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# Preventing Basement Leakage in Treated-Wood Foundations

by

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# Preventing Basement Leakage in Treated-Wood Foundations

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*Abstract.*—Some of the traditional means of preventing basement leakage are ineffective. Far more important than the use of sealants and drain tile are the control of water through effective surface drainage and the maintenance of soil permeability for proper subsurface drainage. Although the methods described in this report are intended for use with treated-wood foundations, they will improve the performance of foundations built with other materials.

KEYWORDS: Basement construction, waterproofing, drainage, moisture control.

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Many homes are now being built with foundation walls constructed of pressure-treated wood instead of masonry block or concrete.[1] [2] Basements (fig. 1) with pressure-treated wood walls have the advantages of being less expensive to construct, easier to insulate, more comfortable to live in, easier to finish off, faster to build, and more easily erected in wetter and colder weather than conventional systems. A unique feature of this new system is its ability to resist leaking and to remain dry without the use of perimeter drain tile, cement parging, or asphalt coating included in other systems. This Paper shows why pressure-treated wood foundations do not leak, even though these traditional methods for preventing leakage are not used.

## CONTROLLING WATERFLOW

In preventing basement flooding, directing rainwater flow away from the house is more important than sealing basement walls or providing elaborate or complicated drainage systems.

In 1966 I studied the causes and prevention of basement leakage for the National Association of Home Builders (NAHB)[3] and was impressed with the importance of controlling water flow. I studied over 130 houses that had a history of leakage. Many of these houses had perimeter drain tile, walls parged with cement plaster, and asphalt coatings on the outside wall surfaces. Nevertheless, these houses leaked. At the same time, some home builders reported that thousands of their houses never leaked, even though these conventional techniques for preventing leakage were absent. From this study we learned how to build basements with masonry block or cast-in-place concrete walls that won't leak.

In the late 1960's I was in charge of a project to develop treated-wood foundations. In designing the treated-wood foundation, we incorporated concepts of leak prevention which we had learned from the study of basement leakage. As a result, we rarely hear of basement leakage with wood foundations. I estimate that about 30,000 treated-wood foundations have been built in the United States and Canada, and I have heard of only seven houses having leaking problems, all of which have since been corrected. The "All-Weather Wood Foundation System: Design,

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[1] American Plywood Association. 1976. The all-weather wood foundation: Why, what and how. 35 p. Am. Plywood Assoc., Tacoma, Wash.

[2] National Forest Products Association. 1975. All-weather wood foundation system: Design, fabrication, and installation manual. 74 p. Natl. For. Prod. Assoc., Washington, D. C.

[3] A pilot study of the causes, prevention, and correction of basement water leakage problems, by Natl. Assoc. Home Build. Res. Found., June 1966.

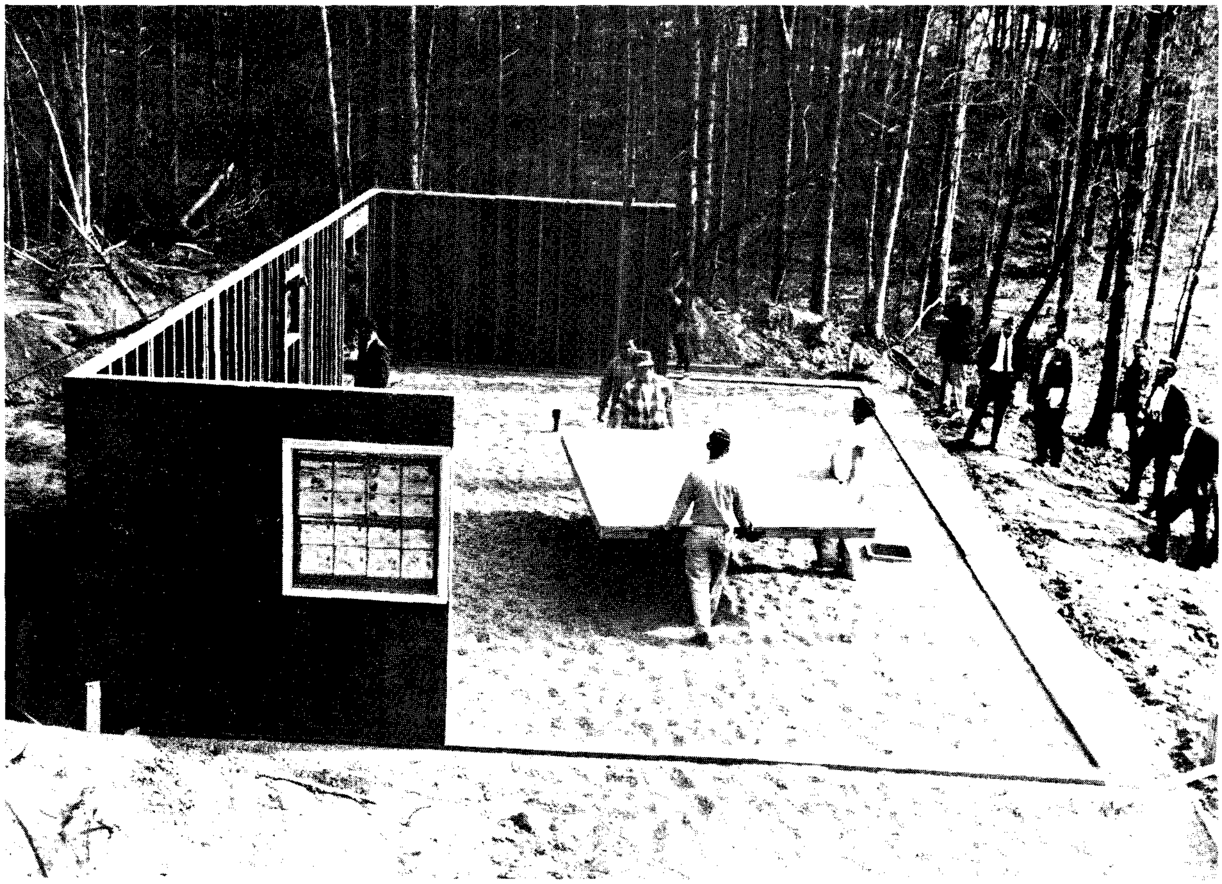


Figure 1.—Basement treated-wood foundation under construction.

Fabrication, and Installation Manual" (*see* footnote 2), published by the National Forest Products Association, contains recommended practices for building a leak-free treated-wood foundation.

To understand how to build a house that will not leak, we must consider two types of drainage: (1) drainage above grade, or surface drainage; and (2) drainage below grade, or underground drainage.

