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FLOOD PROOFING

PREFACE

This Technical Release was developed to provide a general knowledge of flood proofing procudures. It is expected that if the reader requires more guidance on a specific flood problem he will find help in the reference material listed.

Illustrations contained in this Technical Release are reproduced from Introduction to Flood Proofing, by John R. Shaeffer, a 1967 publication of the Center for Urban Studies, University of Chicago.

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FLOOD PROOFING

INTRODUCTION

Floodproofing is a combination of changes or the addition of features to individual buildings, structures or properties to reduce or eliminate flood damage. (Fig. 1) It is important that flood proofing be recognized as one tool among several that can be used in a comprehensive program of flood plain management. This Technical Release is issued as a guide for planning personnel. Its purpose is to give an overview of points to be considered by the planner when contemplating flood proofing as a means to reduce flood damages. Neither flood proofing criteria nor SCS policy regarding flood proofing is presented in this technical Release.

Limitations and Constraints - When considering flood proofing as a flood damage prevention measure, it must be recognized that limitations are associated with it. Some examples are:

1. A false sense of security can develop and thereby encourage further encroachment onto the flood plain. The end result would then be an increase rather than a decrease in the flood damage problem.

2. Some types of flood proofing cannot be effective without reliable and timely flood forecasting facilities.

3. Some buildings are not structurally adequate to support flood proofing measures. In such cases, stresses induced by floods as a result of the flood proofing measures could cause more damage than would flooding of the unprotected building.

Reasons for Flood Proofing

Flood proofing may be considered as a flood damage prevention measure in the following general cases:

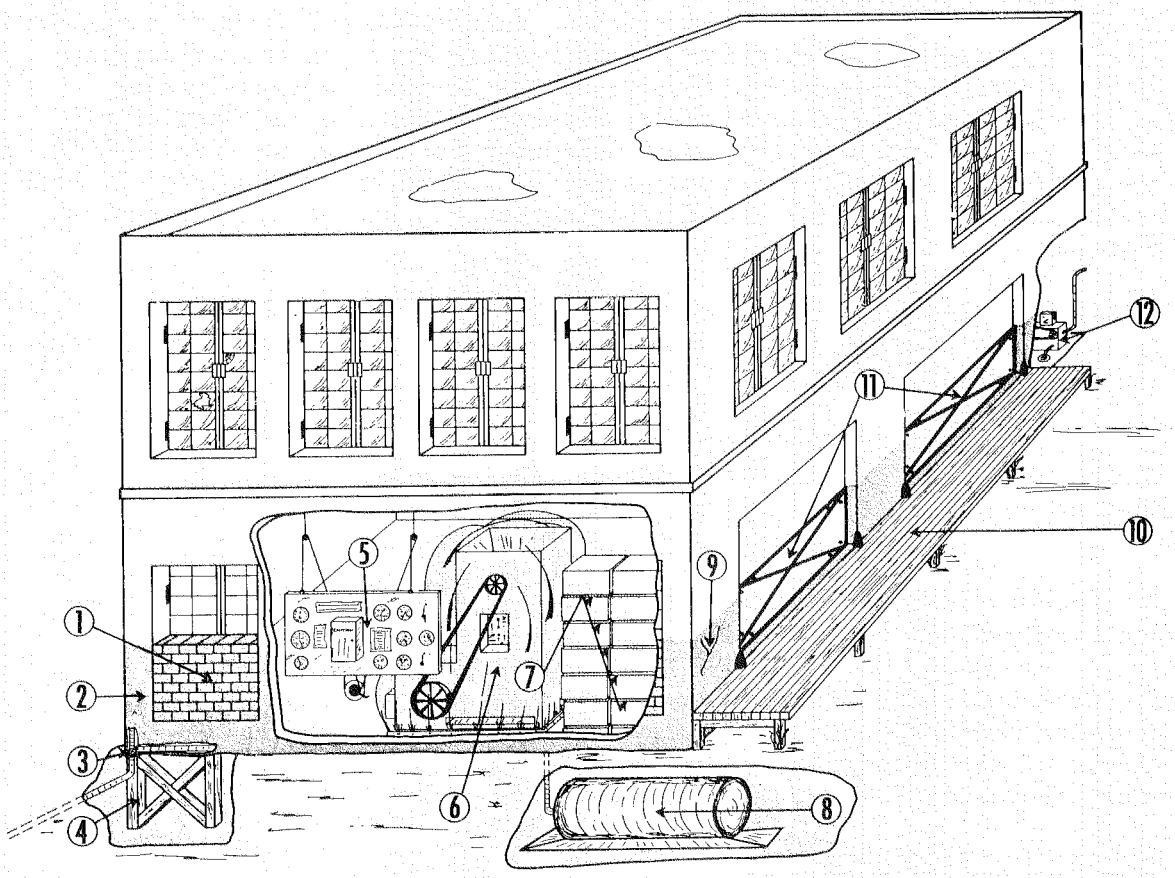
1. In conjunction with flood prevention measures, to increase the degree of flood damage protection, or to reduce costs for a given degree of protection.

2. As an alternative to flood prevention structures in cases where most of the damage is concentrated in a few buildings.

3. Where flood prevention structures are not practical.

4. To reduce the costs of flood damage insurance.

5. Where building in the flood plain is necessary because of a need for water front location.



EXPLANATION

1. Permanent closure of opening with masonry
2. Thoroseal coating to reduce seepage
3. Valve on sewer line
4. Underpinning
5. Instrument panel raised above expected flood level
6. Machinery protected with polyethylene covering
7. Strips of polyethylene between layers of cartons
8. Underground storage tank properly anchored
9. Cracks sealed with hydraulic cement
10. Rescheduling has emptied the loading dock
11. Steel bulkheads for doorways
12. Sump pump and drain to eject seepage

-A flood proofed structure. This sketch illustrates the many items that must be employed to flood proof a structure.

Figure 1

DEFINITION OF TERMS

Flood Forecasting Facility - An installation upstream of the damage area to monitor rainfall and streamflow and with equipment to warn of an impending flood.

Flood Plain - That portion of land along a water course which is inundated during the passage of a flood of a given frequency.

Flood Prevention Measures - Actions taken to reduce or prevent all forms of damage from inundation by floodwaters.

Flood Proofing Measures - Actions taken on site to limit damage caused by water which has reached flood stages.

Floodway - That portion of the flood plain or a by-pass waterway to which flood water can be limited without significantly raising the elevation of water on the flood plain.

Regulatory Protection Elevation - The elevation to which flood proofing protection shall be provided.

PLANNING FOR FLOOD PROOFING MEASURES

Flood Hazard Analysis - When considering flood proofing it is necessary to analyze the flood hazard and identify the cause of the flooding problem so that all applicable flood damage reduction measures can be considered. Flooding problems are frequently caused by local runoff that can be remedied by reshaping the terrain or by using dikes or diversions. Backwater flooding can often be cured by improving the outlet.

