

Dry Floodproofing

Structural: In a building or structure that is dry floodproofed, the exterior envelope of the building or structure acts as the flood barrier. Dry floodproofing is practical when minimal structural design changes are needed to floodproof the building or structure. Dry floodproofing is best suited for buildings and structures that will experience short-term, minor flooding (< 5-feet) on a regular basis (at least once every 5 to 10 years).

Architectural: Using dry floodproofing means making the building, and all its utility systems, completely watertight and impermeable to the passage of water below the base flood elevation.²⁵ Using dry floodproofing will require a certification called the Floodproofing Certificate for Non-Residential Structures (FEMA Form 81-65). Examples of dry floodproofing features include:



- Sealants, coatings and membranes to reduce leakage of floodwater through walls and wall penetrations
- Installation of watertight closures for doors and windows
- Installation of flood barriers or shields around the structure
- Reinforcement of walls to withstand floodwater and floating debris
- Anchoring of the building to resist flotation, collapse and lateral movement
- Installation of pumps to control interior water levels
- Installation of check valves to prevent the entrance of floodwater or sewage flows through utilities
- Location of electrical, mechanical, utility and other valuable damageable equipment and contents above the expected flood level

Relation to Adaptation and Resiliency

Helps achieve protection of structures/facilities in the event of floods or natural disasters.

Benefits

According to FEMA document 551, Chapter 7, Table 7-1, advantages or benefits of dry floodproofing include:

- Dry floodproofing is less costly than other retrofitting methods.
- It does not require additional land that may be needed for other flood control measures like levees and floodwalls.
- Measures may be funded through FEMA mitigation grant programs.
- Dry floodproofing is most likely to be successful in cases where flood depths do not exceed three feet, although floodproofing to a greater flood depth may be possible. If NFIP compliance is required, building code requirements or local regulations govern the level of protection.

For buildings or structures that require minimal modifications for dry floodproofing, the additional cost and resources to dry floodproof the building or structure can be comparable with other floodproofing methods.

Limiting Factors (Constraints)

- Most sealing systems will begin to allow some leakage in after prolonged periods of exposure to water. If the structure is in an area where high flood waters can remain for days, a different measure should be used. Dry floodproofing is not recommended where flooding is expected to persist for a long period (longer than 12 hours). Prolonged contact with floodwaters increases the chance of seepage and structural failure in floodproofed buildings. Additionally, frequent flooding can adversely affect the building's structural integrity over time.
- Measures to remove water that will infiltrate the building are necessary for a dry floodproofing measure to be successful.



- Since dry floodproofing is often best suited for flood conditions that last for a relatively short period of time, warning time and the time it takes to deploy the various components of the dry floodproofing system must be considered. Warning time may be required to activate or deploy a given floodproofing measure before floodwaters begin to impact the site. Adequate warning time estimates should include time for evacuation, notification of key personnel, travel time to the site if key personnel are not located on site, implementation of the measure, and evacuation of key personnel.
- Dry floodproofing is not recommended for wood-frame construction or for areas where flood levels are greater than two to three feet.
- Dry floodproofing is not permitted: in Zone V under NFIP, in Coastal A Zone or Zone V per ASCE 24, and in Zone V if the community enforces building codes based on the IBC.

Design & Preliminary Costs

Design considerations include:

- That dry floodproofing is permitted under the NFIP compliance regulations for buildings that are undergoing substantial improvement or have incurred substantial damage only if the buildings are nonresidential.
- The superstructure and foundation should be able to adequately resist flood-related forces (hydrostatic, hydrodynamic, buoyancy, soil and debris impact) and the non-flood-related forces (e.g., wind, seismic) that are expected at the site.
- The superstructure and foundation should be evaluated by a registered professional engineer or architect. If the structure is not capable of resisting expected forces, additional retrofits to the structure may be necessary before floodproofing work begins.
- Underground utilities may need to be effectively sealed to prevent backflow of floodwaters into the building and electrical utilities below the flood protection level must be protected against floodwaters. Alternate power may be required to operate sump pumps if normal power sources are unavailable during a flooding event.

Additionally, the dry floodproofing design and proposed methods of construction are to be certified as being in accordance with accepted standards of practice. The standards of practice require that the building, together with attendant utility and sanitary facilities, be designed so that it is watertight below the base flood elevation, with walls substantially impermeable to the passage of water and with structural components that can resist hydrostatic and hydrodynamic loads and effects of buoyancy associated with the design flood event.

Costs depend on the type of measure and the flood depth they are designed to withstand. A design professional will require an evaluation of the condition of the specific building structure and the area under consideration to estimate costs. Based on the Consumer Price Index and using 1m or (3.28 feet) approximate flood depth, costs for dry floodproofing an industrial building are estimated to be \$50/sf in 2020, including miscellaneous costs such as overhead and contingencies. Typically, maintenance costs per year are estimated at 1–3% of the investment cost.