## SURFACE DRAINAGE

### Proper Grading

In the NAHB study, 85 percent of the cases of basement leakage were found to occur after rainstorms. The single most important factor in preventing basement leakage, therefore, is getting rainwater or water from melting snow away from the house before the water can enter the ground. Of all the techniques used to prevent basement leakage, proper grading is probably the best; certainly, its importance cannot be overemphasized. The surface of the ground around the house should be sloped away from the house for a distance of 8 to 10 feet. The slope should be at least ½ inch per foot; however, an inch per foot is preferable. Figures 2 through 5 illustrate methods of grading building lots to divert water away from the house.[4] Figure 2 shows how to grade lots that have a high elevation near the rear of the lot and that slope toward the front. Figure 3 shows how to grade lots where the entire lot and surrounding lots have a gentle cross-slope. Figure 4 shows how to grade lots where the entire lot and surrounding lots have a steep cross-slope. Figure 5 shows how to grade relatively flat lots by providing drainage valley and easement near the rear-lot line.

### Gutters and Downspouts

Rainwater from gutters and downspouts must also be directed away from the house. If the gutter fails or overflows, a sloping grade will get the water away from the house. Routing of downspout discharge into underground tile next to the house should be avoided because, if the tile drain becomes plugged, the entire runoff from the roof will collect outside

[4] Reprinted from Federal Housing Administration Minimum Property Standards No. 300.

the basement wall and cause flooding. Under these conditions, expansive soil can swell, causing leakage problems and structural damage to walls.

Since it is unlikely that builders will take time to design gutter and downspout systems, this aspect of preventing basement leakage is not covered in this Paper. However, for interested detailers, designers, and builders, further information on design of gutters and downspout systems may be found in "Architectural Graphic Standards"[5] or other standards on building designs.

[5] Ramsey, Charles G., and Harold R. Sleeper. 1970. Architectural graphic standards. 6th ed. 695 p. John Wiley and Sons, New York.

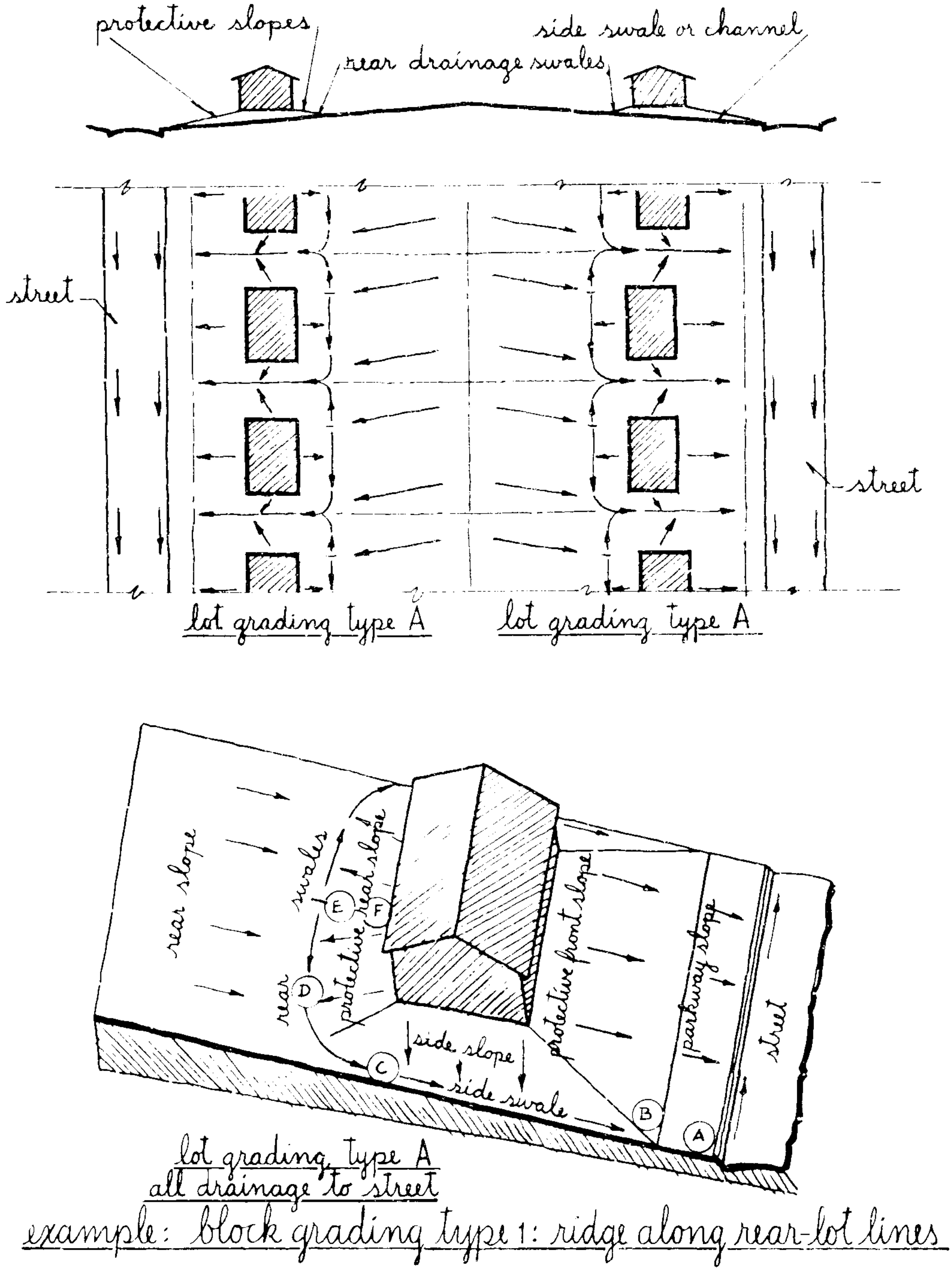



Figure 2.—Proper grading of a building lot with essentially level ground. Figure reprinted from *Federal Housing Administration Property Standards*.