Damage Assessment - All materials which are either presently or planned to be located in the flood zone must be considered. This includes both the construction material used in the buildings and any materials stored there. The degree to which these materials are susceptible to flood damage will affect the amounts and types of flood proofing measures necessary, and how great a cost is justified for their installation.

Physical - The physical characteristics of the expected flooding must be taken into account. Both depth and velocity of flow must be considered when flood proofing is to be used as a flood damage reduction tool. As the depth increases static loading increases. Impact forces from floating debris, ice, and flood water increase with velocity. These forces must be evaluated in determining structural adequacy.

Because of these forces, flood proofing procedures are generally limited to cases where low stages and low velocities are experienced.

Regulatory - Just as flood proofing can be used in lieu of, or as a supplement to, flood control measures, regulatory laws may also be used to minimize future potential flood damages.

If special conditions require encroachment upon the flood plain, building codes should require that flood proofing measures be incorporated into all new buildings. No building without flood proofing capability should be permitted. AP 1165 2314 "Flood Proofing Regulations", Office of the Chief of Engineers, U. S. Army, Washington, D. C., June, 1972 is an excellent guide for building code regulations.

Flood Proofing Measures

Whereas flood prevention measures are installed to prevent the water surface from reaching elevations which cause damage, flood proofing measures accept the water reaching these elevations and attempt to prevent or minimize damages. Examples of specific flood proofing measures are: 1/

1. Anchorage or addition of weight to resist floatation and lateral movement.

2. Watertight closure of openings. (Fig. 2)

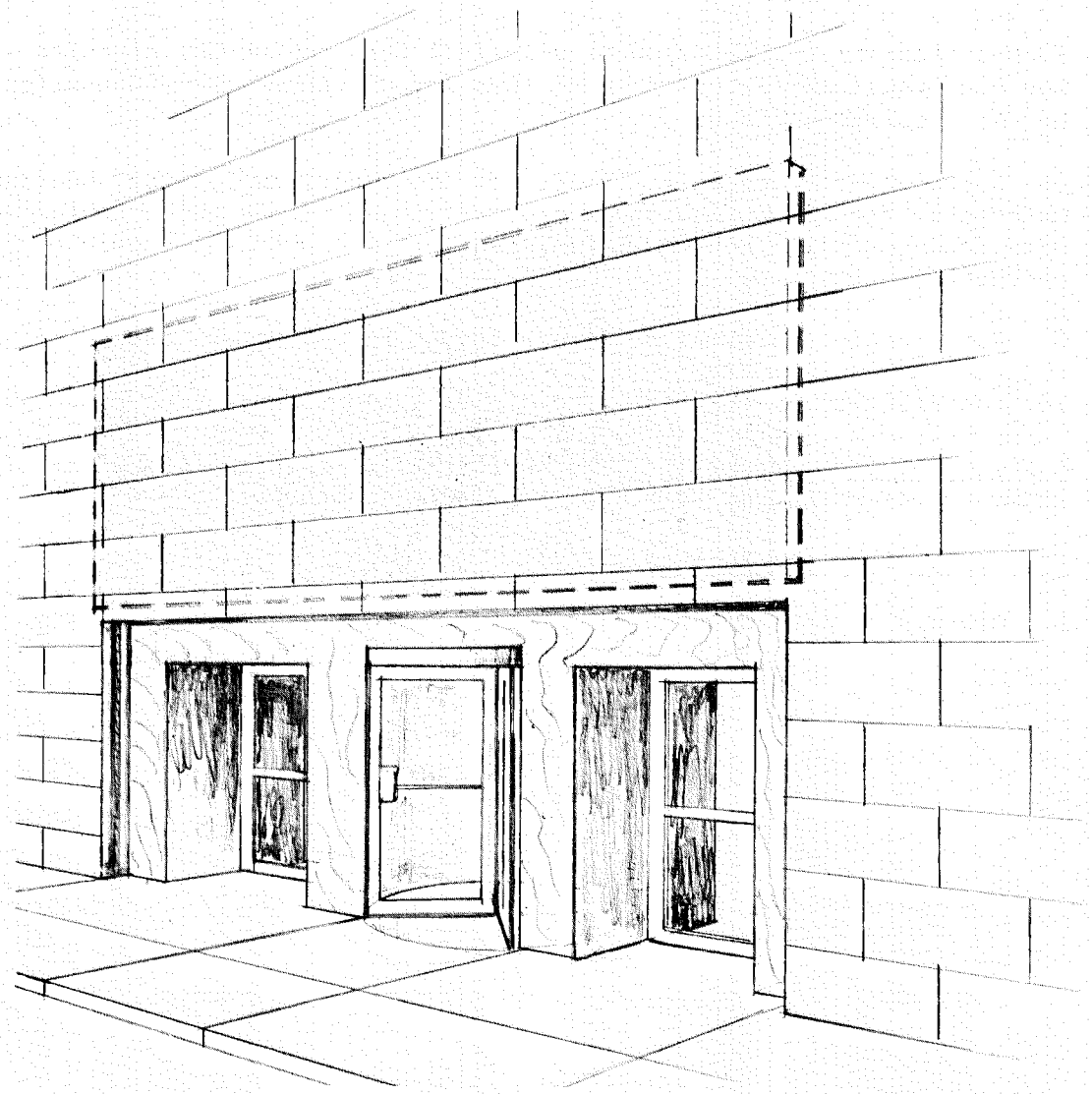
3. Reinforcement of walls and floors to resist water pressures and flooding debris.

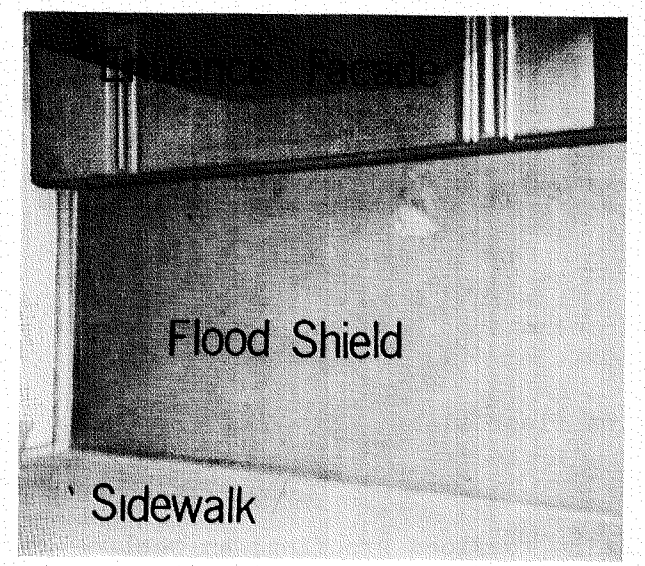
4. Use of paints, membranes, or mortars to reduce seepage of water through walls.

