loads.



*Special inspection required per ICC 500 Section 110.1.2.1

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

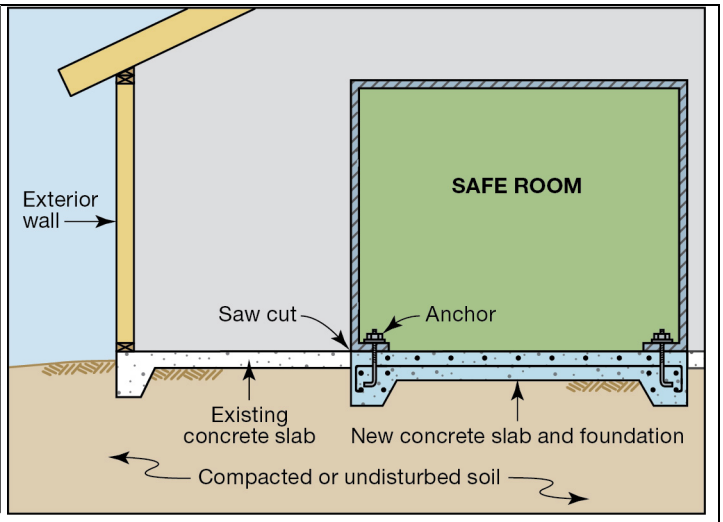


Figure 2: New concrete slab foundation that has been designed to meet the requirements of FEMA P-361 and ICC 500 Section 307

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.

Construction Documents

Safe room construction documents (e.g., plans, specifications, installation requirements) must be prepared by a registered design professional and submitted to the authority having jurisdiction; for prefabricated safe rooms, they should also be made available to the safe room installer and owner. The 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.

Post-Installed Anchors and Special Inspections

Whenever an existing slab is used as the foundation for a safe room, ICC 500 requires a special inspection to verify that post-installed anchor installation and capacity are in accordance with the information submitted in the construction documents.

CONSTRUCTION DOCUMENTS

ICC 500 Section 106.2 provides design information that is required to be submitted for storm shelter or safe room permits 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 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 (as well as forces from saturated soils), 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.

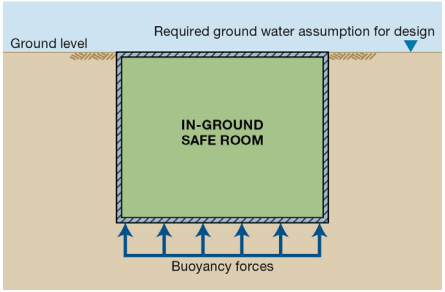


Figure 3: Ground water level for in-ground safe room

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 separate, detached structures. Consumers should be sure to receive confirmation from the manufacturer that buoyancy forces have been considered and that the safe room they are purchasing is able to resist movement due to buoyancy forces.

Resources

ACI 318, *Building Code Requirements for Structural Concrete*, 2019, https://www.concrete.org/store/productdetail.aspx?ItemID=318U19&Language=English.

ACI 332, *Residential Code Requirements for Structural Concrete,* 2020, https://www.concrete.org/store/productdetail.aspx?ItemID=33220&Language=English&Units=US_Units.

FEMA P-320, *Taking Shelter from the Storm: Building a Safe Room for Your Home, 2021*, https://www.fema.gov/emergency-managers/risk-management/safe-rooms/resources.

FEMA P-361, *Safe Rooms for Tornadoes and Hurricanes: Guidance for Community and Residential Safe Rooms*, 2021, https://www.fema.gov/emergency-managers/risk-management/safe-rooms/resources.

ICC 500, *ICC/NSSA Standard for the Design and Construction of Storm Shelters*, 2020, https://codes.iccsafe.org/content/ICC5002020P1.