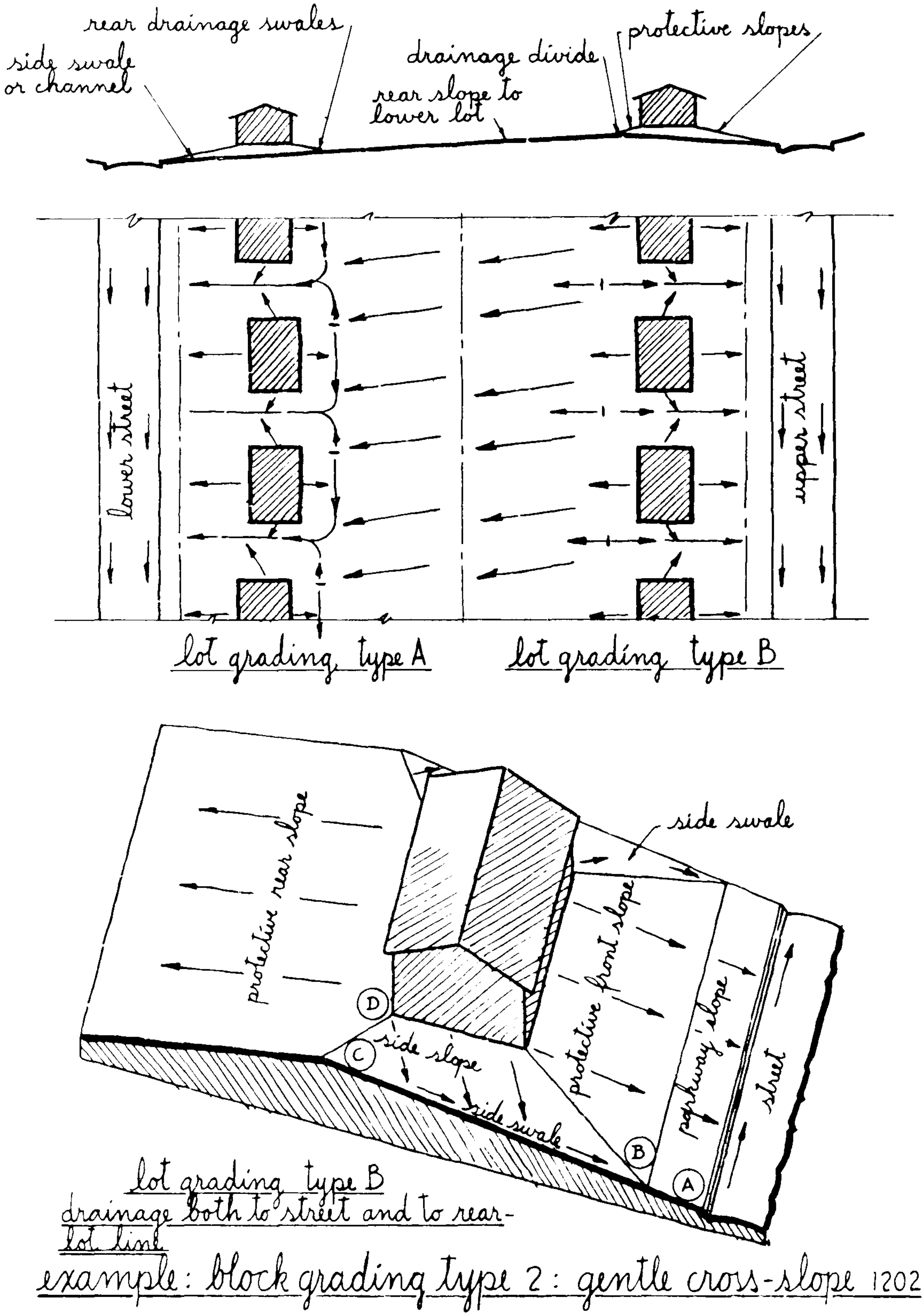



Figure 3.—Proper grading of a building lot with a gentle cross-slope. Figure reprinted from *Federal Housing Administration Property Standards.*

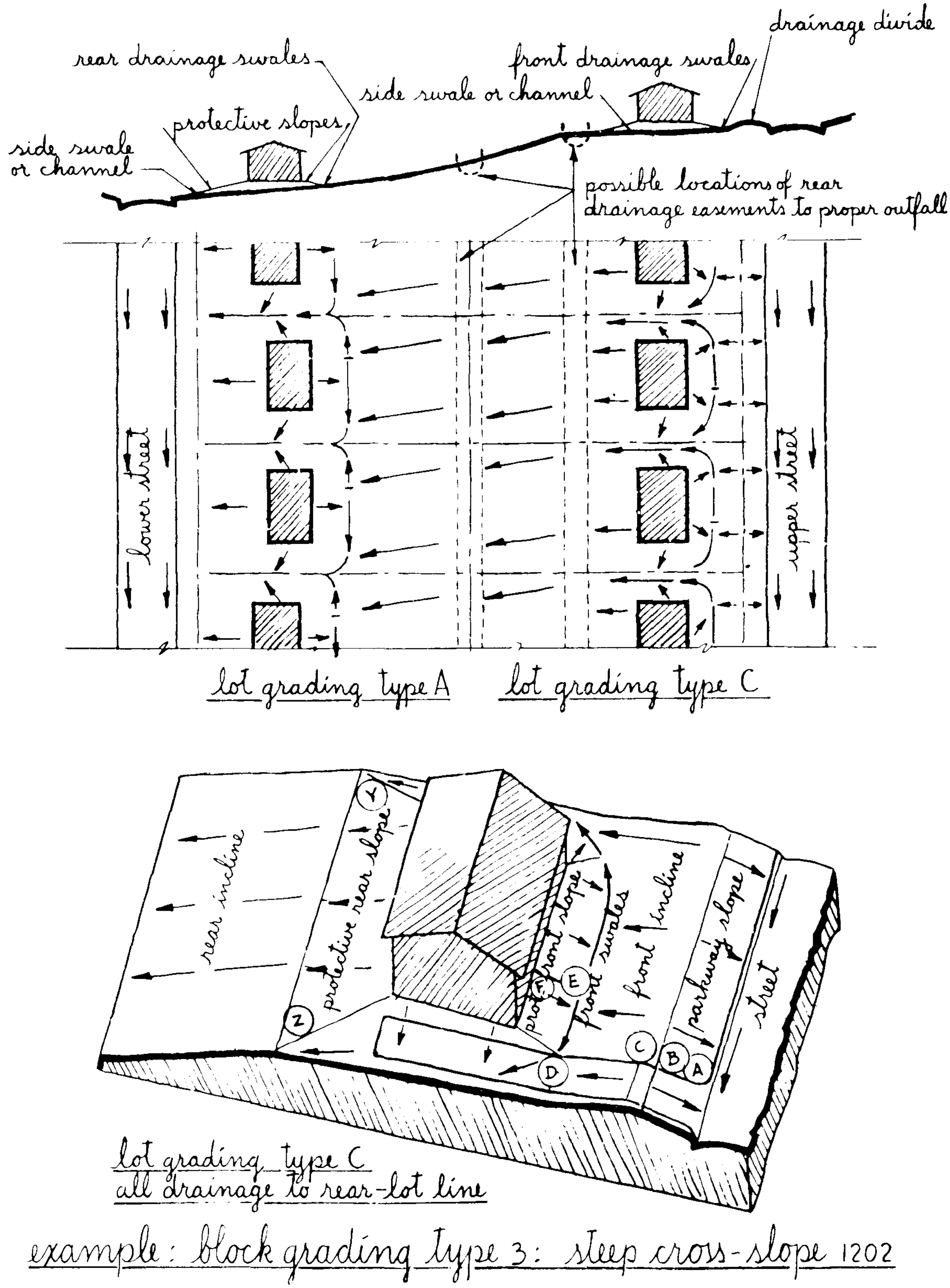



Figure 4.—Proper grading of a building lot with a steep cross-slope. Figure reprinted from *Federal Housing Administration Property Standards.*