5. Installation of pumps to control water levels.

6. Construction or alteration of water supply and waste treatment systems so as to prevent the entrance of flood waters.

1/ Adapted from: Regulation of Flood Hazard Areas to Reduce Flood Losses, Vol. 2, U. S. Water Resources Council.





-Overhead flood shield that is in place for testing. This sketch shows how the shield retracts above the entrance. (Photo by Horne Department Store, Pittsburgh, Pennsylvania.)

Figure 2

7. Location ai installation of all electrical equipment, circuits and electrical appliances so that they are protected from inundation by the regulatory flood.

8. Location of storage facilities for chemicals, explosives, buoyant materials, flammable liquids or other toxic materials which could be hazardous to public health, safety and welfare above the regulatory protection elevation.

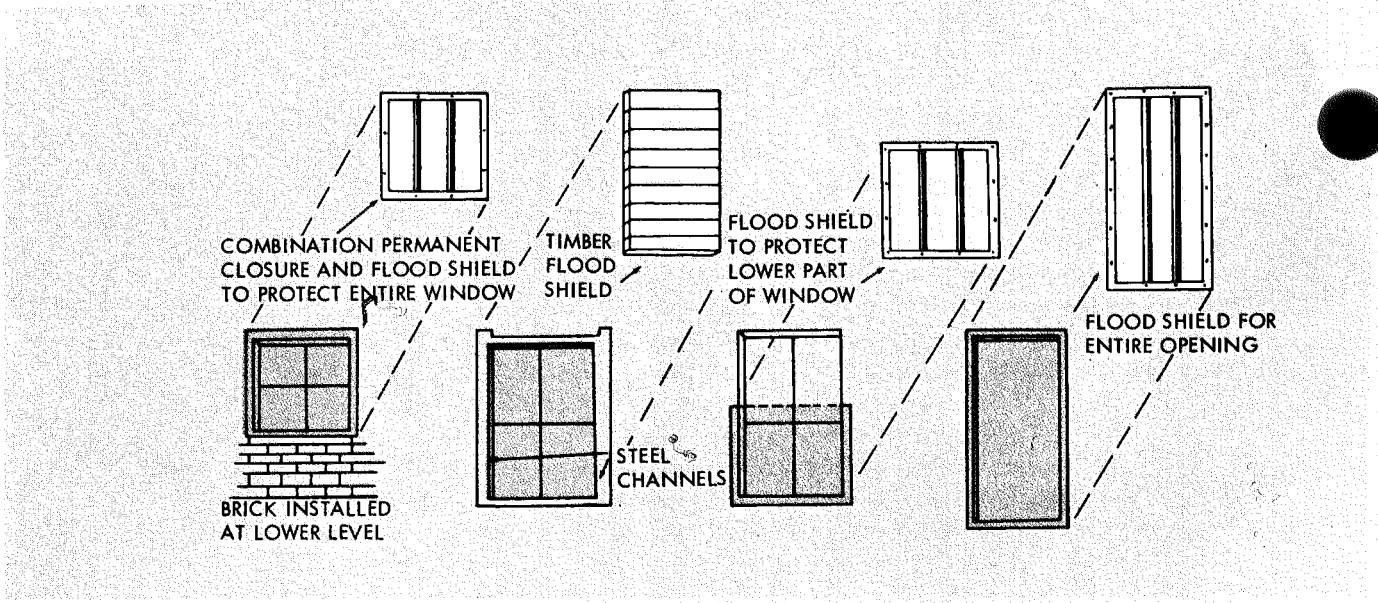
9. Construction of dikes or levees around individual buildings.

10. Installation of facilities to flood basement areas with clean water.

A Flood Proofing Checklist - The following is a general checklist of items to be considered in flood proofing a structure.[2/]

For Foundations and Substructure

1. Closure of openings including doors, windows, and vents. (Fig. 3)



-Types of exterior wall flood proofing closures. These sketches illustrate several approaches which can be employed to flood proof openings in outer walls.

Figure 3

2. Waterproofing and/or reinforcement of basement and foundation walls.

3. Reinforcement or drainage of floor slab.

2/ Shaeaffer, J. R. Introduction to Flood Proofing; an Outline of Principles and Methods. Chicago: University of Chicago, Center for Urban Studies, April, 1967.

4. Valving off or termination of entering utilities.

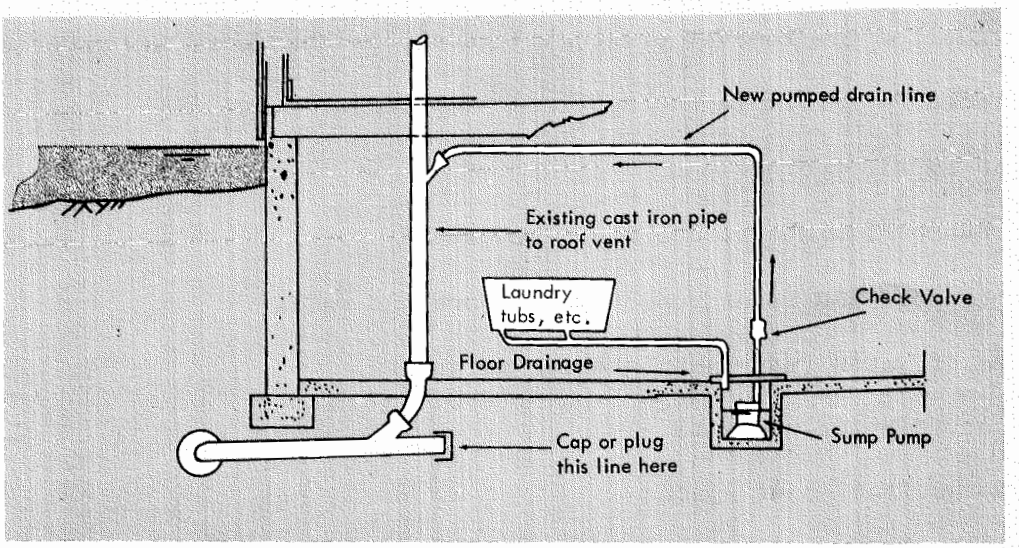
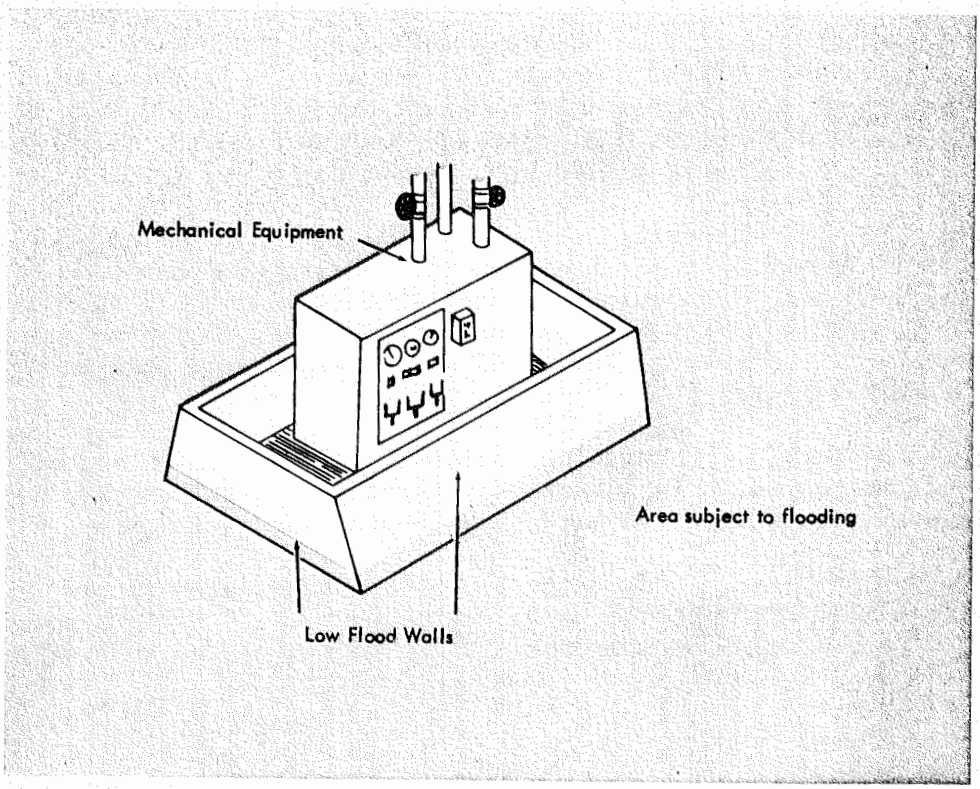


