FEMA

Fact Sheet

Federal Insurance and Mitigation Administration

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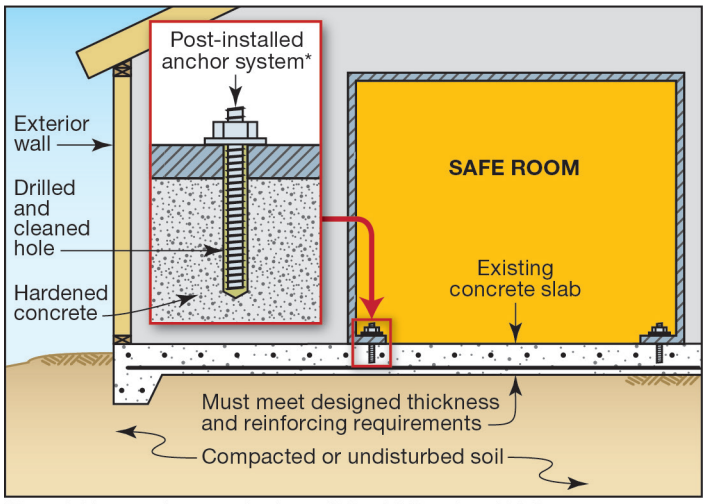
Foundation and Anchoring Criteria for Safe Rooms

Prefabricated safe rooms are becoming more popular as people seek 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 should be designed and manufactured in accordance with the criteria in FEMA P-361, which uses ICC 500, *Standard for the Design and Construction of Storm Shelters,* as a referenced standard. All safe rooms must be capable of resisting the loads and forces specified in ICC 500, which include roof loads, wind loads, wind-borne debris impacts, flood loads, and buoyancy forces (see Buoyancy section on page 2). The purpose of this Fact Sheet is to make homeowners, builders, safe room manufacturers, and design professionals aware of the requirements for safe room foundations and anchoring.

Existing foundations must be carefully evaluated to determine if they are capable of supporting a prefabricated safe room. To perform properly, the foundation of a safe room must be able to resist the uplift, overturning, and sliding forces from the safe room during an extreme wind event. According to ICC 500 (Section 308.1), slab-on-grade foundations must be designed for the applicable loads and must *at a minimum* be 3.5 inches thick, contain steel reinforcement, and take into account the presence of slab joints (Ref. 308.1.1.2).[1] In many cases, the loads created by design wind speeds will require even more robust slabs (i.e., greater than the 3.5-inch minimum). Figure 1 shows a safe room installed on an existing slab-on-grade that meets the designed thickness and reinforcing, while Figure 2 shows a safe room installed on a new foundation required because the existing slab-on-grade did not meet the thickness or reinforcement requirements to resist all applicable loads.



*Special inspection required per ICC 500 Section 106.3

Figure 1: Existing concrete slab that has been evaluated for all applicable loads and meets the designed thickness and reinforcing requirements (see Section 308 in ICC 500)

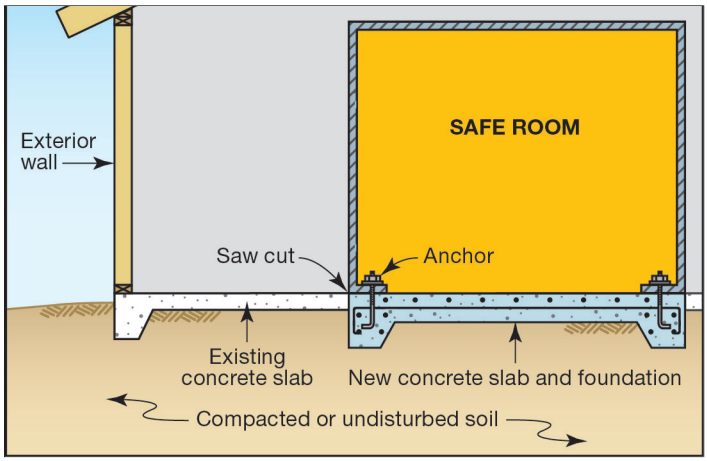


Figure 2: New concrete slab and foundation that has been designed for all applicable loads and meets the designed thickness and reinforcing requirements (see Section 308 in ICC 500)

Construction Documents

Construction documents for a safe room (e.g., plans, specifications, installation instructions) should be prepared by a registered design professional in the state where the safe room is being installed, and made available to the safe room installer and owner. The installer should follow the plans precisely, and if any site conditions differ from the plans, the installer should contact the designer to resolve the conflict.

