CHAPTER 3

CAUSES OF ROOF FAILURES

3.1.1 Lack of Maintenance

The failure to find and correct minor defects and deterioration in its earliest stages is probably the greatest cause of premature roof failures. This is particularly true of built-up roofing applied on relatively low sloped roofs.

3.1.2 Weathering

All roofing materials deteriorate on exposure to the weather, the rate of deterioration being determined largely by the kind of material and the conditions of exposure. Some slate roofs in this country are more than 100 years old; the oldest copper roof is more than 200 years old, and "tin" roofs exposed 80 or more years are not uncommon. On the other hand, roofs of poor quality slate have been known to fail in 10 years; copper roofs may fail within 1 year through failure to provide for expansion and contraction, though the metal has not deteriorated; and "tin" roofs deteriorate rapidly when painting is neglected. These are only a few of the examples that might be given. In general, inorganic roofing materials tend to deteriorate less rapidly on exposure than the organic ones. Metal roofs subject to rapid oxidation must be protected. All types of roofing may be damaged by hail. Exposure to air pollutants, and industrial or salt atmospheres may accelerate the deterioration process of some roofings.

3.1.3 Use of Unseasoned Lumber or Improper Grade Plywood

The use of unseasoned lumber for roof framing and roof decks with subsequent shrinkage and warping was a frequent cause of premature roof failure on World War II, wood, mobilization type construction. Movement in the roof deck may cause breakage of rigid roofing materials such as slate, tile, and asbestos-cement shingles, and unsightly buckles in roll roofings, asphalt shingles, and built-up roofs. The use of interior type plywood for roof decking with subsequent delamination due to dampness or wetting can result in premature roof failure. The roofing membrane can be damaged by the warping of the ends of random length. tongue and groove, wood decking where the end joints do not fall over the supporting joists.

3.1.4 Improper Storage

Roofing materials, though intended for direct exposure to the weather, may be harmed if exposed before application. Consequently, they should be stored under cover at all times. Improper storage often results in damage to roofing materials and poor performance on the roof. The materials, particularly insulation and rolls of felt, must never be stored in direct contact with the ground or stacked too high. Manufacturers' instructions on stacking, storage, and handling should be followed.

3.1.5 Improper Application of Roofing Materials

3.1.5.1 General. Workmanship in applying roofing materials is as important as the selection of the proper materials. Inferior materials applied well will give adequate service as long as the materials resist weathering, but the best roofing materials improperly applied will give poor service from the beginning and result in premature failure.

3.1.5.2 Built-Up Roofs. Some common application faults are:

(1) Failure to take precautions over decks with open joints which permits bitumen to drip (fig. 1).

(2) Failure to provide a felt or metal bitumen stop at eaves and rakes resulting in bitumen dripping down the exterior wall surface, and exposing the unprotected ends of the felt.

(3) Entrapping moisture in roof insulation, resulting in blisters and other failures. A blister is illustrated in figure 19.

(4) Applying built-up roofs in weather which is too cold or wet.

(5) Inadequate adhesion of felts in built-up roofs, resulting in the blowing-off or the slipping of felts on steep slopes. Also inadequate fastening of felts to deck.

(6) Improper moppings of hot bitumen (too much or too little) between the plies of felt.

(7) Inadequate application (mopping instead of pouring) of hot bitumen in the application of