Figure 4

5. Continuation of internal building utility systems. (Fig. 4)

6. Protection for immoveable equipment. (Fig. 5)



-Protection of Mechanical Equipment. This wall was constructed to protect vital equipment from low stage flooding.

Figure 5

7. Plans for the removal of stock - goods, merchandise, raw material, etc.

8. Procedure for implementing flood proofing

For the Superstructure

1. Closure of windows, doors and vents.

2. Anchorage and reinforcement of floors and walls.

3. Use of water resistant interior materials.

4. Evacuation of contents.

5. Reorganization of space.

6. Emergency protection measures.

7. Procedure for implementing flood proofing.

CLOSURE OF OPENINGS

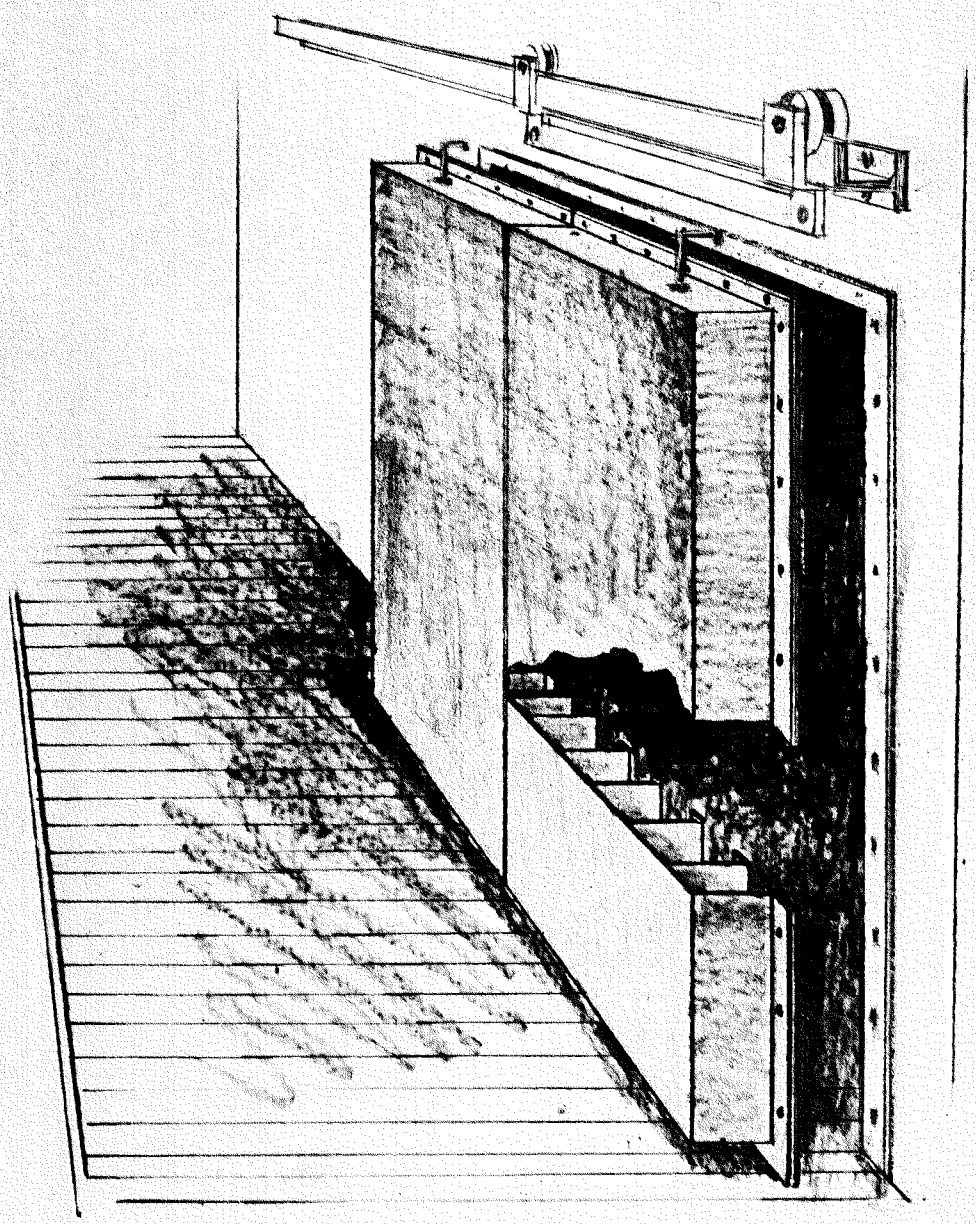
Strength of Materials and Sealing - When openings below expected flood levels are to be closed off, consideration should be given to reinforcing the framework of the opening. In most cases the framework was designed to withstand vertical loads but not lateral loads. With the sealing of openings, lateral pressures are induced, and the framework and walls must be strong enough to withstand these pressures.

