FLOODPROOFING

Combination of adjustments or additions of features to the structure and surroundings designed to reduce or eliminate the damages from a flood.

- NFIP recognizes floodproofing for non-residential structures certified by an engineer or architect.

FORCES ON A STRUCTURE

- Hydrostatic
- Buoyant
- Hydrodynamic
- Debris Impact
- Erosive
HYDROSTATIC FORCES

- Lateral force acting on the walls of a structure
- Continues to act below the ground surface

Resilient Lateral Force Due to Hydrostatic Pressure from Freestanding Water:

\[ F_L = \frac{1}{2}wH \]

where:
- \( F_L \) is the lateral force from freestanding water (in pounds per linear foot of surface)
- \( w \) is the specific weight of water (62.4 pounds per cubic foot)
- \( H \) is the height of the standing water (to the floodproof design level)

If any portion of the building is below grade, then calculate the Resilient Cumulative Lateral Force Due to Hydrostatic Pressure from Saturated Soil:

\[ F_{rs} = 5.5SD + F_L \]

where:
- \( F_{rs} \) is the lateral force from saturated soil
- \( S \) is the equivalent fluid weight of saturated soil (in pounds per cubic foot)
- \( D \) is the depth of saturated soil (in feet)
- \( F_L \) is the lateral force from freestanding water

Note: See Appendix C of the FEMA "Design Manual for Retrofitting Flood-Prone Residential Structures" for further information.
BUOYANT FORCES

- Acts on the bottom floor of the structure pushing the structure upwards
- Continues to act below the ground surface

Buoyancy Force:

\[ F_b = \gamma A H \]

where:
- \( F_b \) is the force due to buoyancy
- \( \gamma \) is the specific weight of water (62.4 pounds per cubic foot)
- \( A \) is the area of horizontal surface (floor or slab) being acted upon (in square feet)
- \( H \) is the depth of building below the floodproofing design level (in feet)

Note: See Appendix C of the FEMA "Design Manual for Retaining Flood-Prone Residential Structures" for further information.
HYDRODYNAMIC FORCES

- Lateral force acting on the walls of a structure
- Increase by the square of the velocity
- If the velocity doubles, the forces quadruple
- Impact force at the upstream wall
- Friction forces along the walls parallel to the flow
- Negative pressure (suction) on the downstream side
DEBRIS IMPACT FORCES

- Increase with the velocity and mass of the projectile
- Objects are estimated to be 1,000 pounds but can be reduced to 500 pounds where there is potential for only minor debris
- Impact duration is assumed to be 1 second
- Mountainous and ice flow areas should be considered as special cases

Debris Impact Force:

\[ F = \frac{Wv}{t} \]

where:
- \( F \) is the Impact Force
- \( W \) is the weight of the object (in pounds)
- \( v \) is the velocity of the object (in feet per second)
- \( g \) is the acceleration due to gravity (32.2 feet per second^2)
- \( t \) is the duration of impact (in seconds)

EROSIVE FORCES AND SCOUR

- Increase with velocity of water
- Increase with volume of material in water
- Can act on soil or structure materials

FLOOD PROOFING TECHNIQUES

- Wall and levees
- Elevation of buildings on fill or piers
- Anchoring structures to resist flotation and lateral forces
- Reinforcement of walls to resist hydrostatic pressure and debris impact
- Sealing walls to reduce seepage
- Installing pumps
- Installing check valves
- Elevating electrical equipment
- Relocation
CLASSIFICATION OF FLOOD PROOFING

- Permanent – Always in place, no action required during a flood
- Contingent – Requires installation during a flood
- Emergency – Improvised as the flood occurs

PERMANENT FLOOD PROOFING

- Pros
  - Protect the structure with a barrier on or away from the structure
  - Typical for areas that flood frequently or where insufficient time is available to implement contingent measures
  - Reduce human error
  - Reduced maintenance
  - May meet minimum requirements for NFIP (non-residential structures)
PERMANENT FLOOD PROOFING

Cons
- Expensive initial construction cost
- May restrict access to structure
- May block weep holes that allow ventilation to remove condensation between the brick and interior sheet rock

TYPES OF PERMANENT MEASURES

- Closures (sealed windows and doors)
- Sealants
- Watertight Cores
- Floodwalls
- Levees
- Elevation

PERMANENT CLOSURES

- Fill an existing window, door, or other opening with a water-resistant material
- Materials: concrete blocks, bricks, glass blocks, cast-in-place concrete, metal plates
- Materials must be impermeable and able to withstand hydraulic forces
PERMANENT SEALANTS

- Waterproof coating
- Applied to an existing or new wall
- Asphalt or polymeric compound
- UV resistant
- Polyethylene sheets can provide additional protection
- Walls must be able to withstand hydraulic forces since sealant adds no additional strength
- May be significant maintenance

WATERTIGHT CORES

- Watertight wall within a building
- Storage for expensive equipment, important records, and vital utilities
FLOODWALLS AND LEVEES

