

and local emergency management agencies, local weather reports, the NWS, or a local flood warning system regarding when to evacuate. The typical flood warning time should be considered when selecting a floodproofing measure.

2.5.4 Flood Emergency Operations Plan

Flood emergency operations plans are highly recommended for floodproofing methods.

Plans should contain information on how floodproofing measures will work during and after the flooding event. For example, equipment such as sump pumps that require electricity will need to maintain power throughout the duration of the flood event. Maintaining power may require installing a generator and developing an operations plan for the generator to function during and after the flood event until power is restored. Maintaining power can be complicated by the fact that dry floodproofed areas should not be occupied during the flood event. Fueling and generator maintenance may require the generator to be located in an area above the desired level of flood protection.

Preparation of plans is the responsibility of the building owner or operator. The design professional certifying the floodproofing project is solely responsible for how the measures resist flood loads and make the building watertight but should be consulted on the maintenance, testing, and inspection schedule of the project.

A flood emergency operations plan should do the following:

- Establish a chain of command and assign responsibilities to each person involved in the installation and maintenance of the floodproofing measures. This will range from the authority to activate personnel through the duration of the event and restoration of the building to normal operations. The assigned personnel should not be assigned additional overlapping emergency duties to make sure that the floodproofing measures are installed in a timely manner and maintained. The chain of command should also take into account where assigned personnel live and their ability to access the site in an emergency. If key personnel are not available, a plan for succession of command and/or delegation of authority should also be covered.
- Delineate notification procedures for all personnel involved in the floodproofing operation. This includes details on making sure personnel can get to the building and enter areas of the building necessary to install the floodproofing measures. These areas include the floodproofed portion of the building and any storage facilities that house the flood shields and pumps.
- Assign personnel duties and include a description of the locations of floodproofing measures, installation procedures, and repair procedures. Instructions for each location should be posted close to the location.
- Include evacuation instructions for all personnel who normally occupy the building, and for the personnel who have installed the measures, what to do after the floodproofing measures are accomplished. Evacuation routes should be posted in the floodproofed areas. Any doors necessary to exit the floodproofed area should be marked and should not be possible to lock in a manner that prevents egress from the floodproofed area.

- Include a periodic drill and training program to make sure personnel clearly understand the procedures and timeliness by which they need to accomplish floodproofing measures and complete evacuation. Drills should be conducted at least once a year and coordinated with community officials.
- Include a schedule for regular evaluation and update of the flood emergency operations plan to reflect changes in personnel and procedures.

At a minimum, the plan should be posted in two clearly marked locations, but it is recommended that either the entire plan or relevant sections be posted close to every location where flood shields are to be installed. Requirements for the flood emergency operations plan are in FEMA's NFIP Technical Bulletin 3-93 (FEMA 1993a).

Although flood emergency operations plans are not required for wet floodproofing and floodwalls/levee mitigation measures, plans should be considered a best practice to ensure the effectiveness of all flood mitigation measures.

2.5.5 Inspection and Maintenance Plan

An inspection and maintenance plan should cover both the maintenance of the floodproofing measures and periodic inspections of the components. Inspections should cover the entire floodproofing system, including the walls, floor slab, openings, flood shields, valves, drainage system, and any pump system. A list of repairs should be developed after each inspection and implemented as required. Maintenance procedures should not rely on the annual inspection for identification but should be part of routine operations of the building's facility maintenance staff. Inspection and maintenance items include but are not limited to:



Special Note

Some communities require annual inspections of dry floodproofed buildings, especially if human intervention is required. Annual inspections lead to an increased awareness and effectiveness of floodproofing systems and also reduce concerns about liability.

- Wall systems, for cracks in the structural system or waterproofing coatings. Repair of cracks should be addressed immediately because ignoring them could result in significant structural damage to the building during a flood event.
- Entire floor slab, to make sure settlement or other cracks have not appeared. Additionally, it is important to make sure the floor slab is able to provide drainage for any water that may leak into the building.
- Openings, to clear debris trapped in the supports for flood shields, damage to permanently mounted hardware or gaskets, which would prevent proper operation of a flood shield.
- Flood shields, for damage to attached gaskets, proper labels identifying the proper location, and damage to the actual shield, which might prevent it from performing properly. The inspection should include an inventory of shields and all the hardware required to properly install them.
- Backflow valves or shutoff valves, to make sure they can properly operate and are clear of debris.
- Drainage system and pump systems, to make sure there is no damage to piping or debris that would prevent the pipes from draining properly. Sump pits should be inspected and cleared of any sediment

that may have built up. Switches and sump pumps should be inspected and tested to make sure they will run properly. If a generator is necessary for operation of the sump pump, it should be tested periodically to verify it will start and run during a flood event.

- An inventory of flood emergency equipment, supplies, and required tools to ensure that all required items are available in the event of a flood. The inventory should include a listing of the tools and where they are stored.

2.5.6 Economic Factors

When floodproofing has been determined to be feasible considering regulatory requirements and the physical characteristics of the site and building, the most cost-effective floodproofing option can be identified. A BCA can be used to validate cost effectiveness. BCA is a way to estimate the future benefits of a mitigation project and compare the benefits to the cost. The result of the analysis is a benefit cost ratio (BCR), which is derived by dividing the project's net benefits by the project cost.

In a cost-effective project, the total cost of floodproofing (installation, operation, and maintenance) is less than the value of physical flood damage, lost earnings, and other economic impacts that are likely to occur if the structure is not floodproofed. The BCR is a numerical expression of the cost effectiveness of a project. A project is considered cost-effective when the BCR is 1.0 or greater, indicating the benefits of a prospective hazard mitigation project are sufficient to justify the costs.

Benefits are defined as avoided damage, and a BCA estimate may not account for all of the potential benefits. Therefore, a BCR of less than 1.0 should not automatically remove dry floodproofing from consideration.

The BCA described in Appendix B is used by FEMA to evaluate cost effectiveness of projects under mitigation grant programs.

2.6 Building Vulnerability Assessments

For a building to remain functional during and following a natural hazard event, it must be undamaged, have sustained limited damage that does not prevent the building from functioning, or have sustained damage that can be readily repaired. Determining how well a building can withstand a natural hazard requires a building vulnerability assessment.

A vulnerability assessment can identify weaknesses in a building's structure, envelope, and electrical and mechanical systems. The assessment can determine which natural hazards the building can withstand *as is* and which mitigation opportunities are *available* to make the building more hazard-resistant.



Cross Reference

FEMA P-424, *Design Guide for Improving School Safety in Earthquakes, Flood and High Winds* (FEMA 2010a), contains checklists that can be used to assess a building's vulnerability to these natural hazards. The manual is geared to schools, but the guidance is also appropriate for other facilities. The flood checklist in FEMA P-424 is provided in Appendix C.