Stairwells - Outside stairwells are often an avenue of entrance for flood waters. Regrading the terrain around the stairway can be used to direct waters away from such openings. The stairwell can be flood proofed by constructing a watertight wall around the opening together with provisions for the installation of a watertight gate when the flooding is anticipated.

Windows, Vents, and Doors - Openings below flood stage which are no longer used can be sealed permanently by masonry or glass bricks, if the walls are strong enough to withstand the increased pressures.

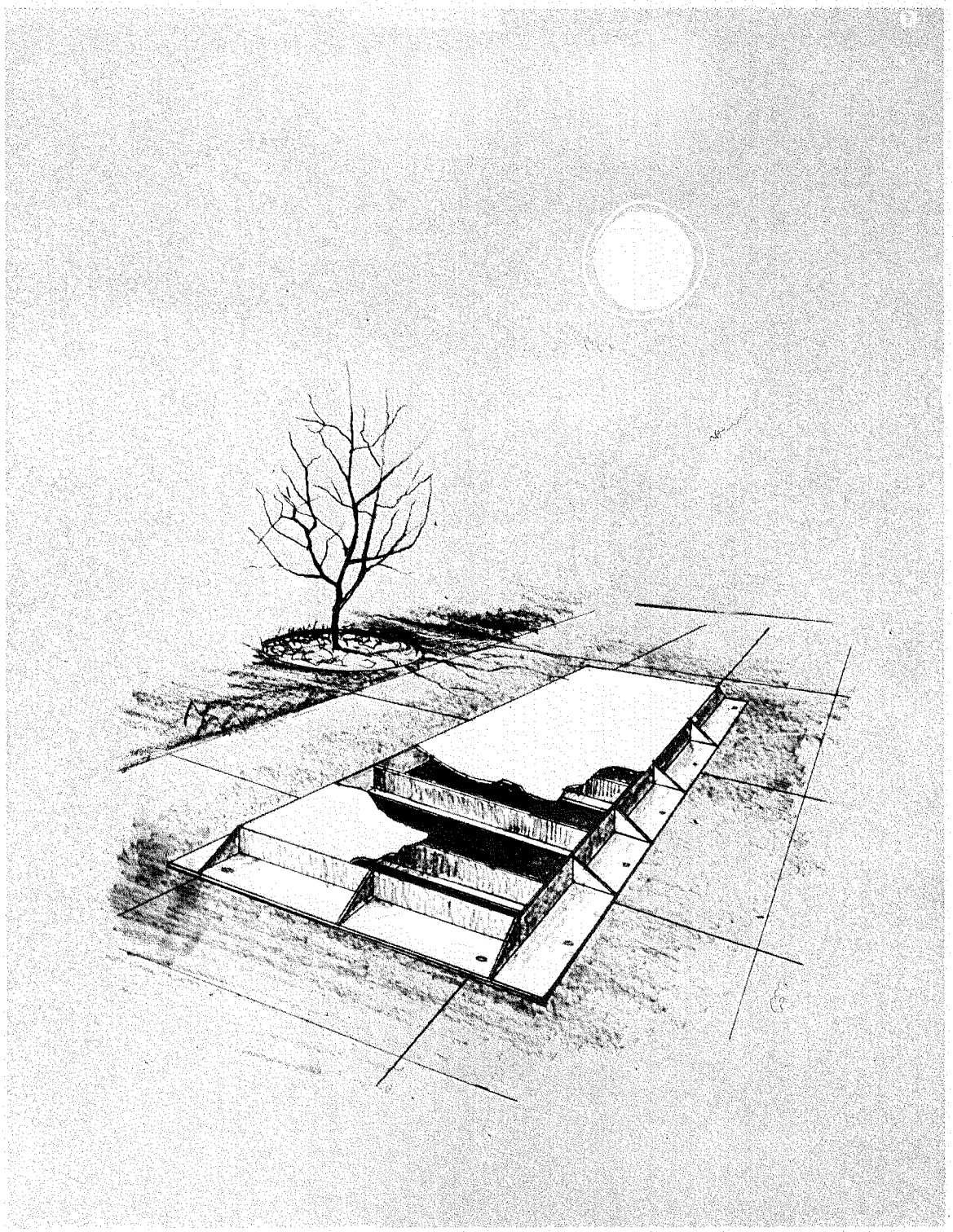
Openings which are in use and cannot be permanently sealed can be fitted with watertight flood shields. (Figures 6, 7, 8 & 9) These shields can be designed to cover the opening to any of the following degrees:

1. Total coverage.



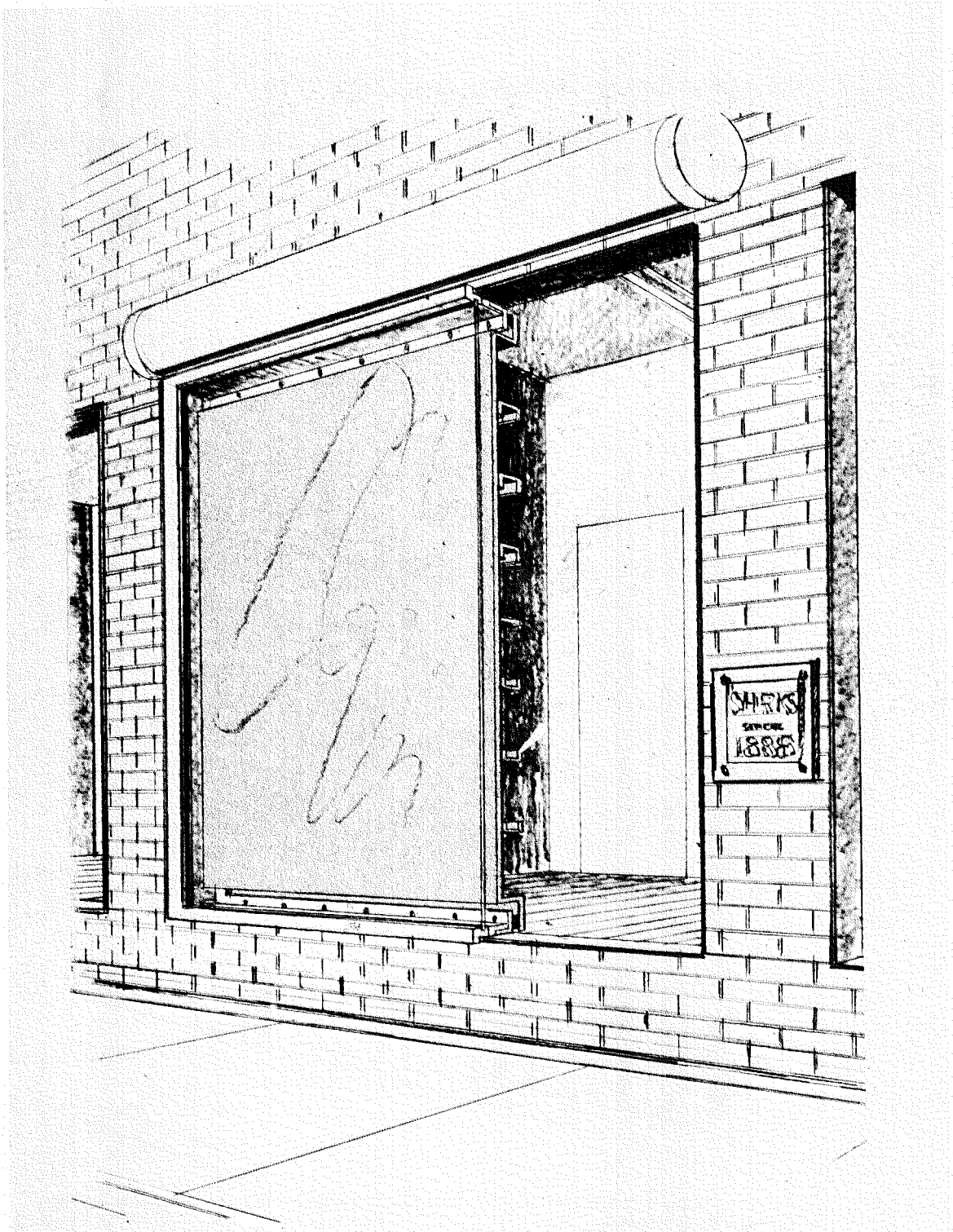
Large flood shield in position about to be bolted into place.