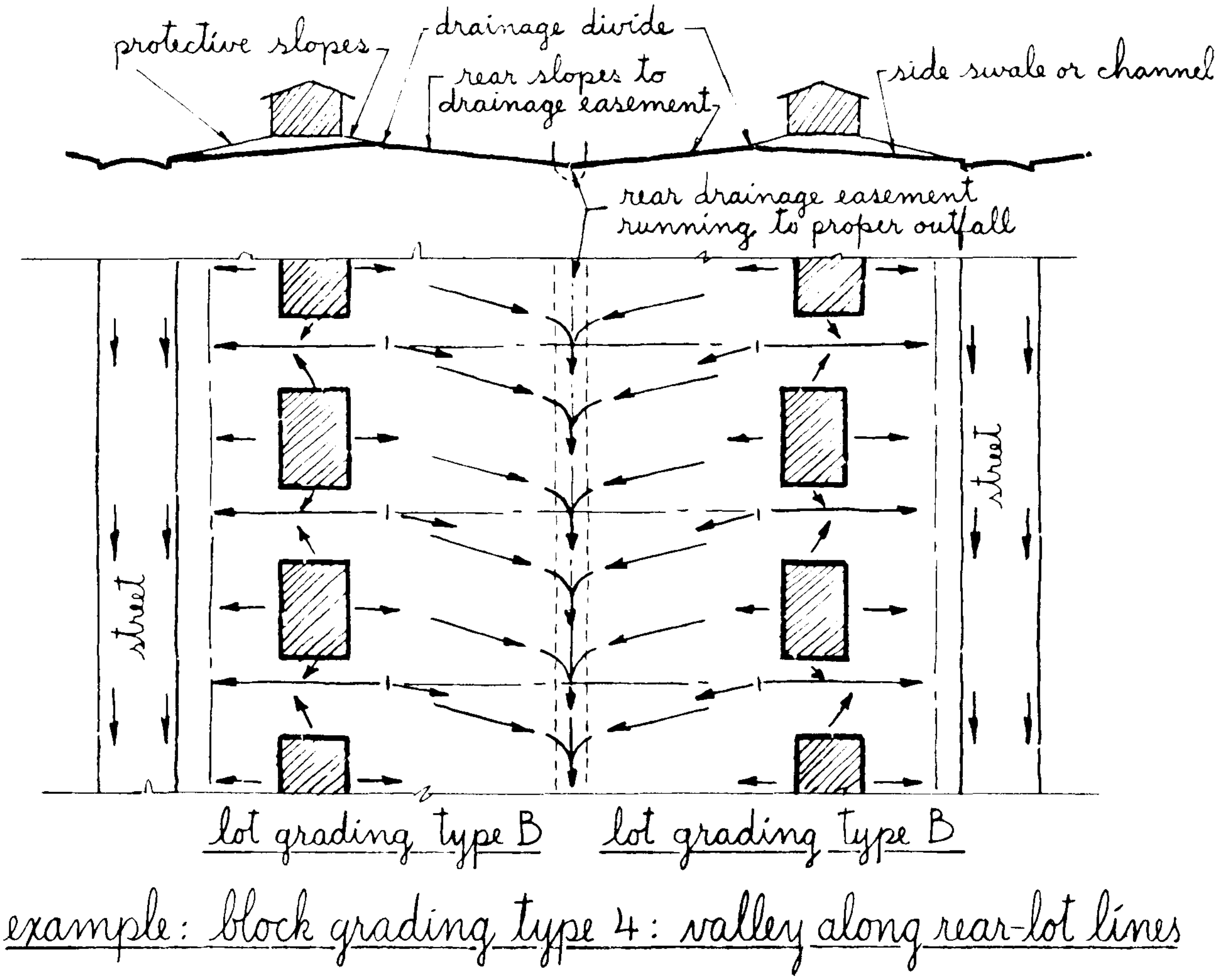



Figure 5.—Proper grading of a building lot with level ground, using rear drainage easement. Figure reprinted from *Federal Housing Administration Property Standards.*

### Problems in Surface Drainage

Poor surface drainage can be aggravated by flowerbeds, depressions under porches, depressions due to settling backfill, window wells, or any other conditions that cause water to collect next to the foundation wall. On the other hand, large roof overhangs help to reduce chances of water collecting near the foundation wall.

In addition to rain or melting snow, water from an overflowing stream or river, or water from an upland waterway (flash flood) may move in when heavy storms occur; the result is frequently a flooded basement. Obviously then, houses should not be constructed on flood plains or in natural drainage areas. Many of these potential flood areas have been located and defined; both the Soil Conservation Service and the U.S. Geological Survey provide information on flood plain areas in the United States.

In summary, proper grading is the most reliable method of controlling surface water and preventing basement leakage.

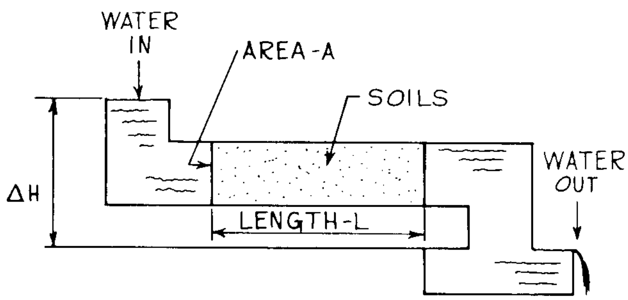
## SUBSURFACE DRAINAGE

### How Water Behaves in Soils

To understand control of water below grade, it is necessary to know how water moves through or is retained by soils. This knowledge is the key to understanding why some basements leak, even though all of the usual techniques for preventing leakage have been used; this behavior also helps to explain why some basements never leak even though apparently no measures have been taken to prevent leaks. Water movement in soils explains why treated-wood foundations, which do not use perimeter drain tile, can have an extremely low incidence of leakage.

## Darcy's Waterflow Study

A French physicist named Darcy studied the flow of water in soils. In his test setup (fig. 6), Darcy placed a sample of soil between two reservoirs of water. The level of water in one reservoir was higher than the level in the other reservoir by an amount $\Delta h$. For a length of soil (L) and cross-sectional area (A), Darcy measured the flow of water (Q) through the soil. He found that the flow of water through the soil was directly proportional to the area (A) and the hydraulic gradient ($i = \Delta h/L$). The constant of proportionality (k) is called the coefficient of permeability. Figure 7 provides a sample computation. If it is assumed that the cross-sectional area of the soil is 1 square foot, the length of the soil sample 3 feet, and the head loss ($\Delta h$) 3 feet, then the flow of water (Q) through the soil is simply equal to k, the permeability. For various types of soil, it is possible to see how much water will pass through in 1 day. For each square foot of coarse clean sand, gravel, or crushed stone, several thousand cubic feet of water can move through 3 feet of soil with a hydrostatic head of 3 feet. On the other hand, if this clean, coarse soil becomes infiltrated with silt or clay, its capacity to move water will decrease to less than 100 cubic feet per day. If soil is a clay or solid rock, then essentially no water moves through.




$$Q = kiA$$

$$i = \frac{\Delta H}{L}$$

Q = FLOW OF WATER IN $FT^3$/DAY
k = SOIL PERMEABILITY IN FT/DAY
i = HYDRAULIC GRADIENT
A = CROSS-SECTIONAL AREA IN $FT^2$
$\Delta H$ = HEAD LOSS IN FT
L = DISTANCE WATER MOVES THROUGH SOIL IN FT

Figure 6.--Darcy's equation for waterflow through soil.

$$A = 1\ FT^2$$
$$L = 3\ FT$$
$$\Delta h = 3\ FT$$
$$i = \Delta h / L = 1$$
$$Q = k \times 1 \times 1 = k$$

| TYPE SOIL | k FT/DAY | Q $FT^3$/DAY |
|---|---|---|
| CLEAN GRAVEL | 22,500 | 22,500 |
| CLEAN COARSE SAND | 5,100 | 5,100 |
| CLEAN FINE SAND | 36 | 36 |
| SILTY SAND AND GRAVEL | 15 | 15 |
| CLAY | 0.0003 | 0.0003 |

Figure 7.--Computations for waterflow through various soils using Darcy's equation, assuming a cross-sectional area of 1 square foot, length of soil of 3 feet and a head loss of 3 feet.

