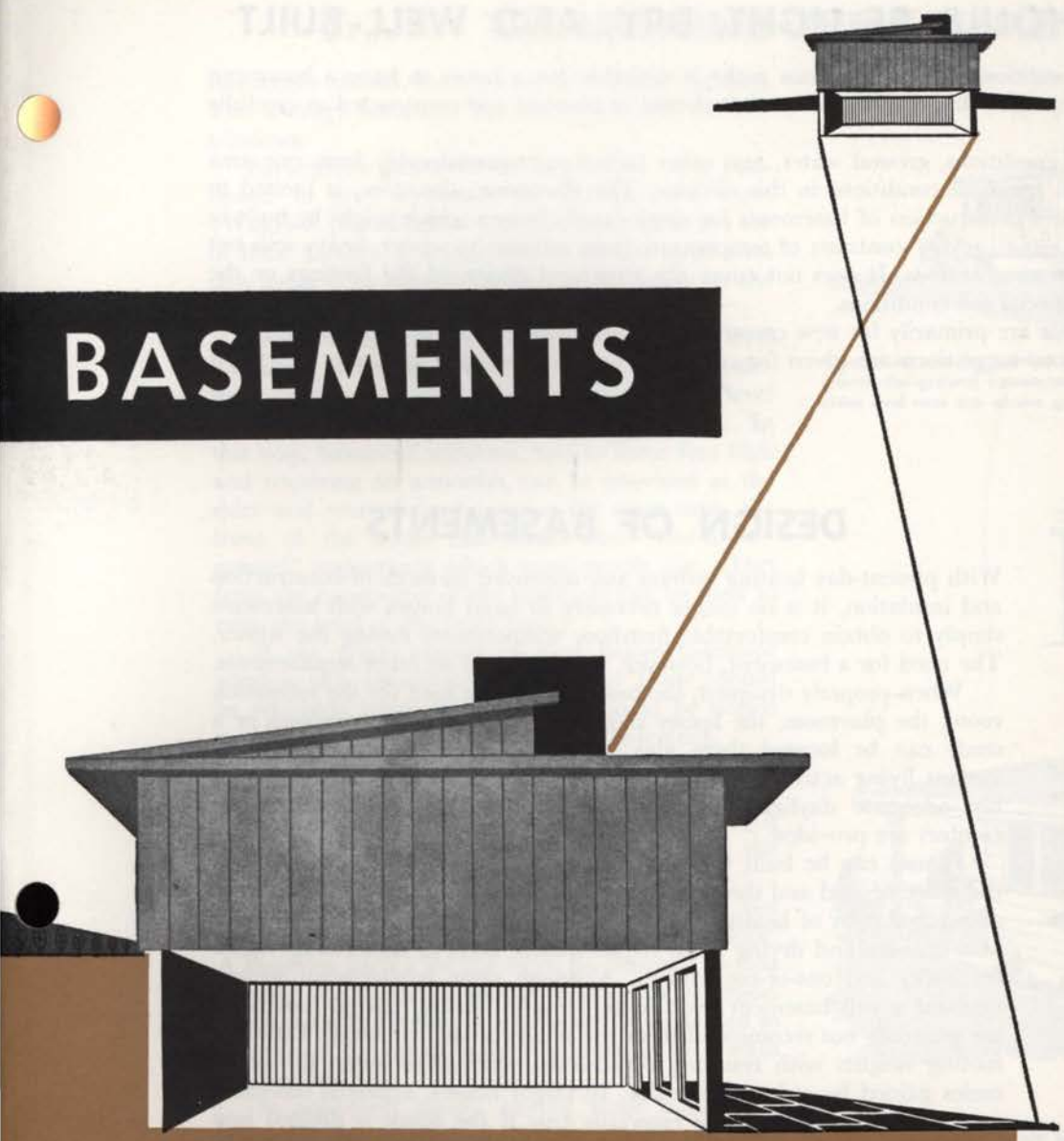
CIRCULAR SERIES

INDEX NUMBER F2.0

BASEMENTS



ISSUED BY THE
SMALL HOMES COUNCIL – BUILDING RESEARCH COUNCIL

This circular is one of a series on residential construction. Other circulars are available for 25c each. For information, write to Small Homes Council-Building Research Council, University of Illinois at Urbana-Champaign, One East Saint Mary's Road, Champaign, Illinois 61820.

