

RESIDENTIAL BUILDINGS IN FLOOD-PRONE AREAS: Selecting Materials for Constructing an Elevated Conditioned Space Enclosure

Based on requirements for City of Houston, TX and Harris County, TX

Disclaimer: This TechNote is not intended to supersede applicable laws, codes, or ordinances.

Introduction

Following Hurricane Harvey, the City of Houston and Harris County, TX, introduced new ordinances for construction in flood-prone areas. The purpose of this TechNote is to provide guidance to builders and designers on selecting building materials for constructing elevated conditioned space enclosures for new residential buildings that will be located within these jurisdictions.

This TechNote features solutions that maximize the flexibility in material choices, such as insulation products, for construction of the elevated conditioned space. Specifically, the TechNote provides guidance on the requirements for floor systems in various flood zones.

Flood-Resistant Design

After the flood zone designation for the site has been identified by the local building department, key steps in implementing flood-resistant building design include:

- **Step 1** — Identifying the minimum elevation requirements ([Page 2](#))
- **Step 2** — Selecting foundation type appropriate for the flood zone and elevation ([Page 3](#))
- **Step 3** — Identifying elements of the buildings where flood-resistant materials are required ([Pages 3-5](#))

This TechNote highlights each of these steps from the standpoint of selecting solutions for the elevated conditioned space enclosure.

How to Insulate a Home with Minimal Material Restrictions

This TechNote outlines practices for constructing a home within a flood zone with minimal restrictions on insulation materials. The primary strategy for achieving this goal is to raise the elevation of the conditioned space enclosure, including the insulation, above specific flood elevations for your location.

Homes that include conditioned spaces that are not above these elevations are subject to restrictions in material requirements in accordance with FEMA Technical Bulletin 2 (TB-2, August 2008) — refer to [Page 5](#) of this TechNote for more information on TB-2.

FIGURE 1.
Zone A Foundation
Example: Perimeter
Walls

Description:
**Bottom of the Floor
is Elevated 2 ft Above
500-Year Flood**

Elevated Conditioned
Space: Class 1-5
Materials Can Be Used



Local Requirements

The City of Houston and Harris County each implemented a set of requirements for construction in flood-prone areas that are based on and, in several aspects, exceed FEMA NFIP. The key differences between the requirements as related to the scope of this TechNote are highlighted below. Neither jurisdiction's rules regarding the use of flood damage-resistant materials make changes to FEMA TB-2.

Flood Zone Designation

The local building department will provide the flood zone designation for the construction site as part of the permitting process. Zones reflect the intensity and type of flood hazard.

Elevated Conditioned Space Enclosure

In this TechNote, the term "Elevated Conditioned Space" Enclosure is used to describe the walls, floors, and ceilings that envelop the conditioned space of the building.

Enclosed Area—Unconditioned Space

The term "Enclosed Area or Enclosure," often used in various documents on flood-resistant construction, refers to the space enclosed by walls below the elevated building. This space requires flood openings in walls or breakaway walls or open construction to allow water flow into the area below the elevated building. Enclosed areas are not part of the elevated conditioned space of the building and do not need to be insulated.

STEP 1: ELEVATION REQUIREMENTS

To provide an added level of protection against damage from future floods, the City of Houston and Harris County established elevation requirements at levels more stringent than either the National Flood Insurance Program or the International Residential Code (see Table 1).

Two key requirements:

1. **Design Flood Elevation (DFE)** is set at 0.2% annual probability of exceedance (500-year flood).
2. **Freeboard** is set at **2 feet or more above the DFE**.