- Watertight wall surrounding one or more structures
- Structurally designed to resist hydrodynamic forces
- Could hinder access to site but allow more access to the building
- Need to provide internal drainage with a sump and pump

FLOODWALLS

- Floodwalls are generally concrete or masonry
- Levees
  - Earthen structures
  - Require a large “footprint”
  - Can be used for other activities such as a trail
ELEVATION

- Feasible for new construction or some existing structures
- Elevation can occur on piers, fill, walls, piles, or posts
- Must resist erosive, hydrostatic, hydrodynamic, and debris impact forces
- Should be used in areas where adequate warning time can allow occupants the opportunity to vacate
FLOODPROOF
RELOCATION
ELEVATION
DEMOLITION
INCREASED COST OF COMPLIANCE

- $30,000
- Provides for the payment of a claim to help pay for the cost to comply with community floodplain management standards
- After a flood event in which a building has been declared substantially or repetitively damaged.

CONTINGENT FLOODPROOFING MEASURES

- Require installation, activation, or preparation just prior to a flood event
- System must be manned, activated automatically, or remotely activated
- Includes flood shields, moveable flood walls, and watertight doors
- Adaptable to any structure

FLOOD SHIELDS

- Watertight barrier installed against doors, windows, ventilation shafts, and other openings
- Made of steel, aluminum, or plastic
- Gasket material to create seal
- Bolted (or otherwise attached) to the opening
- Should be located as near as possible to opening requiring quick, easy access
**WATERTIGHT DOORS**

- Similar to flood shields but function as a door
- Can close and seal every time that the door is used
- Can eliminate the need for contingency measures
- However:
  - Doors are heavy
  - Doors are costly

**MOVEABLE FLOODWALLS**

- Used in situations where accessibility may be an issue
- More aesthetic than permanent floodwalls
- May require installation with mechanical assistance due to weight
**EMERGENCY FLOODPROOFING MEASURES**

- Short notice
- On-hand or easily accessible materials
- Labor intensive
- Not useful when a flood rises quickly or has high velocities
- Do NOT satisfy NFIP requirements for floodproofing

**SAND BAG DIKES**

- Diagram of sand bag dikes

**EARTHFILL CRIB RETAINING WALLS**

- Diagram of earthfill crib retaining walls
STOP LOG BARRIERS

WRAPS AND PLASTIC SHEETING

- Attached to buildings with sufficient structural strength to withstand hydrostatic forces
- Not suitable in moving water
- Guard against tears from nails, downspouts, and other sharp edges
- Can be spliced with duct tape

Building Wrapped with Polyethylene Sheeting

- Use 3" x 5" lumber
- Anchor with sandbags
- Place 4"-inch drain pipe with drain heads, behind the wall or foundation base
- Lay plastic through a shallow drain to drain away water
- Start a little to a sump area
# Wet Floodproofing

- Allows portions of the interior of a structure to become wet
- Allows for hydrostatic equalization between the interior and exterior wall
- Will NOT reduce residential flood insurance premiums
- Should provide elevated location to store furniture and contents during a flood
- Clean-up after the flood

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# Wet Floodproofed Appliances

- Elevated, in a floodwall, wrapped in plastic sheeting, or in a plastic bag
- Turn off power, gas, and the pilot light
- May need to remove hoses to allow adequate application of plastic sheeting or bags

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# Flood Resistant Materials

- Suitable for the depth and duration of the design flood
- Do not deteriorate over the life of the structure
- Can be easily maintained and cleaned
STRUCTURAL FLOOD RESISTANT MATERIALS

- Steel, treated wood, and concrete for pilings and piers
- Treated wood, brick, masonry, and concrete for foundations
- Steel, aluminum, concrete, and treated wood for framing

CORROSION RESISTANT FLOOD RESISTANT MATERIALS

- Structural damage typically starts at a joint
- Connectors in coastal environments should be resistant to corrosion from ocean salts
- Salt spray can come from breaking waves and onshore winds
- Salt may be significant 3,000 feet inland
- Joist hangers, truss plates, hurricane straps, nails, and screws are all susceptible
- Galvanized steel is 50 times more resistant than plain steel
- Paint coatings can be effective provided that they are properly applied and maintained

FLOORING FLOOD RESISTANT MATERIALS

- Clay, stone, or brick tile with waterproof grout
- Solid vinyl floors with cement set adhesives
- Stained concrete and terrazzo
- Treated wood
WALL FLOOD RESISTANT MATERIALS

- Vinyl siding and moldings
- Concrete siding
- Masonry and rock with waterproof grout
- Treated lumber
- Sheet rock can be used above the flood level

INSULATION FLOOD RESISTANT MATERIALS

- Closed cell insulation
- Fiberglass batting will allow wicking and will remain wet for extended periods providing a haven for molds

WET FLOODPROOFED WALLS AND FLOORS

PREVENT DAMAGING.