MATERIAL IN THIS CIRCULAR BY R. A. JONES, W. H. KAPPLE, AND J. T. LENDRUM

Editor: M. H. Kennedy

Illustrator: J. J. Sorbie

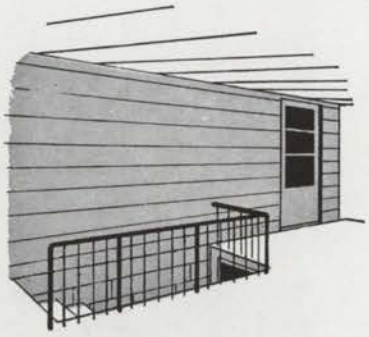
BASEMENTS
SMALL HOMES COUNCIL F2.0

BASEMENTS SHOULD BE LIGHT, DRY, AND WELL-BUILT

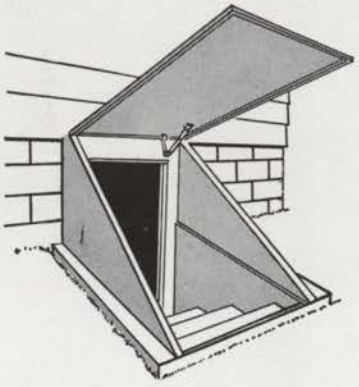
If space requirements, site conditions, or other reasons make it desirable for a house to have a basement, then it should be a well-built, light, dry, and useful area. It should be planned and constructed as carefully as the rest of the house.

Since soil types, drainage conditions, ground water, and other factors vary considerably from one area to another, it is impossible to cover all conditions in this circular. The discussion, therefore, is limited to general principles of design and construction of basements for single-family houses which might be built in areas similar to the midwest — *i.e.,* severe contrasts of temperature from summer to winter, heavy soils but no rock, and heavy rainfall in some seasons. It does not cover the structural design of the footings or the foundation, nor does it treat special soil conditions.

While the recommendations are primarily for new construction, most of them can be made to apply to existing basements. In addition, suggestions are given for correcting some of the more common difficulties found in basements.



An exterior stairway can be placed under cover by locating it in the breezeway.



An areaway-type of entrance can be covered by a modernized version of the old-fashioned cellar door.

A grade level entrance to the house and basement is another way of obtaining direct access from the outdoors.

DESIGN OF BASEMENTS

With present-day heating systems and improved methods of construction and insulation, it is no longer necessary to build houses with basements simply to obtain comfortable first-floor temperatures during the winter. The need for a basement, however, may be based on other requirements.

When properly designed, the basement can be used for the recreation room, the playroom, the hobby shop. In some instances, bedrooms or a study can be located there also. The basement's usefulness for these various living activities depends largely on its design and on whether or not adequate daylighting, ventilation, moisture control, and thermal comfort are provided.

Houses can be built with full or partial basements, depending upon the space needed and the costs involved. Basements intended only for the accommodation of heating equipment can be very small. The addition of a laundry and drying room requires more area, as does storage space for bulky and out-of-use articles. Although these requirements seldom demand a full basement even in the smallest house, partial basements are generally not recommended for the small rectangular house. Different footing heights with resulting construction difficulties lessen the economies gained by reducing the size. In larger houses, a partial basement may be economical. This is especially true if the house is divided into two sections, such as in "T-" or "L-" shaped houses.

Entrances

A direct outside entrance to the basement increases its usefulness for hobbies, garden tool storage, laundering, and other activities since such an entrance eliminates tracking through the house. With a direct basement entrance, the location of the interior stairway (first floor to basement) is not restricted by service needs and therefore can be placed to give convenient access to recreation rooms.