TABLE 1. Elevation Requirements

Flood Zones	City of Houston	Harris County
Floodways	New construction not permitted	Lowest Horizontal Structural Member (LHSM) at DFE (500yr flood) plus 3 ft
A Zones	Top of Lowest Floor at DFE (500yr flood) plus 2 ft^a	Top of Lowest Finished Floor at DFE (500yr) plus 2 ft
AO Zone	Top of Lowest Floor at average depth plus 2 ft, OR plus 3 ft above highest adjacent grade	Top of the Lowest Finished Floor is at FIRM-specified average depth^b plus 3 ft
V Zones	LHSM at DFE (500yr flood) plus 2 ft	LHSM at DFE (500yr food) plus 3 ft
X Zone Shaded	Top of Lowest Floor at DFE (500yr flood) plus 2 ft^a	Finished floor elevation at DFE (500yr flood), or If LAG below BFE – Class II permit^b
X Zone Unshaded	N/A	Finished floor elevation at least 12 in. above adjacent ground

a. As an exception in A Zone and X Zone only, the City of Houston allows a minimum elevation of DFE plus 1 foot for additions of 33% or less.

b. Refer to Harris County Regulations for Flood Plain Management for defining average depth and adjacent grade reference point.

TERMS AND ABBREVIATIONS

BFE = Base Flood Elevation – flood corresponding to 1% annual probability of exceedance (i.e., 100-year flood)

DFE = Design Flood Elevation

FEMA = Federal Emergency Management Agency

FIRM = Flood Insurance Rate Map

Freeboard = Distance between the designated reference surface of the lowest floor and either (1) the base flood elevation (BFE) or (2) the design flood elevation (DFE), whichever is applicable

IRC = International Residential Code

LAG = Lowest Adjacent Grade

LHSM = Lowest Horizontal Structural Member

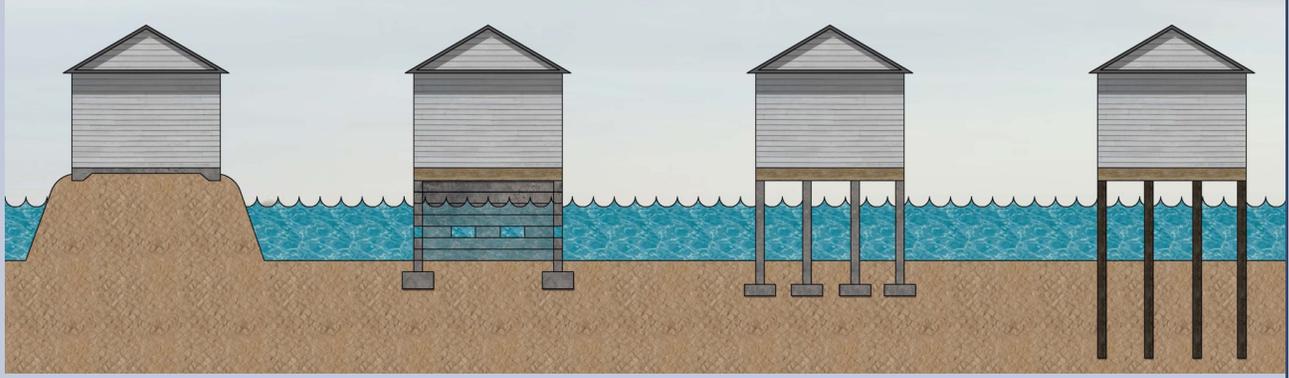
NFIP = National Flood Insurance Program

SFHA = Special Flood Hazard Areas – land assigned an A Zone or a V Zone designation on the FIRM

STEP 2: FOUNDATION TYPES

Foundation options permitted for elevating buildings in flood-prone areas depend on the flood zone designation for the site. Table 2 summarizes foundation types required in the City of Houston and Harris County, TX.

TABLE 2. Elevated Foundation Types



Flood Zones	Type I: Slab-on-Fill		Type II: Perimeter Wall		Type III: Piers, Posts, Columns		Type IV: Piles	
	Harris County	City of Houston	Harris County	City of Houston	Harris County	City of Houston	Harris County	City of Houston
X Zones	✓	✓	✓	✓	✓	✓	✓	✓
A Zones	∅	✓	✓	✓	✓	✓	✓	✓
V Zones	∅	∅	∅	∅	✓	✓	✓	✓
Flood Way	∅	∅	∅	∅	✓	∅	✓	∅

STEP 3: SELECTION OF MATERIALS

After the foundation type has been selected, the next design step is to identify where flood damage-resistant materials are required within the building. The foundation type and the selected elevation will determine the material choices. See Table 5 for material classification.