According to the Southern Tier Central Regional Planning and Development Board, July 2019, itemized costs for specific dry floodproofing features are:

- Dry Floodproofing Sprayed-on cement (above grade) – \$3.50 per square foot
- Waterproof membrane (above grade) – \$1.17 per square foot
- Asphalt (2 coats below grade; not including cost of excavation) – \$1.17 per square foot
- Perimeter drainage – \$33 per linear foot
- Plumbing check valve – \$660 lump sum
- Sump pump (with backup battery) – \$1,060 lump sum
- Metal flood shield – \$77 per square foot
- Wood flood shield – \$24 per square foot
- Sprayed-on cement (above grade) – \$3.50 per square foot

Additional Costs:

- Compliance with building codes – These estimates do not include additional expenditures that may be required to bring the building into compliance with building codes.
- Professional or architectural design – 10% of estimated costs
- Contractors' profit – 10% of estimated costs
- Contingency to account for unknown or unusual conditions



- Annual maintenance expenses – Levees, floodwalls, dry floodproofing, and wet floodproofing projects all require ongoing maintenance.

Additional Information: FEMA's Benefit-Cost Analysis methodology and tools (or similar) can be used to evaluate the cost effectiveness of proposed retrofitting projects.

Permits & Approvals

- 44 CFR 60 3(a)(1) & (b)(1)
- 44 CFR 60 3(a)(2)
- 44 CFR 59.1
- COMAR 26.17.04.11(B)(7)
- COMAR 26.17.04.03(A)

Additional permitting requirements and information regarding implementation of this measure can be found in the "Maryland Model Floodplain Management Ordinance (May 2014) MODEL RESOURCE", Section 3.4, page 21.28

Implementation

Dry floodproofing should be implemented during a station's design and construction to seal and strengthen the structure. Some dry floodproofing strategies will need to be deployed immediately before a flood (e.g. activate any pumps, deploy barriers). The act of deploying these strategies varies in duration depending on staff levels and complexity of implementation.

FEMA identifies the following dry floodproofing implementation challenges:

- Dry floodproofing may not be used to bring substantially damaged or substantially improved residential structure into compliance with the community's flood plain management ordinance or law.
- Dry floodproofing requires human intervention and adequate warning to install protective measures.
- Dry floodproofing does not minimize the potential damage from high-velocity flood flow and wave action.
- Flood shields may not be aesthetically pleasing.
- Flood proofing does not eliminate the potential for all flood damage.
- The areas above the protection levels of both dry and wet floodproofing are still at risk of damage from higher-than-expected floodwater levels, contamination, toxic materials near or inside the building, and mold from higher-than-normal humidity.
- When dry floodproofing measures are proposed for non-residential buildings, communities that participate in the National Flood Insurance Program (NFIP) require applicants to provide certification that registered professional engineers or architects have developed or reviewed the structural design, specifications, and plans for proposed dry floodproofing measures
- The NFIP's performance requirements are identical for both new construction and for substantial improvements or repairs to substantially damaged existing buildings.

Additional challenges may include:

- Most often existing buildings have mechanical systems that are located on floors below the base flood elevation. Moving equipment from basement areas requires finding new locations for the equipment, some structural/architectural changes to ensure new locations can accommodate equipment, and may require moving vents, louvers, wiring, and controls. Retroactively changing equipment positions can be a large and expensive renovation to make.
- A dry floodproofing retrofit project may trigger several sections of the building code that must be considered during the design. (The International Building Code (IBC) references the ASCE 7, Minimum Design Loads for Buildings and Other Structures, and ASCE 24, Flood Resistant Design and Construction.)



Maintenance Requirements

Dry floodproofing measures require annual maintenance to ensure that they are kept in working order. Maintenance will also vary depending on the dry floodproofing features implemented. Generally, dry floodproofing maintenance plans should include:

- An inventory and location list of all flood shields and closures.
- An inspection plan to ensure flood shields and other closures fit properly.
- Checking walls, floors, and floodproof coatings for cracks and leaks.

Useful Life

Dry floodproofing measures generally have an expected useful life ranging from 15 to 30 years and extensive annual maintenance costs needed to maintain the various elements.

References/Specifications

References:

https://www.fema.gov/media-library-data/20130726-1608-20490-9182/fema_551_ch_07.pdf

https://www.fema.gov/media-library-data/06dabddadc3887f91906172d863749ab/P-936_sec3_508.pdf

<https://www.wbdg.org/FFC/DHS/femap936.pdf>

https://mht.maryland.gov/documents/PDF/plan/floodpaper/1_Flooding%202018-06-30a.pdf

https://mdfloodmaps.net/pdfs/MD_FPM_Model_Resource.pdf

Dry Floodproofing Products:

The floodproofing products to be used need to be specified and included as part of the contract documents signed by a registered engineer or architect. <https://www.floodproofing.com/dry-floodproofing>