1 ICC 500, Section 308.1.1.1 requires minimum steel reinforcement for slabs-on-grade be 6x6 – W1.4 x W1.4 welded wire reinforcement or No. 4 bars, at a maximum spacing of 18 inches (457 mm) on center, in two perpendicular directions. ICC 500 does provide an exception to the thickness and reinforcement requirement for concrete and concrete masonry unit safe rooms in one- and two-family dwellings. However, the exception requires that the soil pressures meet certain criteria. In addition, the shelter must be anchored to the slab, at a minimum, at each corner of the structure and on each side of the doorway opening, and be heavy enough to independently resist overturning.

CONSTRUCTION DOCUMENTS

Safe room construction documents are required to provide the following foundation and anchoring information as specified in ICC 500:

- Design parameters and assumptions
- Manufacturer's installation instructions and recommendations
- Minimum foundation capacity requirements
- Anchor locations
- Minimum required capacity for each anchor
- Minimum requirements for post-installed anchor adhesive or epoxy (if applicable), including product specifications, allowable edge distance, and installation instructions

Special Inspections

Whenever an existing slab is used as the foundation for a safe room, ICC 500 requires a Special Inspection.[2,3] The Special Inspection is intended to verify the anchor installation and capacity, and the foundation adequacy. At a minimum, the following must be reviewed and verified:

1. The thickness of the slab and required reinforcing steel meets or exceeds what is shown on the construction documents.
2. The installation and capacity of the safe room anchors are in accordance with contract documents and manufacturer's instructions
3. Installation of post-installed anchor is in accordance with manufacturer's instructions
4. Bearing capacity of soil, if required

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.

Post-Installed Anchors

Post-installed anchors typically depend on adhesive bonding or friction for pull-out resistance, making the performance of the connection highly dependant on its proper installation, including meeting the required thickness for the anchor

2 Special Inspection is a defined term in ICC 500.

3 The Special Inspection requirement can be bypassed on residential safe rooms only if the authority having jurisidiction (AHJ) verifies that the foundation and anchoring complies with the requirements of the safe room or storm shelter design. FEMA strongly recommends that building officials or other AHJ ensure that the installation of the safe room complies with the design plans or the manufacturer's installation instructions before granting a waiver for the Special Inspection. This can be done by having the installer provide the AHJ with the relevant information ahead of the construction process, including the engineering calculations verifying the adequacy of the slab and any existing conditions, such as the thickness of the slab and the presence of required steel reinforcement.

POST-INSTALLED ANCHORS

Post-installed anchors are anchors that are installed into hardened concrete or masonry. This is typically done by drilling a hole to install an anchor system. Post-installed anchors can be convenient, but also require careful attention during installation to be effective.

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 in ICC 500 and Chapter 17 of the American Concrete Institute (ACI) standard ACI 318-14, *Building Code Requirements for Structural Concrete.*

Buoyancy

Underground safe rooms must be designed to resist buoyancy. Section 303.3 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.

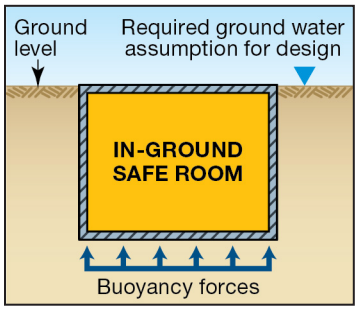


Figure 3. Diagram showing the buoyancy forces applied to an in-ground safe room; designers must assume that the ground water level will be at the surface of the ground.

This means that all in-ground 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

FEMA P-361, *Safe Rooms for Tornadoes and Hurricanes: Guidance for Community and Residential Safe Rooms*, 2015, https://www.fema.gov/fema-p-361-safe-rooms-tornadoes-and-hurricanes-guidance-community-and-residential-safe-rooms.

ICC 500, ICC/NSSA Standard for the Design and Construction of Storm Shelters, 2014, http://shop.iccsafe.org/icc-500-2014-icc-nssa-standard-for-the-design-and-construction-of-storm-shelters-1.html.