Figure 6



-Flood shield in place over an air vent. This shield prevents flood waters from entering the subsurface of a building through the air ducts.

Figure 7



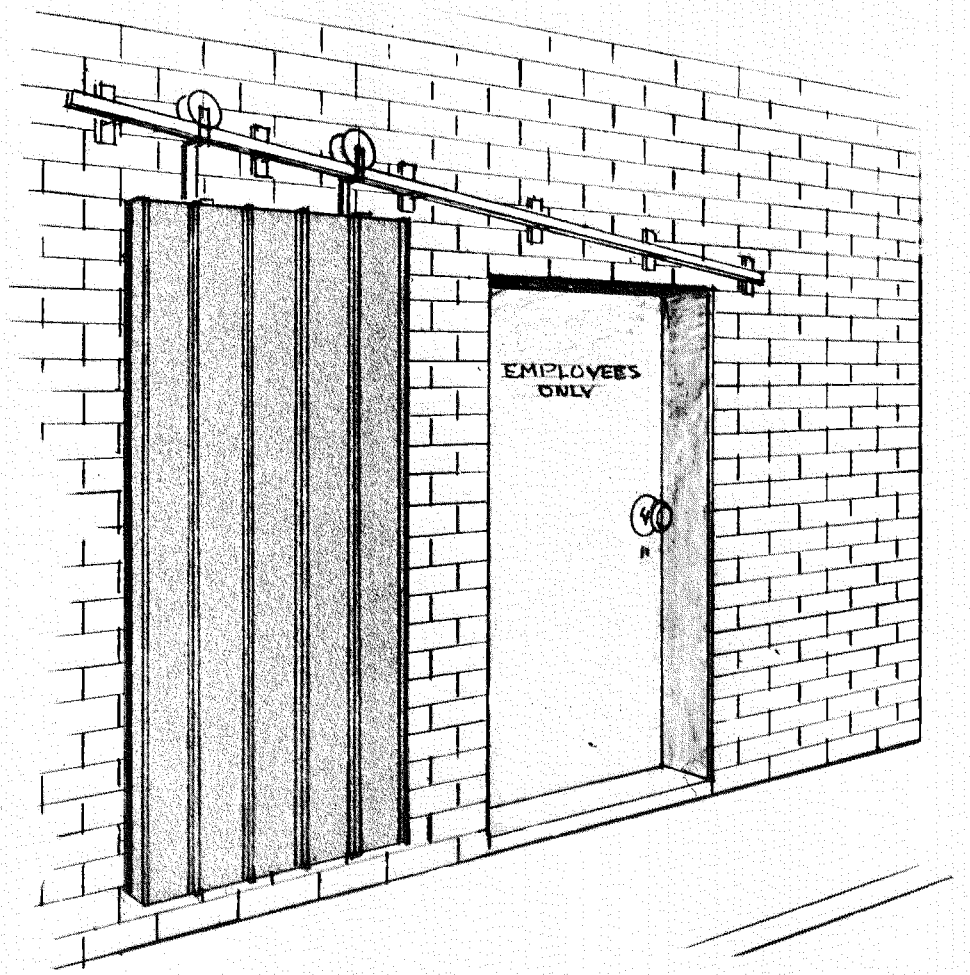
-Aluminum flood shield in position at a show window. The glass is cut away to show its location 4 inches behind plate glass.

Figure 8

2. To the elevation of desired protection.

3. To the elevation at which induced hydrostatic pressures begin to endanger the wall.

The type of flood shield varies with types of structures and needs.



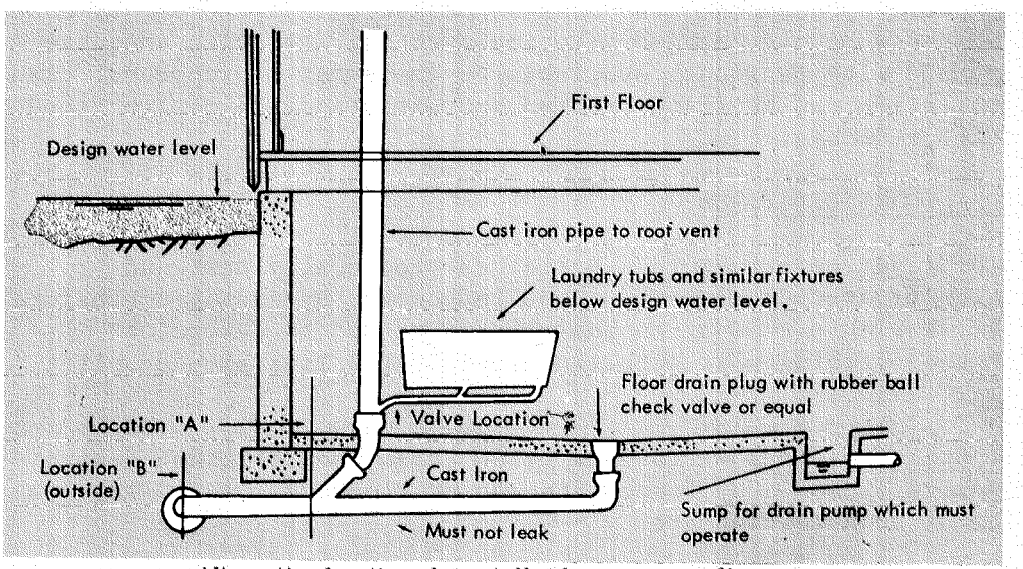
-Sliding flood shield in open position. This shield is for a service entrance and is strictly functional.