An exterior basement entrance can easily be provided in houses on sharply sloping lots since such houses can usually be designed so that a section of the basement wall is above grade and the basement floor is at ground level.

When the exterior entrance necessitates a stairway, try to place it under cover of the garage, breezeway, or porch so that it is protected from ice, snow, and rain. Where this cannot be done, a covered areaway-type of entrance can be used.

If a direct entrance to the basement is not possible, a grade-level entrance to the house and the basement should be provided. In such a design, the entrance door usually is slightly above grade and opens onto the landing of an interior stairway. From here, one can go down to the basement or up into the house proper.

DAYLIGHTING THE BASEMENT

Basements should have plenty of natural lighting. The average basement has too small and too few windows.

Particularly desirable are large glass areas positioned to give occupants an unobstructed view. (Windows placed below grade in small areaways are of little value.) The best way to obtain large window areas is by proper location of the house on the lot and by well-planned grading.

A well-lighted basement for a house on a level lot can be achieved by setting the top of the basement wall two to three feet above the normal level of the lot and grading up the front yard only. In this way, basement windows, two to three feet high and requiring no areaways, can be provided at the sides and rear of the house; at the same time, the front of the house can retain that "low-to-the-ground" appearance which most people like. (Dirt from the excavation of the basement can be used to raise the level of the front yard.)

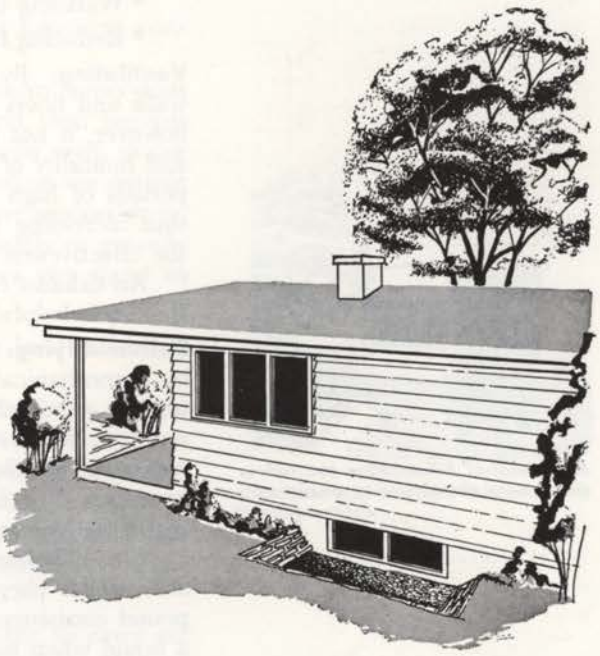
If the grade cannot be kept below basement window sills, areaways are necessary. These should be relatively large, and the walls should be sloped so that sunlight can easily reach the basement.

In some cases, these areaways can be extended to form a small sunken garden. Such garden areas add to the attractiveness of the house and make it possible to have a large expanse of glass on the basement wall facing the garden.

The problem of adjusting grading does not usually exist on lots which have a pronounced slope. A house on such a lot can often be designed so that at least one basement wall is entirely above grade. Since the effect is that of a full story being added to one side of the house, large glass areas in such walls are possible.

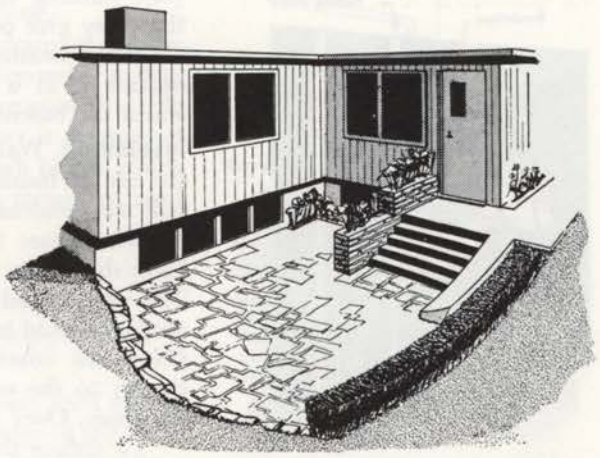
In split-level houses having three basic floor levels (living, utility, and sleeping levels), the basement or utility section is only one-half story below the first floor and, in effect, becomes another ground floor at a slightly lower level than the first floor. Windows can be tall enough to allow good vision from the room and good natural light in the room.