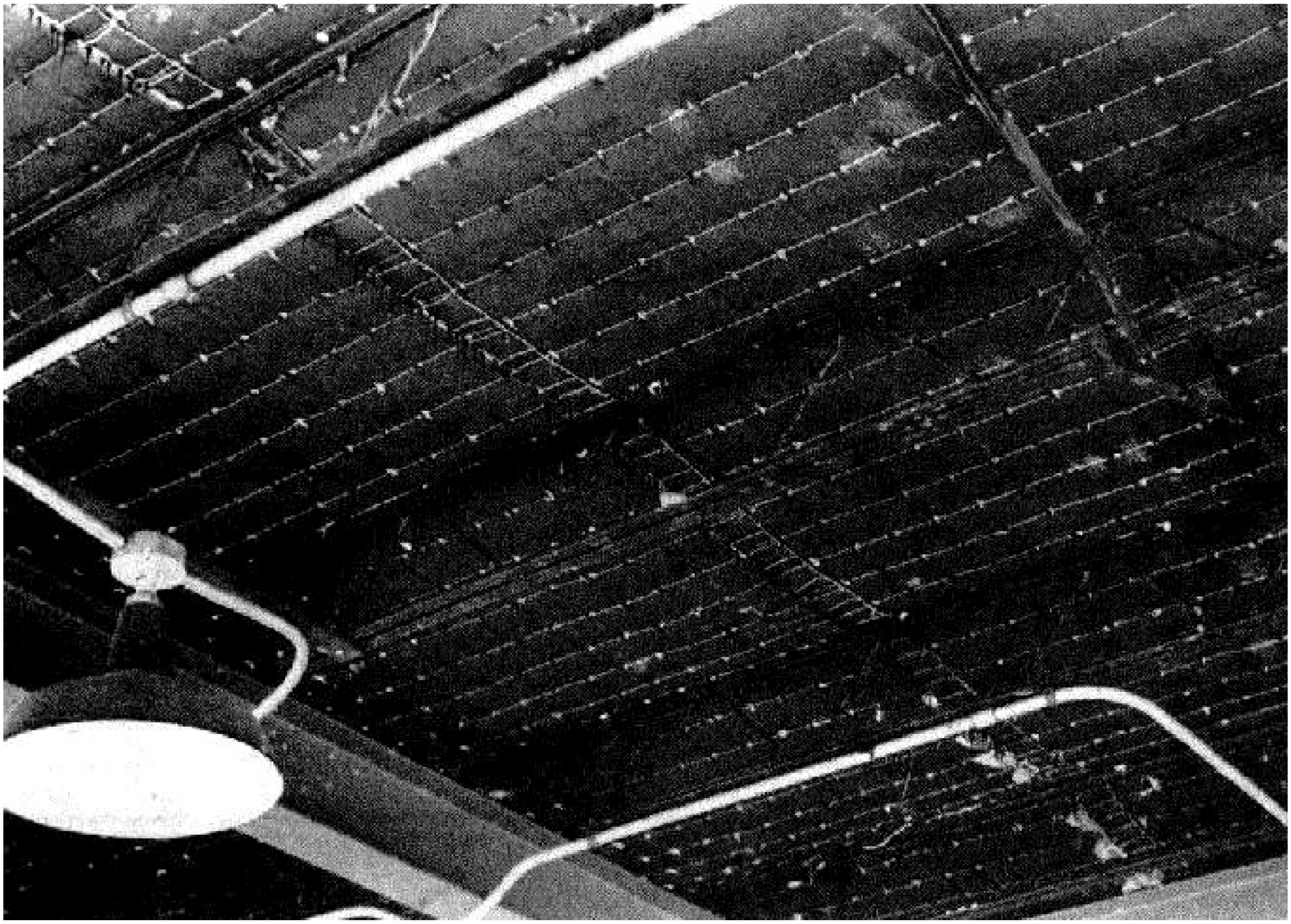

Figure 1. Bitumen flowing between open joints.