Slab on Grade or Slab on Fill Foundations (A Zones & X Zones Only)

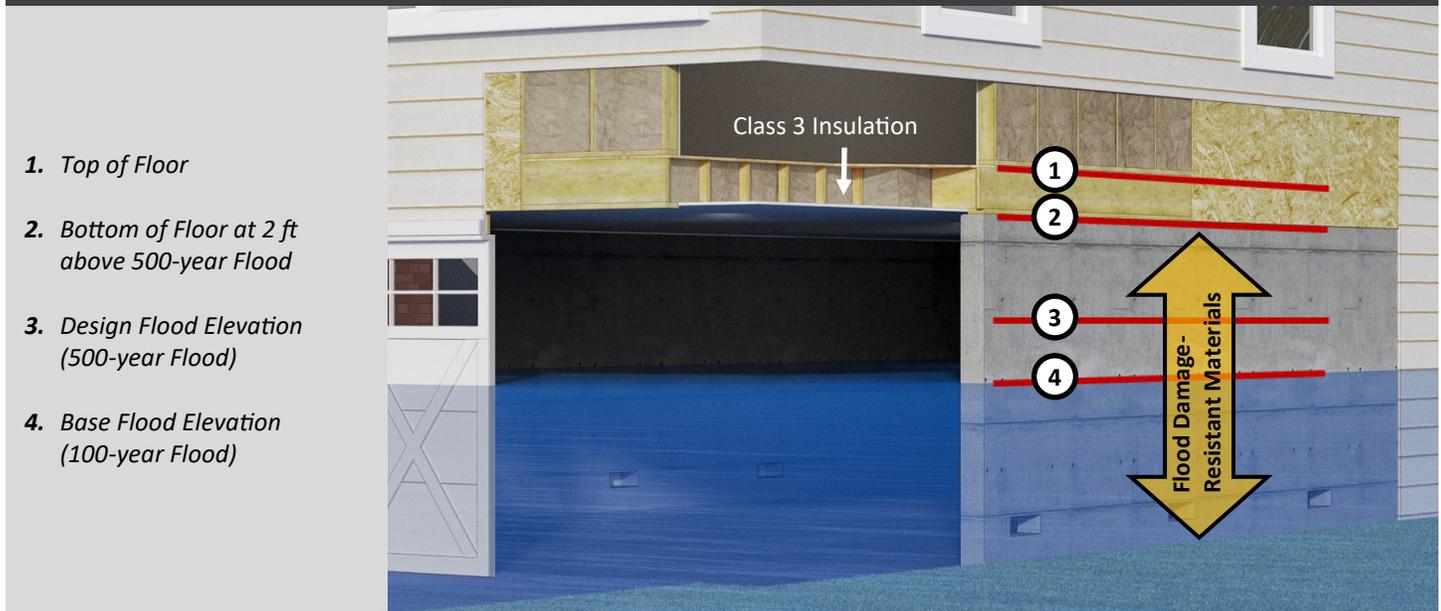
In a building supported by a slab foundation, concrete is the only material located below the required elevation level. Therefore, there are no special requirements for selection of materials for the Elevated Conditioned Space Enclosure for buildings supported on a slab. The walls supported directly on the slab can be built using Class 1-5 materials that comply with all applicable requirements of the building code. If edge slab insulation is specified, only closed-cell plastic foam or another Class 4-5 material is permitted for this application.

Perimeter Wall Foundations (A Zones & X Zones Only)

Perimeter walls can be used in A Zones and X Zones to elevate the house to the levels in Table 1. The space enclosed by the perimeter walls can be used only for parking, building access, or storage. Permanent flood openings are required in perimeter walls to allow water to enter and exit the space enclosed by the perimeter walls so that the hydrostatic pressure can be equalized across the wall. Therefore, the area enclosed by the perimeter walls cannot be constructed as conditioned space and does not need to be insulated.