A level lot can be graded so that the front of the house has a low-to-the-ground appearance, while basement windows at the sides and rear are above grade level.



Areaways should be large and the walls sloped.

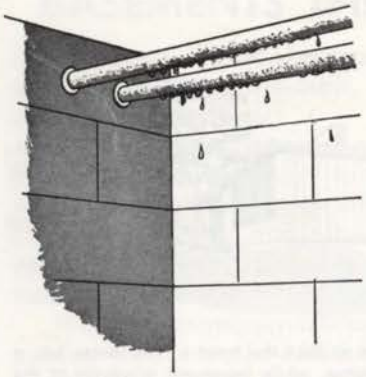
The house on a sloping lot can often be designed so that one basement wall is entirely above grade.



Sometimes areaways can be extended to form a small sunken garden.

KEEPING THE BASEMENT DRY

If the basement is to be a truly useful space, it must be a dry area. Leaks and seepage (capillary transmission) of water through the walls should be prevented, and moisture condensation controlled.



When water vapor in air is excessive, it frequently condenses on cold water-pipes.

Moisture Condensation

Dampness in a basement in the summer is frequently caused by condensation of moisture from the air.* This moisture problem occurs when warm moist air from the outdoors comes in contact with cool basement walls and floors, and with uninsulated cold water-pipes. The water vapor in the air turns into drops of water when the air strikes a cool surface. The temperature at which the vapor condenses varies in relation to the surface temperature and the amount of water vapor in the air.

Dampness caused by moisture condensation can usually be cured by:

- Warming the basement (by ventilating, insulating, or heating).
- Reducing the amount of moisture in the basement (dehumidifying).

Ventilating: By opening basement windows in **dry weather**, basement walls and floors can be warmed during the summer. Ventilation alone, however, is not a particularly dependable "cure" since the temperature and humidity of the outside air will greatly influence the results. During periods of high humidity the air entering the basement will be damp, thus increasing the amount of moisture in the basement and reducing the effectiveness of ventilation.

An exhaust fan installed in a basement window and operated during the day is helpful in circulating air through the basement.

A mechanical dehumidifier can reduce the amount of moisture in a basement.

Dehumidifying: The amount of moisture in a basement can be reduced by a mechanical dehumidifier. This is essentially a small refrigeration unit in which the cooling coil is exposed to the air in the room. The moisture in the air condenses on the coil since it is colder than any other surface in the basement. The water so formed is drained away. In the operation of a dehumidifier, some heat is given off. This heat helps to warm the basement and, hence, to control condensation.

Also effective in producing a dry atmosphere are calcium chloride and similar chemicals which absorb moisture from the air. Several 25-pound containers are needed in an average basement. The salt turns to a liquid when moisture is absorbed. This liquid must be disposed of and the salt replenished daily. Keep the liquid away from vegetation and also, because it is highly corrosive, wash it from metal surfaces.

Heating: By supplying a small amount of heat in the basement, the floors and walls can sometimes be warmed enough to prevent condensation. A fire in a basement fireplace, a laundry stove, or a water heater (one burning solid fuel . . . most other heaters are so well insulated that they give off very little heat) are suggested for a few hours a day.

If the heating system of the house has an automatically-fired boiler, operate it at a minimum temperature all summer. This will help to warm the basement, as well as to keep smoke pipes from rusting.

Insulation helps to keep basement walls warm; thus, water vapor does not condense on them readily.

Insulating: Walls can be kept above the temperature of the ground by the use of insulation. The walls being warmer, the moisture in the air will not condense so readily on them. Moisture-resistant insulation with a mineral base (inorganic) and an integral vapor barrier must be used. Care should be taken that moisture does not get behind the insulation. The wall should be waterproof (see page 7). In addition, a bituminous coating should be applied on the interior surface of the foundation wall. Over this coating, fasten furring strips (pressure-treated to prevent decay) to the wall. Install the insulation with the vapor barrier facing the room. Over this, any room-finish material may be applied.