Figure 9

WATER PROOFING

Sealing Joints and Seams - Seepage through joints can be prevented in new construction by the use of waterstops. Seepage through cracks and crevices in the walls of structures can be prevented by applying a waterproof coating to the walls. For maximum effectiveness, the coating should be applied to the exterior surface. Many products are suitable for waterstops and sealing and the one selected depends on the requirements and availability.

Check Valves in Plumbing - A common source of flood damage is backflow through the sewage system. This can be prevented by use of check valves on basement fixtures and drains or a valve where the sewer system enters. The pipes should have adequate strength to prevent rupture. (Fig. 10)



-Alternative locations for cutoff valves on sewer lines.
Figure 10

A sump pump can be installed to remove any leakage and to supplement the check valves in preventing damage. These pumps should outlet above expected high water.

Building on Fill, Post or Pilings - When construction is necessary on the flood plain, it should be limited to fringe areas and not encroach on the floodway. The main floor can be raised either on posts or should be above the 100 year storm level and provisions made to supply access and utilities to the building to allow continued use during flood periods.

Dike or Levee - Dikes and levees would be classified as flood proofing when they are designed to benefit a single beneficiary rather than a group. However, dikes and levees can be used as flood proofing measures and should be included among the alternate means of preventing flood damage.

Structural - The structural capabilities of buildings being flood proofed must be considered. In the original design of many buildings, the possible induced lateral load of flood waters was not considered. Therefore, structural analyses should be included in the planning of flood proofing measures.

Type of Operation - Flood proofing measures can be classified as automatic or manual.

The automatic measures, such as dikes, check valves, and sealing of openings, do not require additional action at times of flooding.

The manual measures must be installed or implemented when the threat of flooding is present. In order for these measures to be effective, an adequate flood warning system must be operational in the area. A flood proofing procedural plan must be developed and thoroughly understood by those people charged with implementing it. With adequate warning, and with personnel available to implement a procedural plan, an installation can be flood proofed and withstand the design flood with minimum damage.

STRUCTURAL CONSIDERATIONS

Hazard of loads on structure - Buildings are usually designed without consideration given to loads induced by hydrostatic pressure. (Fig. 11) For this reason, an analysis is needed to determine whether the building will withstand anticipated lateral and uplift forces.

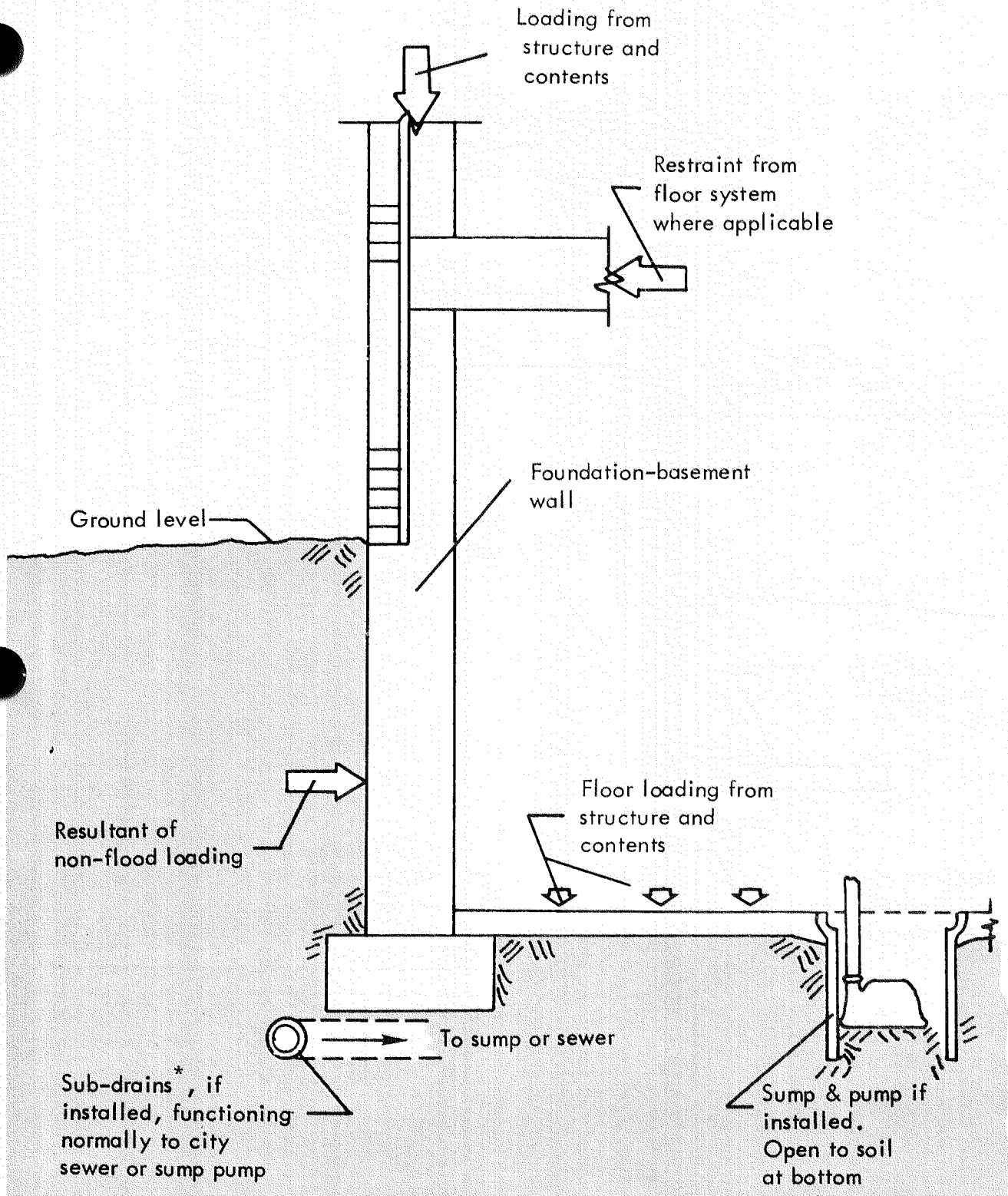
Flood Induced Loadings - Problems often arise when original design loadings are exceeded by forces induced by flooding. (Fig. 12) Examples of such loading are:

Uplift - buoyant forces on the foundation and basement floor can cause buckling of the floor slab.

Lateral Hydrostatic Force - induced hydrostatic forces against building walls can create excessive moments and shear forces.