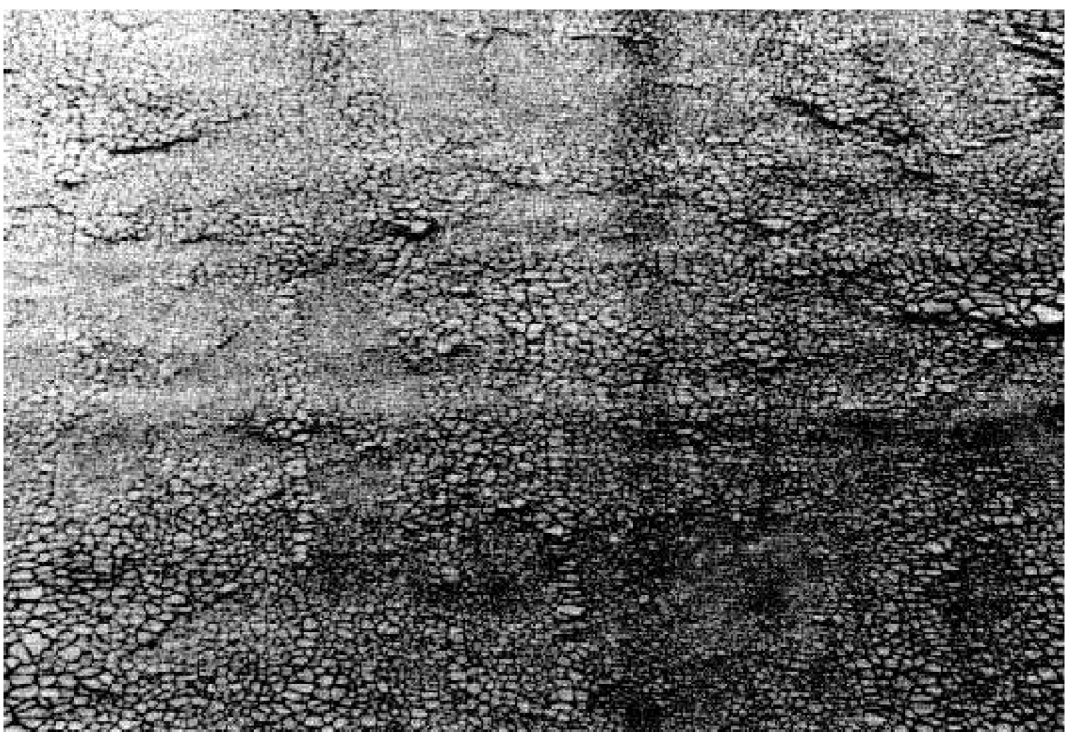

Figure 2. Alligatoring caused by heavy application of asphalt on smooth-surfaced built-up roof.

Figure 3. Wrinkles, buckles, lack of adhesion of felts.

flood coat for slag or gravel surfaced roofs. Pouring of bitumen is shown in figure 10.

(8) Improper application temperature of asphalt or tar bonding coats (too cold may result in lack of adhesion or use of too much bitumen; too hot may result in not enough bitumen between plies).

(9) Too heavy application of asphalt on the weather surface of smooth surfaced built-up roofs resulting in alligatoring of coating (fig. 2).

(10) Failure to broom felts smoothly behind the mop, resulting in poor adhesion, wrinkles and buckles (fig. 3).

(11) Improper preparation of surfaces to be bonded, particularly in patching slag or gravel surfaced roofs.

(12) Failure to embed metal gravel stops or metal expansion joints in roofing cement; failure to adequately nail gravel stops.

(13) Placing drains too high resulting in ponded water.

(14) Failure to provide smooth flat fit of roofing felt against cant strips, parapet walls and similar areas of flashing, causing air pockets and nonsupport of felts, resulting in holes being kicked in the roofing in these areas.

3.1.5.3 Asphalt Roll Roofing. Some common application faults are—

(1) Failure to cement the seams of roll roofing or to use the proper kind of cement.

(2) Applying roll roofings with exposed nails.

(3) Nailing roll roofing too close to the edge of the sheet.

(4) Failure to cut roll roofing into short (12 to 18 foot) lengths and failure to permit it to lie flat to lose the "roll."

(5) Failure to cover resinous knots, knotholes, or wide cracks in the roof deck with sheet metal.

(6) Failure to use metal drip edge at eaves and rake.

3.1.5.4 Asphalt Shingle Roofing. Some common application faults are—

(1) Nailing asphalt shingles too high (fig. 4).

(2) Failure to use wind resistant asphalt shingles having factory applied adhesive or to cement down tabs of asphalt shingles with quick-drying cement in windy areas or where slope is less than 4 inches per foot.