FIGURE 2. Zone A Foundation Example: Perimeter Walls

Description: Conditioned Space Enclosure (Including Insulation and All Floor Materials) is Elevated 2 ft Above 500-Year Flood



1. Top of Floor
2. Bottom of Floor at 2 ft above 500-year Flood
3. Design Flood Elevation (500-year Flood)
4. Base Flood Elevation (100-year Flood)

The choice of materials for constructing the floor system in this case depends on the selected elevation – see Table 3.

Where a **Class 3** insulation, such as fiberglass or mineral wool, is the preferred insulation material, the bottom of the floor must be elevated such that the insulation material is above the minimum flood elevation for Zone A. Figure 2 shows an example of a perimeter wall supporting a floor insulated with a **Class 3** material where the bottom of the floor is elevated 2 feet above a 500-year flood level.

If the floor system enclosing conditioned space is elevated to the minimum level required by the flood regulations for A Zones (i.e., top of the floor is at DFE+2 feet), all floor materials including insulation must be **Class 4 or 5**.

The walls supported by the lowest elevated floor will be always above the level for flood damage-resistant materials. Therefore, the walls can be constructed and insulated with any materials compliant with the building code for non-flood areas.

TABLE 3. Floor System in A Zones and X Zones Only

Elevation Requirement	Requirements for Material Used in Floor Systems
Bottom of floor at DFE+2 ft or more (DFE: 500-year flood)	Class 1-5 materials can be used
Top of floor at DFE +2 ft or more (DFE: 500-year flood)	All materials used in the floor system must be Class 4 or 5

The perimeter foundation walls must be constructed using **Class 4 or 5 flood** damage-resistant materials. Where the perimeter walls extend above the minimum elevation requirement, those portions can be constructed using standard

materials compliant with building codes for non-flood areas. Where using perimeter walls, the code requirements for the maximum unsupported wall height must be followed.

Pier, Posts, Columns, Piles (Any Flood Zone)

These foundation types can be used to elevate buildings in any flood zone. The minimum elevation requirement varies based on the flood zone:

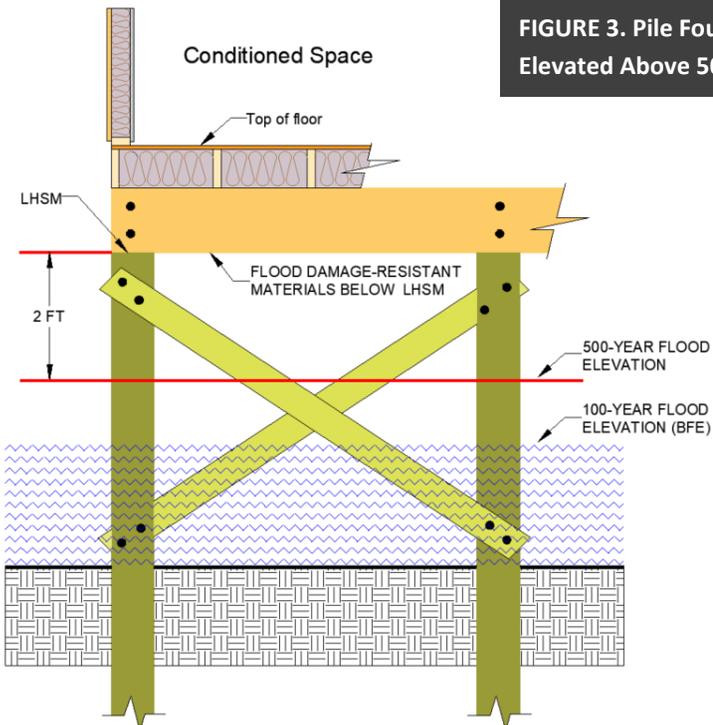
- **V Zones:** Building must be elevated such that the **lowest horizontal structural member (LHSM)** is at the designated level in accordance with Table 1.
- **A Zones:** Building must be elevated such that the **top of the lowest floor** is at the level designated in Table 1.