Figure 8 shows a house built where the soil is well drained and has a high permeability. Even if no techniques to prevent leakage were used, a basement built on such a site would probably never leak, for rainwater would rapidly penetrate the soil to the water table. From Darcy's equation, we can see that the soil has a built-in water drainage system. This situation is typical in sandy soils like those in parts of Florida, where water from a 2-inch rainstorm disappears almost as quickly as it falls. Of course, the water table will rise, and in Florida or any other such area, this high water table may prevent the building of basements.

Figure 9 illustrates a house built where the soil is poorly drained and has low permeability. A basement built on such a site would probably leak even though a builder employed all of the usual techniques to prevent leakage. Since rainwater cannot easily penetrate this soil, water collects on top of the ground. The water runs along the surface toward the basement on one side of the house. Because the builder has backfilled this area with sand, the water rapidly penetrates the backfill, establishing a hydrostatic head outside the wall. Overflowing gutters (or the absence of gutters) will contribute to the problem. The surrounding clay is essentially impervious,

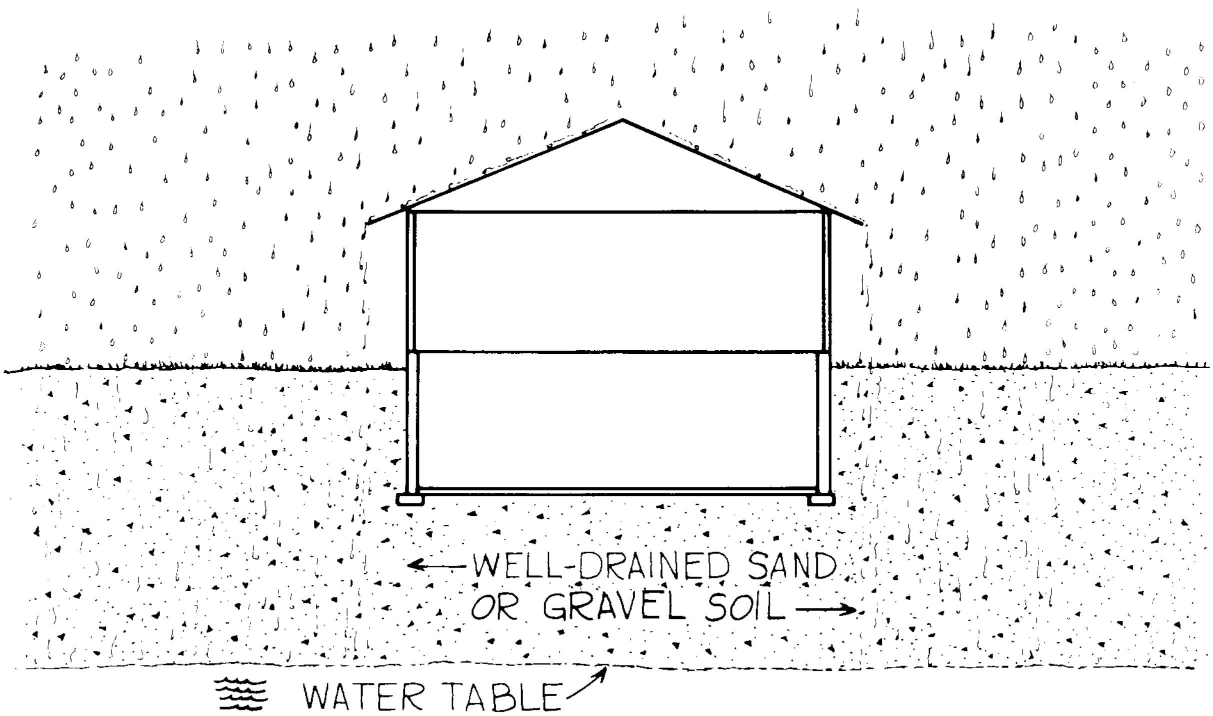



Figure 8.—Foundation built in well-drained soil is not likely to leak.

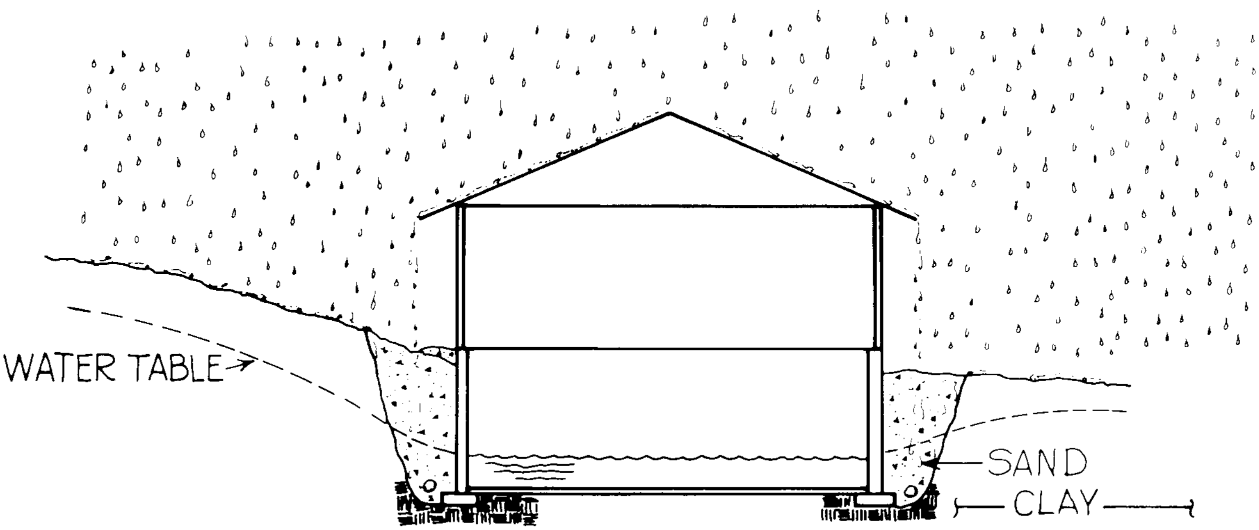



Figure 9.—Conditions that lead to basement leakage.

and no water can escape except through cracks or holes in the basement walls. If the perimeter drain tile fails (or if its capacity is inadequate), this basement will surely flood. Where concrete footings are used, they rest directly on the clay soil and block any chance for the water to escape to a reservoir under the basement floor. A deep, porous fill under a floor slab might easily hold all the rainwater penetrating the backfill, but the concrete footing will block this potential source of drainage.