To reduce the amount of water vapor forming on cold water-pipes, insulate them with "anti-sweat" covering.

* See Small Homes Council circular, F6.2 — "Moisture Condensation."

Preventing Leaks and Water Seepage

By selecting the right type of construction and the correct waterproofing method, a basement can be kept dry. Certain information about the site is needed to insure dry construction; namely, ground-water level, type of soil, grading possibilities, storm drainage facilities.

Ground-Water Level: The level of ground water varies considerably from locality to locality and also during the year.

Builders should check the behavior of ground-water levels with persons who know conditions in the vicinity of the site. Ground-water levels can also be determined by digging a test pit. It is important that the level of ground water be measured when it is at its highest — usually in the spring after a heavy rainfall.

In areas where the ground-water level is continuously above the basement floor, waterproofing problems will be severe. For this reason, a basement may not be advisable.

Type of Soil: The layers below the surface soil affect basement construction more than the surface soil.

Heavy soils of clay and silt are dense and often form impervious layers — that is, they absorb water, expand slightly, and then prevent the water from draining into the ground. Where such soils exist, drainage problems are frequently difficult. A layer of heavy soil on the outside of the basement walls may hold water and create pressure against them.

The drainage problem is relatively simple in light sandy or gravelly soils where the rain water disappears readily and does not stand in pools after heavy rains.

Grading for Proper Drainage: In grading the lot, the land should be sloped away from the house.

On low lots, the house should be set high and fill brought in around the house so that the water will flow away from it. Where there is no natural drainage for both front and back yards, the site should be graded so that there is a swale along the lot line between two houses.

Where there is a heavy slope leading to the house, an intercepting drainage ditch should be located at the base of the hillside to collect any water flowing toward the house.

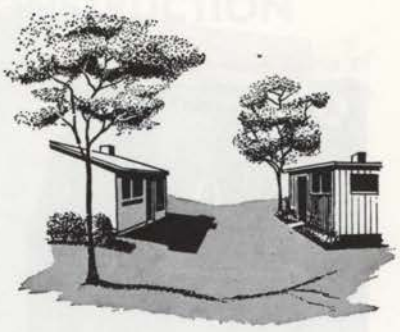
Storm Drainage: Most communities have a public sewer to carry off storm water from downspouts and from footing, areaway, and floor drains. This sewer must be adequate in size to avoid storm drainage backing up into the basement.

Before construction of the house is started, find out the past performance of the drainage system at the site and check its operation with neighbors, the city engineer, and contractors. Best drainage is obtained when the drain lines are below the basement floor.

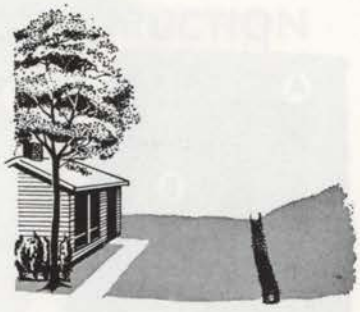
If no public storm sewer is available, make certain drainage can be handled satisfactorily by nearby streams, ditches, or a dry-well. A dry-well should be used only when there is reasonable assurance that the soil will absorb the water. When underground storm water is discharged into a dry-well, downspouts should be discharged on splash blocks which extend at least three feet from the house. Splash blocks should be used only if the ground slopes sharply away from the house.

Sump Pumps: If underground storm drainage lines in a house are too low to be discharged into the public sewer or ditches, they may be connected to a sump (a receiving tank in the floor). An automatic pump in the tank lifts the water to a higher level for discharge.