For V Zones, the material selection choices for the floor supported by the foundation are outlined in Table 4. Figure 3 shows an example of a pile foundation supporting a floor with **Class 3** insulation elevated 2 feet above 500-year flood in a V Zone. For A Zones, the requirements of Table 3 apply.

TABLE 4. Floor System Supported by Piers, Posts, Columns, or Piles (V Zones)

Jurisdiction	Elevation Requirement	Material Used in Floor Systems
City of Houston	Lowest horizontal structural member at DFE+2 ft (DFE: 500-year flood)	Class 1-5 materials can be used
Harris County	Lowest horizontal structural member at DFE+3 ft (DFE: 500-year flood)	Class 1-5 materials can be used

FIGURE 3. Pile Foundation Supporting a Floor with LHSM Elevated Above 500-Year Flood plus 2 ft (Zone V)



MATERIALS

FEMA Technical Bulletin 2 (TB-2) sets criteria for where flood damage-resistant materials are required to be used in a building and provides a classification of common construction materials for flood exposure. TB-2 applies to buildings located in Special Flood Hazard Areas (SFHAs – A & V Flood Zones) where construction below a specified elevation must consist of flood damage-resistant building materials (Class 4 & Class 5 materials). TB-2 does not require flood-resistant materials in X Zone Shaded and X Zone Unshaded or other areas outside of the SFHAs.

TB-2 defines flood-damage resistant materials as building products capable of withstanding direct and prolonged contact with floodwaters without sustaining significant damage. Table 5 summarizes classes of materials and provides examples of materials used for construction of

TABLE 5. Construction Materials Classification

Class	Brief Description	Allowed Below Target Elevation	Examples of Building Materials Used in Enclosure Assemblies
5	Highly resistant to floodwater damage, including moving water	Yes	Cement board/fiber-cement board; concrete; marine-grade plywood; solid decay-resistant wood; closed-cell plastic foam; concrete
4	Resistant to floodwater damage from wetting and drying, but less durable when exposed to moving water	Yes	Water-resistant fiber-reinforced gypsum exterior sheathing; Exterior Grade/Exposure 1 WBP plywood; solid standard structural 2x4; solid preservative-treated wood; ceramic tile with mortar set; vinyl sheets or tiles with chemical-set adhesive
3	Resistant to clean water damage but not floodwater damage	No	Paper-faced gypsum board; gypsum sheathing panels, exterior grade; fiberglass or mineral wool insulation in batts, blankets, or blown; I-joists
2	Not resistant to clean water damage	No	Edge swell-resistant OSB; open-cell plastic foam; cellulose insulation; solid wood floor; ceramic tile with organic adhesives
1	Not resistant to clean water damage or moisture damage	No	Mineral fiberboard; OSB; linoleum; carpeting; vinyl sheets or tiles with non-set adhesives

Source: Federal Emergency Management Agency (FEMA) Technical Bulletin 2: Flood Damage-Resistant Materials Requirements

References

- [1] Regulations of Harris County, Texas for Flood Plan Management, Harris County Engineering Department, Effective 1 January 2018. www.eng.hctx.net/Portals/23/Publications/FPMRegs120517.pdf
- [2] Code of Ordinances City of Houston, Texas, Chapter 19 – Floodplain. November 9, 2019. https://library.municode.com/tx/houston/codes/code_of_ordinances?nodeId=COOR_CH19FL_ARTIIISTFLHARE_DIV2STHOSPFLHAAR_S19-32GEST
- [3] 2015 International Residential Code, International Code Council. www.iccsafe.org
- [4] Flood Damage-Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas in Accordance with the National Flood Insurance Program, Technical Bulletin 2, FEMA, August 2008. https://www.fema.gov/media-library-data/20130726-1502-20490-4764/fema_tb_2_rev1.pdf