## HOW TO MAKE A BASEMENT LEAKPROOF

Figure 10 shows how to build a leakproof basement on the site shown in figure 9 with masonry-block walls, cast-in-place walls, or treated-wood walls.

### BACKFILL

In figure 10, the surface has been properly

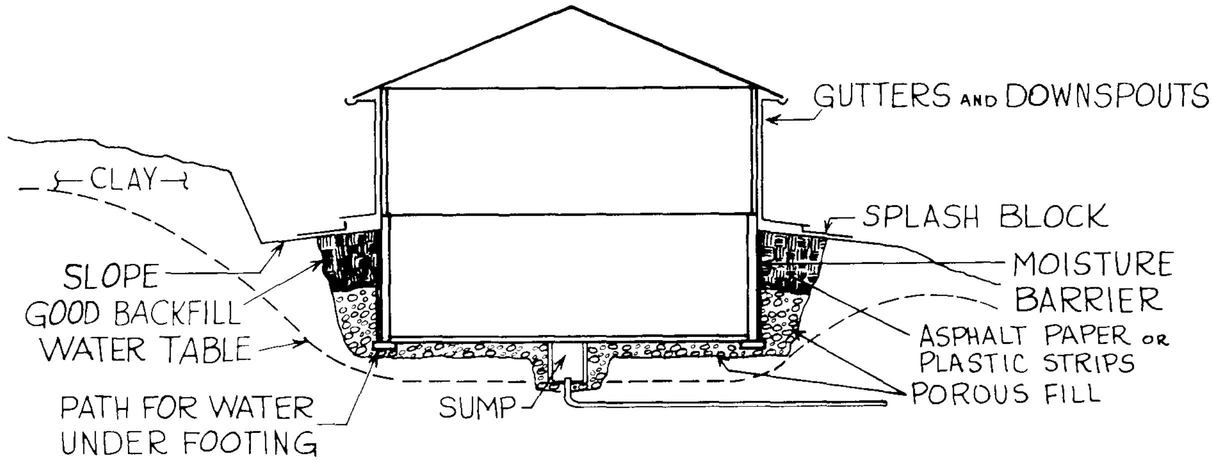



Figure 10.--Construction features that prevent basement leakage.

graded and gutters have been added to get water away from the house. The backfill near the footing is crushed stone or washed gravel, which is so permeable, according to Darcy's equation, that it will transport thousands of gallons of water per hour. Installing this backfill is easier and more foolproof than installing footing tile. Asphalt paper or strips of plastic laid loosely over the gravel or crushed stone will let water through but prevent silts or clays from infiltrating and plugging the porous material below. The area near the surface should be backfilled with soil containing some clay to prevent water from entering the backfill. To eliminate depressions that could hold ground water, the surface should be covered with moist, easily compacted soil. If backfill contains organic material, chunks of frozen earth, or construction debris, settling will eventually occur and a collection spot for water will be formed next to the wall.

## DRAIN TILE

Any water that collects outside the wall must be removed. Builders have traditionally used perimeter drain tile to carry away such water, but this tile may fail to function because of improper installation or infiltration by silts, clays, or fine sands. Once a tile system has been covered with backfill, it is inaccessible for repair or maintenance without completely reexcavating. In the NAHB study we found that some builders, who had no basement leakage problems and who did not use drain tile, relieved water pressure outside basement walls by providing a system of weep holes through the basement walls to a point beneath the basement slab. These builders used pipe, angle irons, or special concrete blocks with weep holes, or they formed channels in the top of concrete footings to relieve water pressure outside walls. They filled in 4 to 6 inches of gravel or crushed stone under the floor slab to receive water coming through the weep holes. A plastic vapor barrier was placed over this fill to prevent moisture from moving upward into the floor. In wood foundations, the gravel footing is a natural drain to the porous fill under the slab.

## SUMPS

The fill under the slab is drained to a sump that maintains the water table well below the floor-slab elevation. In some cases, builders used a collection pit (with no access through the basement slab) at the low point of discharge (fig. 11). The positive point of discharge should preferably be the storm sewer, the sanitary sewer, or a point above the ground surface if the grade permits. In some communities local laws prohibit connection of sumps, downspouts, footing drains, or under-floor basement drains to sanitary sewers. If this is the case, there should be a drain or pump to the surface. The only other alternative is to drain or pump water to an underground seepage pit or drain field which can adequately absorb the water. Unfortunately, in many types of soils, especially clay soils, the latter method is usually impractical because when drainage is most needed, the seepage pit is least likely to work.

A better solution is to provide a sump with an access opening through the basement floor (fig. 12). Builders can use three drainage methods from this sump: (1) An automatic float or pressure-actuated sump pump can be installed which goes into operation when the water level in the sump reaches a point

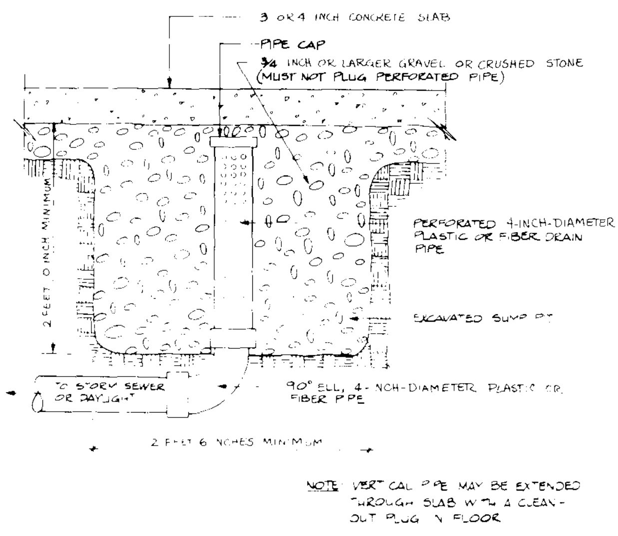



Figure 11.–Sump for medium- to well-drained soils.

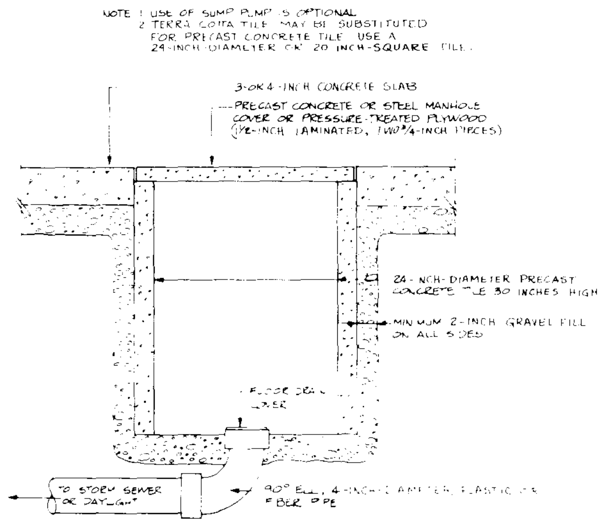



Figure 12.–Sump for poorly drained soils.

several inches below the bottom of the basement slab; (2) a drain line from the sump to storm sewers, sanitary sewers, or the outside ground surface may be used; or (3) as an extra precaution, the builder can make a trough in the surface of the basement slab from the top of the sump to the sanitary drain; however, this practice is prohibited in most communities. Any of these three drainage methods (or some combination) may be used, depending on the apparent need. An advantage of a sump is that it is accessible throughout the life of the structure and can be cleaned or maintained without expensive excavating.