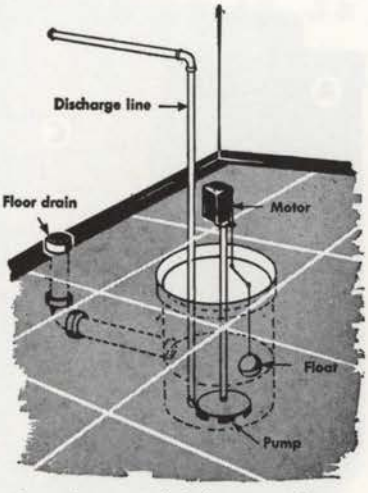
Basement Floor Drainage: Basement floors which are built level can be drained easily if a graded gutter is provided around the edge of the floor. If a floor drain is installed in the center of the basement, the floor should slope to it.



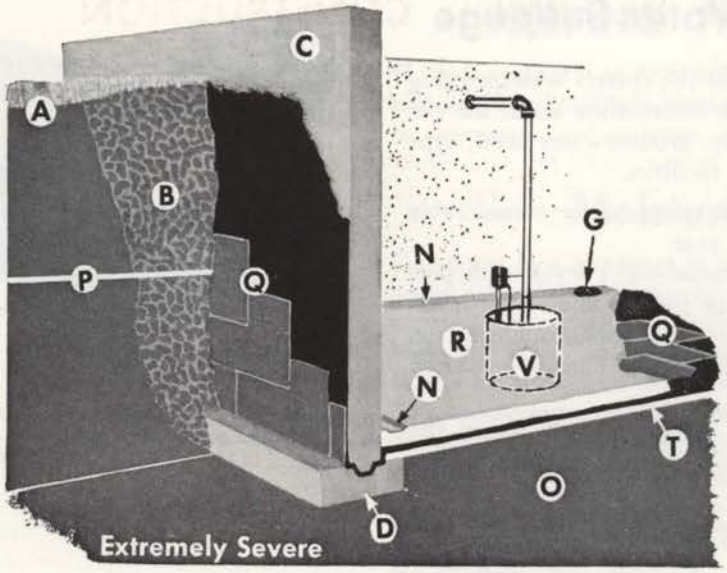
Site is graded so there is a swale between houses.