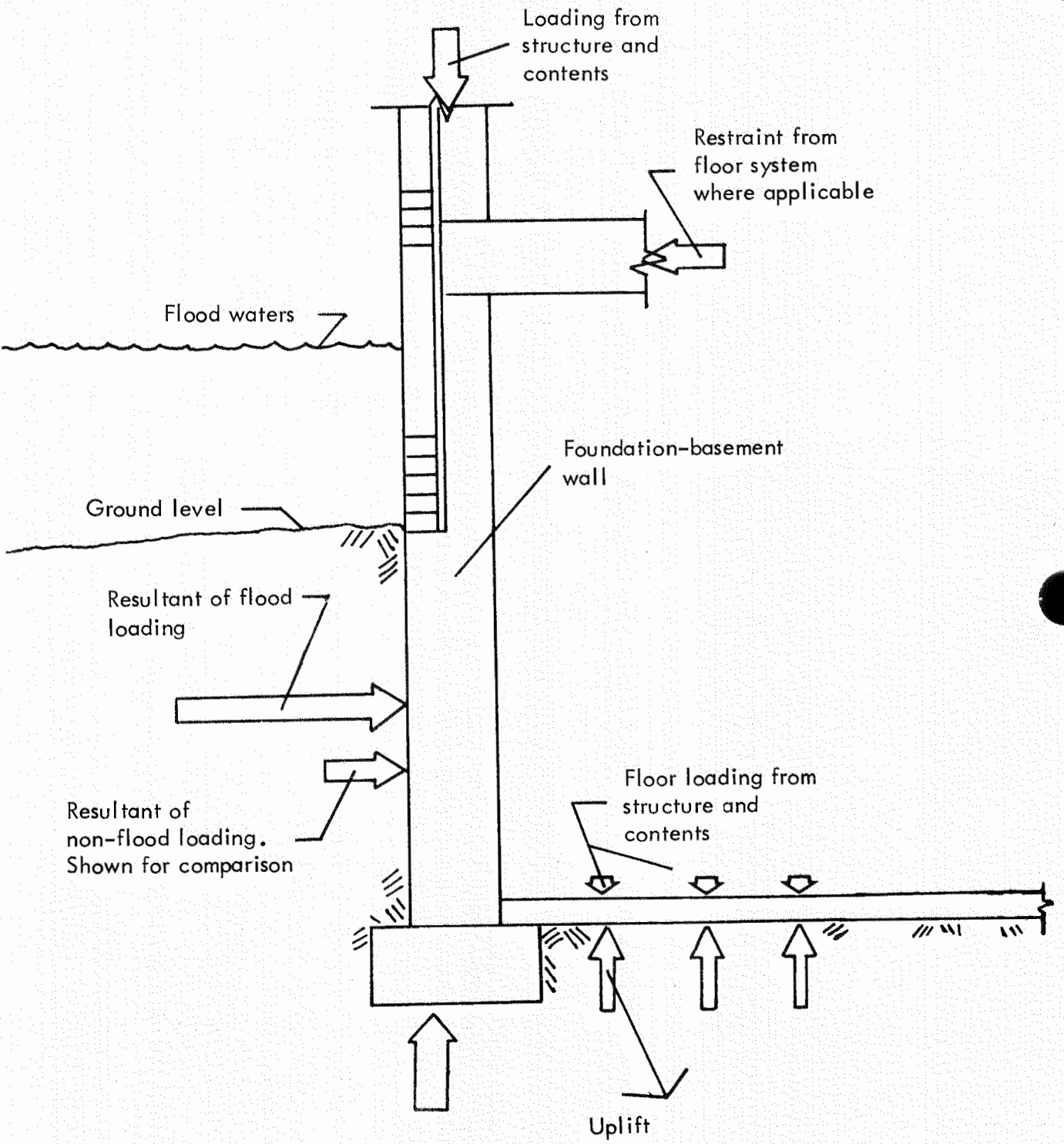
Hydrodynamic and Impact force - if flood water has any velocity, the impact force of the water and floating debris on the building walls must be considered.

The main points to keep in mind when considering flood proofing measures are that components of the structure, and all loadings induced by flooding and flood proofing measures must be carefully analyzed. If flood proofing measures are installed without consideration of all possible loadings, more damage can result to the building than would have sustained without the measures.



*Existence of subdrains depends upon the requirements of local building codes, ground water conditions, soil conditions, storm or combined sewerage systems if any, etc.

Figure 11



-Typical building loads under flood conditions without subsurface drainage.

Figure 12

ELECTRICAL AND MECHANICAL SYSTEMS

Electrical - The source of power to buildings being flood proofed should be above the elevation of desired protection. Buildings that will be isolated by flood water should have a remote disconnecting switch installed above the flood line.

Electric motors and equipment should be located above the expected flood level wherever possible. If it is impossible to raise the electrical equipment, other measures such as diking should be considered. Any unprotected electrical equipment below the expected flood elevation should be of the submersible type. That portion of the electrical circuit below the expected flood elevation should be isolated by an automatic circuit breaker.

Mechanical - Heating, air conditioning, ventilating and plumbing systems should also be considered for flood proofing. If these facilities cannot be located above the expected flood line, flood proofing measures must be adopted for their protection.

Flood proofing of the energy source can prevent a serious safety hazard and should also be given prime consideration. When gas or oil is used as an energy source, the storage tanks and fuel lines must be anchored securely to prevent flotation or rupture. Automatic valves should be installed either in the lines or at the storage tank to cut off the flow when the water level approaches the elevation of the fire box.

Electric circuits to heaters, air conditioners, and controls to gas and oil heaters should be equipped with automatic switches which will de-energize the circuit.

Hot water and steam pipes should also be fitted with cutoff valves which are either controlled from an accessible location or automatically shut off before flood waters reach the elevation of the pipes.

Warm air and ventilation ducts should have ports installed to admit and drain flood waters. They should also be fitted with waterproof mechanical closure devices where they extend through the wall and where they connect to heating or air conditioning units.

When fixed machinery cannot be installed above the expected flood elevation, protective measures will be needed. Diking around such machinery can be used to exclude floodwater, and will also protect the machinery when intentional flooding with potable water is used to maintain structural integrity of the building. Diking is a permanment measure and would function automatically.

Waterproof membranes can be used in conjunction with, or in lieu of, diking, depending on flooding depths, machinery locations and other factors.

Coverings of hot kip plastics, spray plastics, polyethylene, or vinyl films will effectively seal off the machinery from the flood waters. However, advance warning is necessary to apply this type of protection and some difficulty may be encountered when removing the plastic film.

Plumbing and sewage systems are susceptible to flood damage and must be considered in the overall flood proofing program.

Contamination of the water supply is a concern. The fixtures and plumbing should be secure from physical damage caused by materials stored in the vicinity which can be shifted by floodwater. Pressure greater than the hydrostatic pressure of the floodwater should be maintained in all water lines below the expected flood elevation.

When the source of the water supply is in danger of contamination it should be protected by dikes or the openings sealed to prevent the entrance of floodwaters.

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