Many builders were startled when we said that tile drains were ineffective and should be eliminated as an unnecessary expense. However, when builders who had had basement leakage problems for many years used the leakage prevention methods for masonry walls suggested in the NAHB report, they stopped having leaky basements.

## WATERPROOFING BASEMENT WALLS

Having gone into dark crawl spaces on bright, sunny days, I can testify that masonry block walls, even those that have been sprayed with asphalt, are full of holes. Daylight is clearly visible through the wall at many points. Contrary to what the average builder thinks, the general practices of "waterproofing" walls with parging (cement plaster), asphalt, or other sealants do not prevent basement leakage. Coatings made from asphalts with a high (400° to 600° F) melting point are solid at normal ambient temperatures. These asphalts are dissolved in solvents and sprayed on the basement walls. When the solvent evaporates, a rigid, solid asphalt coating is left on the wall; however, this coating (like parging) cracks wherever the wall cracks. Since all masonry and cast-in-place concrete basement walls settle and consequently crack, openings that will let in water must be expected. Although all types of basement walls are subject to cracking, wood foundation walls can move substantially without cracking, thus reducing the risk of leaks.

On some walls, plastic film may be worth using as a water barrier, especially where the surrounding soil is poorly drained. Attached to the wall only at the top and vertical seams, plastic film will help control water. Under the force of gravity, water that enters behind the film will flow downward and out the bottom. Although it is less likely to crack than other sealants, plastic is subject to puncture and, consequently, is not a cure-all.

Sealant systems, which are both costly and time consuming to install, are not the solution to leaky basements. Again, proper grading is the more effective method of prevention.

## SUMMARY

Figure 13 depicts the methods necessary for preventing basement leakage. These methods and the key to their identity on figure 13 are:

A – Check for high water table
B – Slope ground surface away from house
C – Consolidate backfill; use soil with low water permeability
D – Use plastic moisture barrier on wall
E – Provide path under wall for passage of water
F – Use a sump in soils that are poorly drained

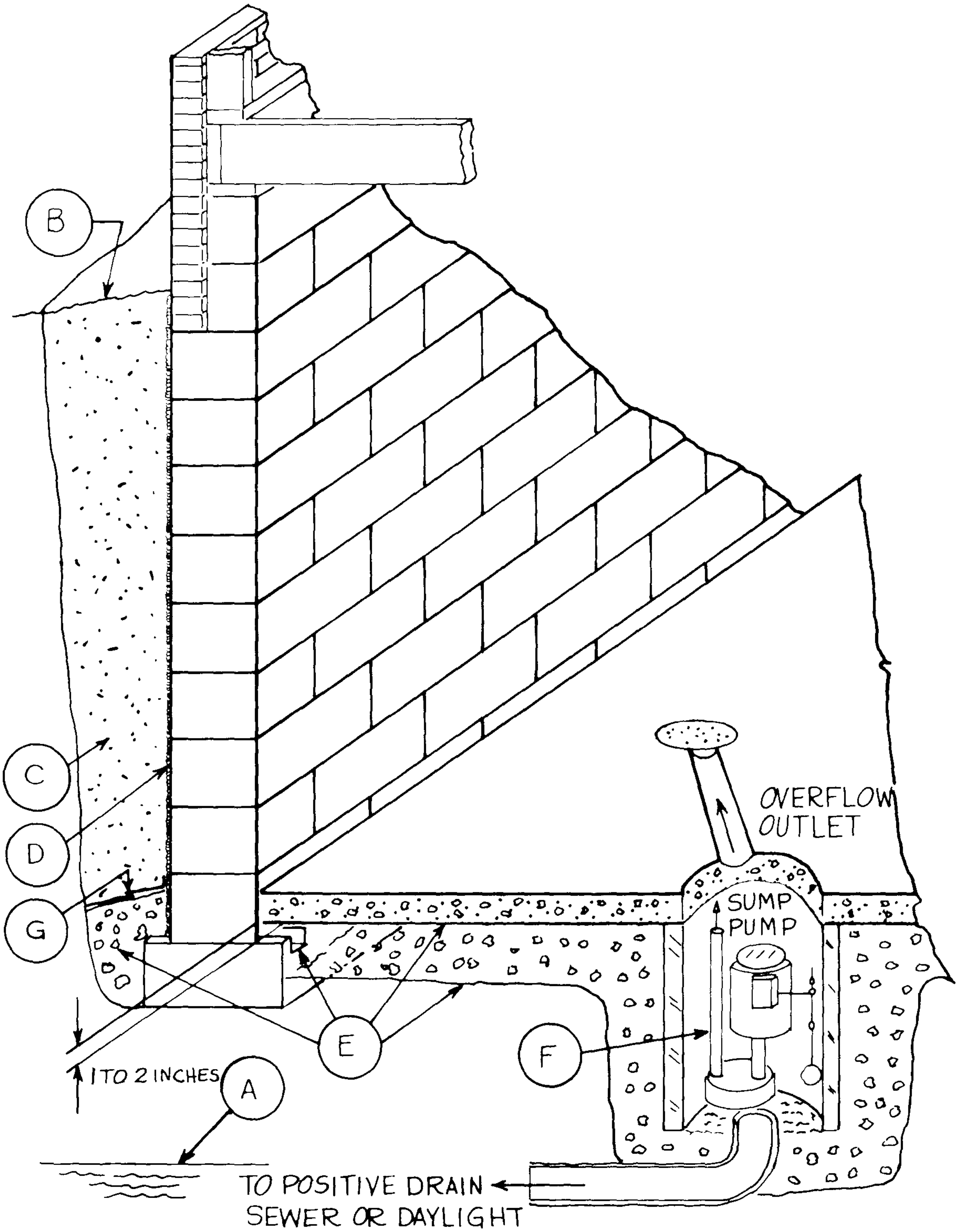



Figure 13.—Steps suggested to prevent leakage in basements with wood, masonry block, or cast-in-place walls.

G — Cover crushed stone with strips of plastic or asphalt

If the topography, ground cover (marsh-type grass, etc.), or experience in the vicinity indicates that there may be a problem with ground water or springs, the builders should bore a hole to several feet below the basement level. The height of standing water in the hole indicates the height of the ground water table at that time; even if no ground water is present, the builder should determine how high the ground water has been in the past. The U.S. Geological Survey monitors water table elevations in a number of locations; it often has useful data for builders. Obviously, a basement should not be built in natural drainage. If the elevation of the ground water table is at or near the level of the finished basement, the builder has two choices: (1) reject the site, or (2) provide a sump and pumping system with sufficient capacity to maintain the water table level below the slab.