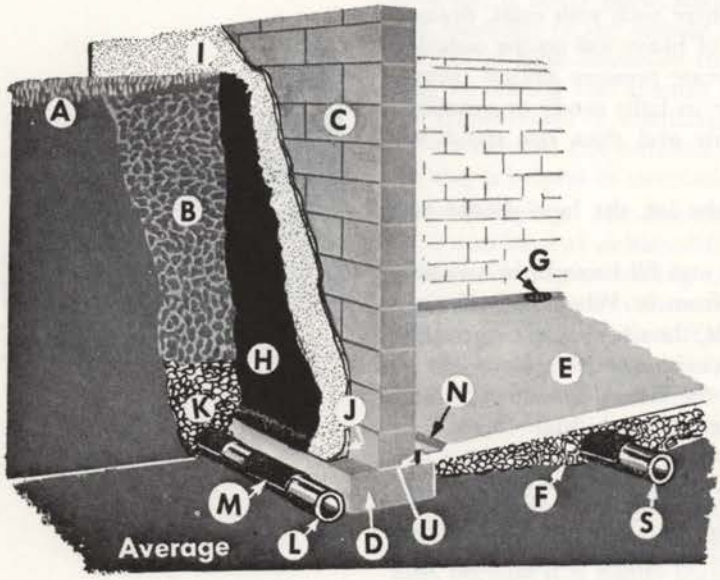


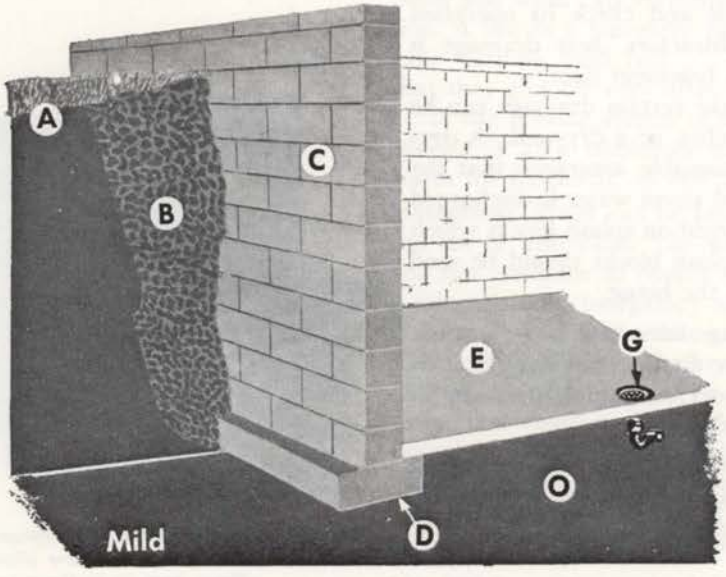
Tile laid in gravel forms intercepting drainage ditch.



Sump is recessed in basement floor.







KEY TO DRAWINGS

A. Ground should slope away from house
B. Backfill
C. Foundation wall
D. Concrete footing
E. Concrete floor slab
F. Porous drainbed or firm undisturbed soil
G. Floor drain with trap
H. Bituminous coating
I. One-half inch mortar (not necessary on poured concrete foundations)
J. Cove
K. Coarse gravel or other porous fill
L. Footing drain of field tile with open joints
M. Building paper over joints
N. Perimeter gutter sloping to floor drains
O. Firm undisturbed soil
P. Ground-water level
Q. Membrane waterproofing
R. Structural slab with reinforcing if necessary
S. Underfloor drain laid in gravel
T. Thin concrete slab
U. Hot tar or asphalt poured in joint
V. Sump pit with pump

SOIL AND DRAINAGE DETERMINE CONSTRUCTION

The type of construction, waterproofing, and drainage for water-tight basements depends on conditions of soil and drainage. Three conditions are described below and recommended construction for each is given in the chart.

- **Extremely severe conditions** exist where water pressure against the side walls or the floor of the basement cannot be relieved by the standard drainage methods of footing or underfloor drains leading to natural drainage or storm sewer. This condition is most likely to occur in low areas near swamps, rivers, or lakes.
- **Average conditions** exist where heavy soil normally holds water, but where the water pressure on the basement walls can be readily relieved by footing drains. This condition is found in localities not affected by swamps, rivers, or lakes. In such areas, the storm sewers may, however, be occasionally subject to back-up during heavy rains.
- **Mild conditions** exist where water readily disappears in sandy or gravelly soil, and the ground-water level is below the basement floor, making footing drains unnecessary.

In the chart, drain lines leading to sanitary sewers and septic tanks are grouped together as *sanitary drains;* drain lines connected to storm sewers, dry-wells or open ditches, as *storm drains.* The proper disposal of drainage water will depend on whether the sanitary and storm drain lines are both low, both high, or one is low and the other is high. Drain lines leading to the sanitary or storm sewer are classified as *low* if they are below the basement floor.

RECOMMENDATIONS FOR BASEMENT CONSTRUCTION

	Extremely Severe Conditions	Average Conditions	Mild Conditions
Walls (Foundation)	Poured concrete recommended. (Reinforcing may be needed.)	Poured concrete or masonry.	Poured concrete or masonry.
Floor	Double concrete slab with membrane waterproofing between. (The thickness and reinforcing depend primarily on water pressure.)	Concrete slab on firm undisturbed soil or drain bed of gravel or crushed stone.	Concrete slab on firm undisturbed soil.
Waterproofing or Dampproofing	Membrane extending above waterline on outside of foundation, and continuously under slab.	Bituminous coating on outside of all foundations from grade to footing. Masonry foundations should first be coated with mortar ½-inch thick.	None required.