The test boring described above will also indicate the presence or absence of clay or fine organic soils that are relatively impervious to water. If this type of soil is present, surface water will not readily penetrate downward; consequently, precautions should be taken against the likelihood of basement leakage.

Since grading is the most effective means of preventing leakage, the ground surface should be sloped away from the house for a distance of 8 to 10 feet. The slope should be at least ½ inch per foot, though some builders suggest using 1 inch per foot. When establishing this grade, the builder should allow for subsequent settling of the backfill around the basement. If downspouts are used, the water should be directed well away from the basement wall.

No more soil should be removed from the area beside the basement wall than is necessary to promote safety and provide room for construction; this restraint also minimizes excavation costs. When the backfill is placed, it should be compacted to eliminate voids in the soil that would permit water to collect outside the wall. Tamping or compacting backfill increases soil pressure against the wall, which may cause it to collapse. Some builders maintain wall braces until backfill has been placed and consolidated and for as long afterward as the sequence of construction will permit. Special care should be taken to avoid backfilling with clay chunks, which are difficult to consolidate.

If the soil does not permit good percolation, below-grade waterproofing with plastic film on the basement wall is appropriate.

To allow water that has collected outside the basement wall to flow through the wall to a point beneath the basement slab, the builder should provide a system of weep holes. These weep holes, which should be placed 4 to 8 feet apart around the foundation, may be made with pipe, angle irons, or special concrete blocks. It is necessary to make certain that the weep holes are not clogged during subsequent construction. For treated-wood foundations, a crushed-stone footing is excellent for relieving water pressure from walls (fig. 14). The builder should place 4 to 6 inches of gravel or crushed rock under the basement slab to an elevation 1 or 2 inches above the top of the footing. A plastic vapor barrier should then be placed on top of the gravel fill.

The basement floor excavation may be sloped from all directions to a single location where the sump is to be located. If gravel or crushed-rock fill is larger than pea gravel, it is probably not necessary to provide any slope since water will flow rapidly through the rock or gravel.

The area around the outside of the foundation wall and footing should be backfilled with gravel or crushed rock. This porous backfill should extend halfway up the wall for poorly drained soils but less than a foot for well-drained soils. The gravel or crushed stone should be covered with asphalt paper.

The sump should be constructed according to the details shown in figures 11 or 12. After estimating the probable rain intensity, hydraulic gradient, and soil permeability, the builder can calculate the size and number of sumps needed for the site. Darcy's equation provides valuable assistance in determining this need.

Good supervision at the job site is important. The construction superintendent should make sure that the workmen carefully comply with all construction details.

Figure 14 is a cross section of a typical treated-wood foundation wall.

Many builders will find it difficult to depart from their traditional reliance on drain tile and sealants; however, it should be noted that thousands of treated-wood and masonry-block foundations have been built using the water-control techniques advocated here and that these foundations are performing better than basements using some of the commonly accepted methods of preventing leakage.

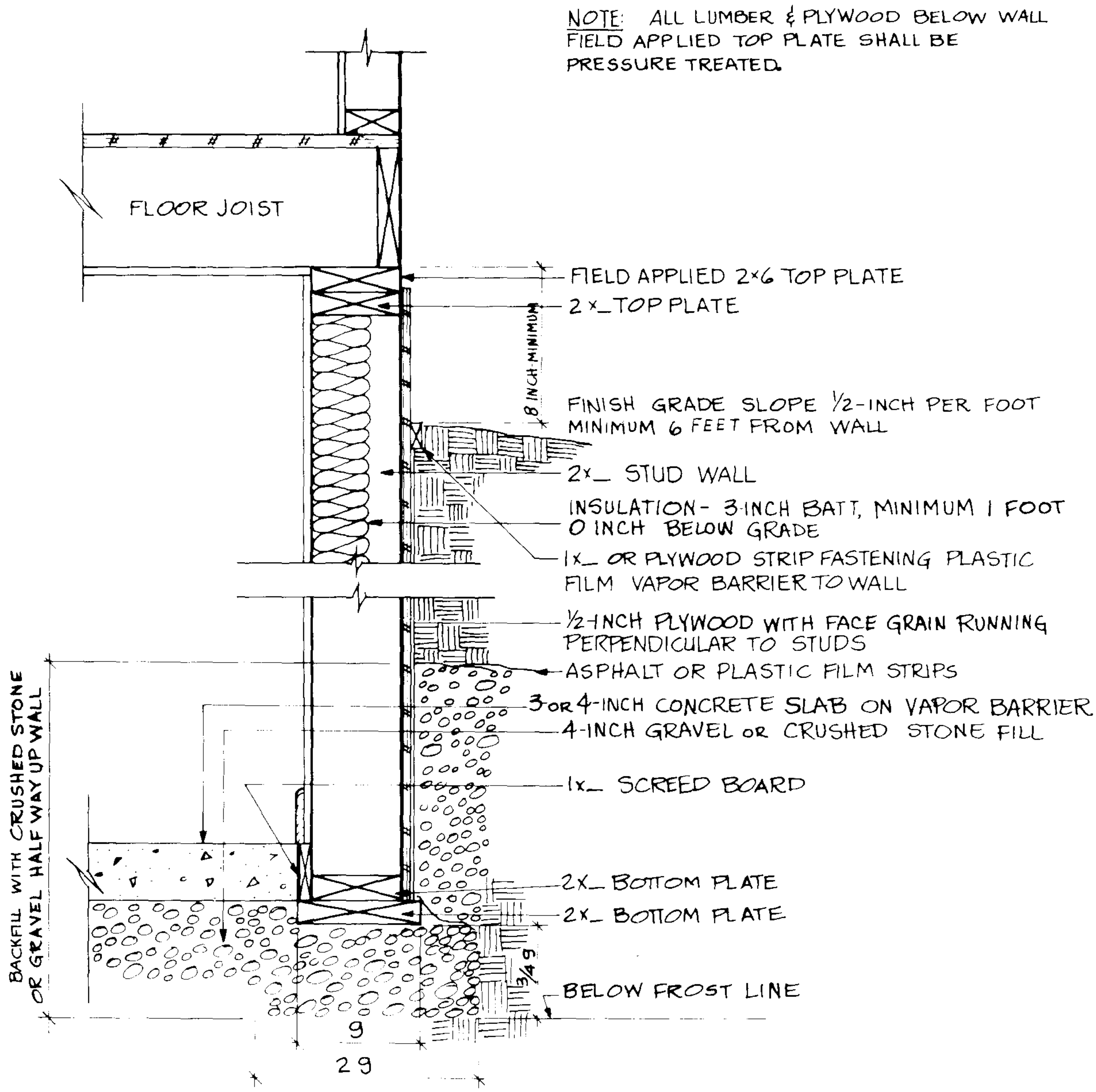



Figure 14.—Basement wall constructed of treated wood incorporates design concepts to prevent basement leakage.

Koenigshof, Gerald A.
1978. Preventing basement leakage in treated-wood foundations. U.S. Dep. Agric. For. Serv., Res. Pap. SE-195, 13 p. Southeast. For. Exp. Stn., Asheville, N. C.

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