Drainage Connections (Numbers refer to notes below)	Sanitary, low Storm, low	Sanitary, low Storm, high	Sanitary, high Storm, low	Sanitary, high Storm, high	Sanitary, low Storm, low	Sanitary, low Storm, high	Sanitary, high Storm, low	Sanitary, high Storm, high	Sanitary, low Storm, low	Sanitary, low Storm, high	Sanitary, high Storm, low	Sanitary, high Storm, high
Floor Drain	2	2	5 or 4	4	2	2	5 or 4	6 or 4	2	2	5 or 4	4
Underfloor Drain	Conditions prevent use.				7 & 1	7 & 3	7 & 1	7 & 3	Not required.			
Footing Drain	Conditions prevent use.				1	3	1	3	Not required.			
Areaway Drain	Connect to storm drain.				Use post-hole filled with gravel to lead water to footing drains.				Not required.			
Gutter & Downspout	Connect to storm drain.				Connect to storm drain *or* Discharge on splash block *or* Omit gutter.				Discharge on splash block *or* Omit gutter.			

1. Connect to storm drain.
2. Connect to sanitary drain.
3. Connect to sump, then to storm drain.
4. Connect to sump, then to sanitary drain.
5. Connect to storm drain if code allows. No laundry or shower discharge permitted in floor drain.
6. Connect to sump, then to storm drain if code allows. No laundry or shower discharge permitted.
7. Required only if underground spring feeds water beneath floor slab.

REPAIR OF BASEMENT LEAKS

Scrub cement base waterproofing into basement wall to eliminate seepage.

After a house has been constructed, any one or all three forms of dampness — leakage, seepage, condensation — may appear in the basement. Leakage and seepage can be reduced or eliminated by the same techniques recommended for new construction; however, most of those methods entail considerable expense since they require excavation of the earth down to the footing. Interior waterproofing and drain lines, if applied and installed correctly, will be effective in all but the most severe cases.

Dampness on walls can be controlled by applying several coats of cement-base waterproofing to the inside surface of the basement wall. The waterproofing, which is packaged in dry form and mixed with water to a pancake batter consistency, should be scrubbed into the pores, cracks, and crevices with a bristle brush.

Leaks Due to Water Pressure Against Wall

Seepage or leaks with a visible flow indicate that the exterior face is faulty in preventing water from entering the wall. Methods for combating this type of leak are:

- Apply mortar coat to inside surface of the wall. (Cement mortar should be applied at least ⅜-inch in thickness; quick-setting waterproofing cement, ⅛-inch thick.)
- If there is reason to believe that the footing tile is clogged, dig down and rod out this line, replacing any broken tile so the flow of water can be restored. Cover the joints with small pieces of tarred felt before back-filling with at least one foot of gravel or crushed stone.

Leaks between foundation wall and footing can be eliminated by building a cove of quick-setting waterproofing cement.

Many leaks occur at the joint between the foundation wall and the footing (and up to the floor level). These can usually be eliminated by building a cove of quick-setting waterproofing cement along the intersection of the wall and the floor. The cove should be keyed into the basement floor which should previously have a depression (2 inches wide and 1 inch deep) cut next to the wall.

Leaks Due to Water Pressure Under Floor

Hydrostatic pressure under the floor forces the water up through cracks and around the edge of the floor. The pressure should be relieved by installing a tile drain under the floor and next to the footing.

This underfloor drain can also be used to remove water inside of hollow masonry blocks or outside of the foundation. To do this, cut holes in the foundation and install ½-inch pipes. Placing cement around the pipes insures a watertight foundation. This system should be used only if there is no danger of the storm water backing up after a heavy rainfall.

If there is a danger of backup or if the underfloor drain is not adequate, a membrane can be placed on the existing floor and lapped up on the side walls. A structural cover slab of reinforced concrete can then be placed over the membrane as a wearing surface. Where the pressure from below is great, the slab must be reinforced to resist pressure against the membrane.

A tile drain installed under basement floor relieves water pressure.

Faulty Drainage

Water which backs up into the basement through the sewer or drain line can be controlled by a rubber plug or threaded standpipe set into floor drains. The height of the standpipe will depend upon the water pressure in the drain lines. The customary height is two to three feet. Water pressure which requires a taller standpipe may eventually burst the pipes and back up through the floor. To avoid this, back flow should be controlled by cutting off the drain lines outside of the house so that no water can get under the floor. To remove water, install a sump pump and connect the floor drain to it.