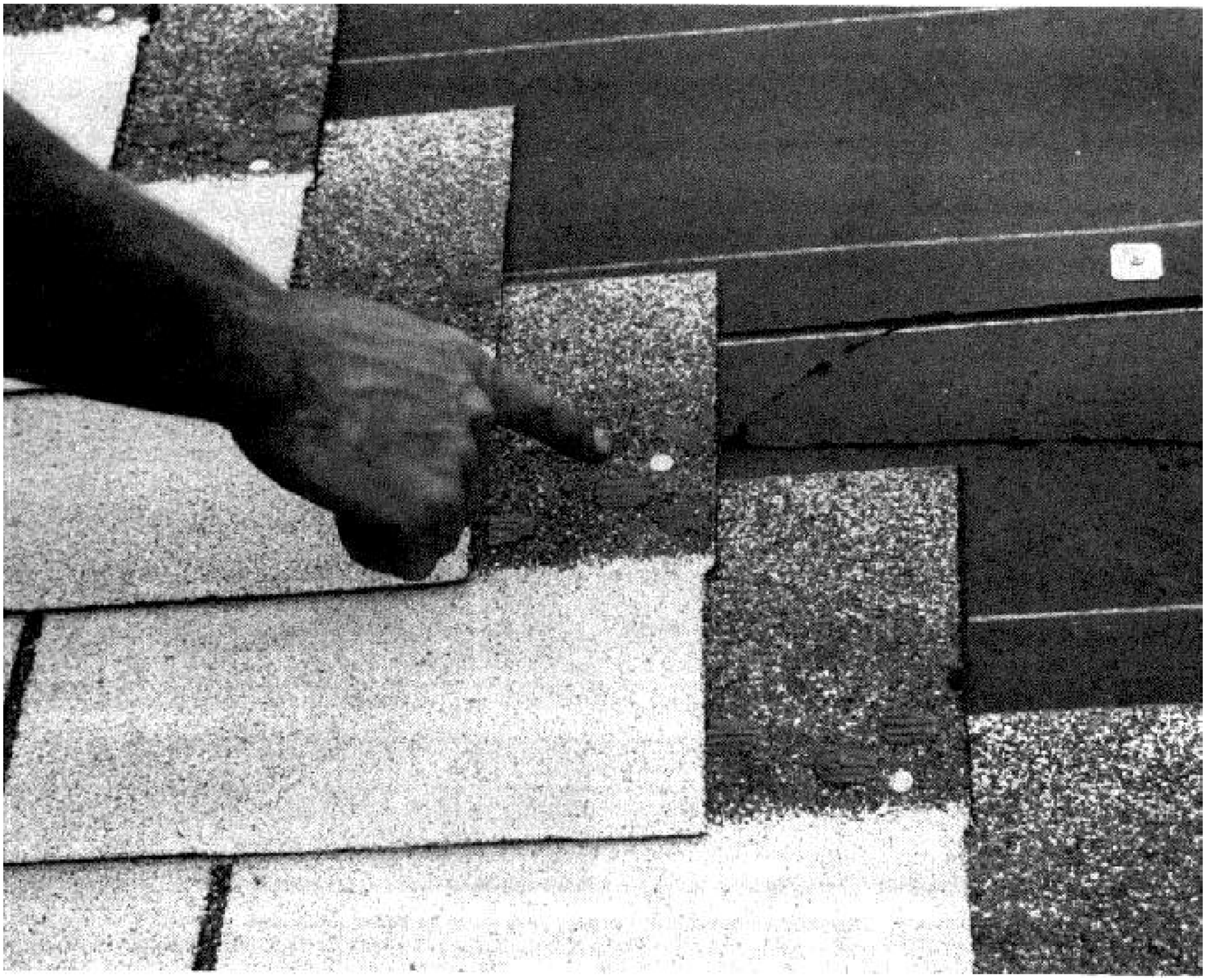

Figure 4. Asphalt shingles nailed too high.

(3) Failure to provide for proper drip at eaves or rake either by overhanging shingles sufficiently or by using a metal drip edge (fig. 5).

(4) Failure to provide roll roofing or double felt underlay over eaves wherever there is a possibility of an ice dam forming along the eaves and causing a backup of water; failure to provide a sheet metal eaves flashing in locations where there is a possibility of glaciation and ice damage at the eaves.

(5) Failure to use double felt underlayment on roofs having slope of less than 4 inches per foot.

3.1.5.5 Metal Roofs. Some common application faults are—

(1) Failure to provide adequate side and end laps with corrugated sheet roofings.

(2) Failure to use mastic sealing compound at end and side laps.

(3) Failure to use asphalt or rubber filler strips where required.

(4) Failure to paint tin (terne) roofing.

(5) Failure to provide adequately for expansion and contraction with changes in temperaure.

(6) Failure to fasten sheets adequately.

(7) Locating exposed fasteners in valleys instead of ridges for standard corrugated sheets.

3.1.5.6 Rigid Roofing Materials(Slate, Asbestos-Cement, Tile).

(1) Nailing too tightly.

(2) Using improper nails.

3.1.6 Use of Improper Materials

Practically all roofing materials are best suited for a particular type of service and some are definitely unsuited to certain conditions. It is obvious that shingle-type materials serve best on the steeper slopes and that the lower pitched roofs require roofing that will provide a continuous sheet over the entire area. Generally, shingle-type roofing (asphalt, asbestos-cement, slate, wood) may be used safely on slopes of five inches or more per foot. Shingle-type roofing may be used on lower slopes if proper precautions are taken.

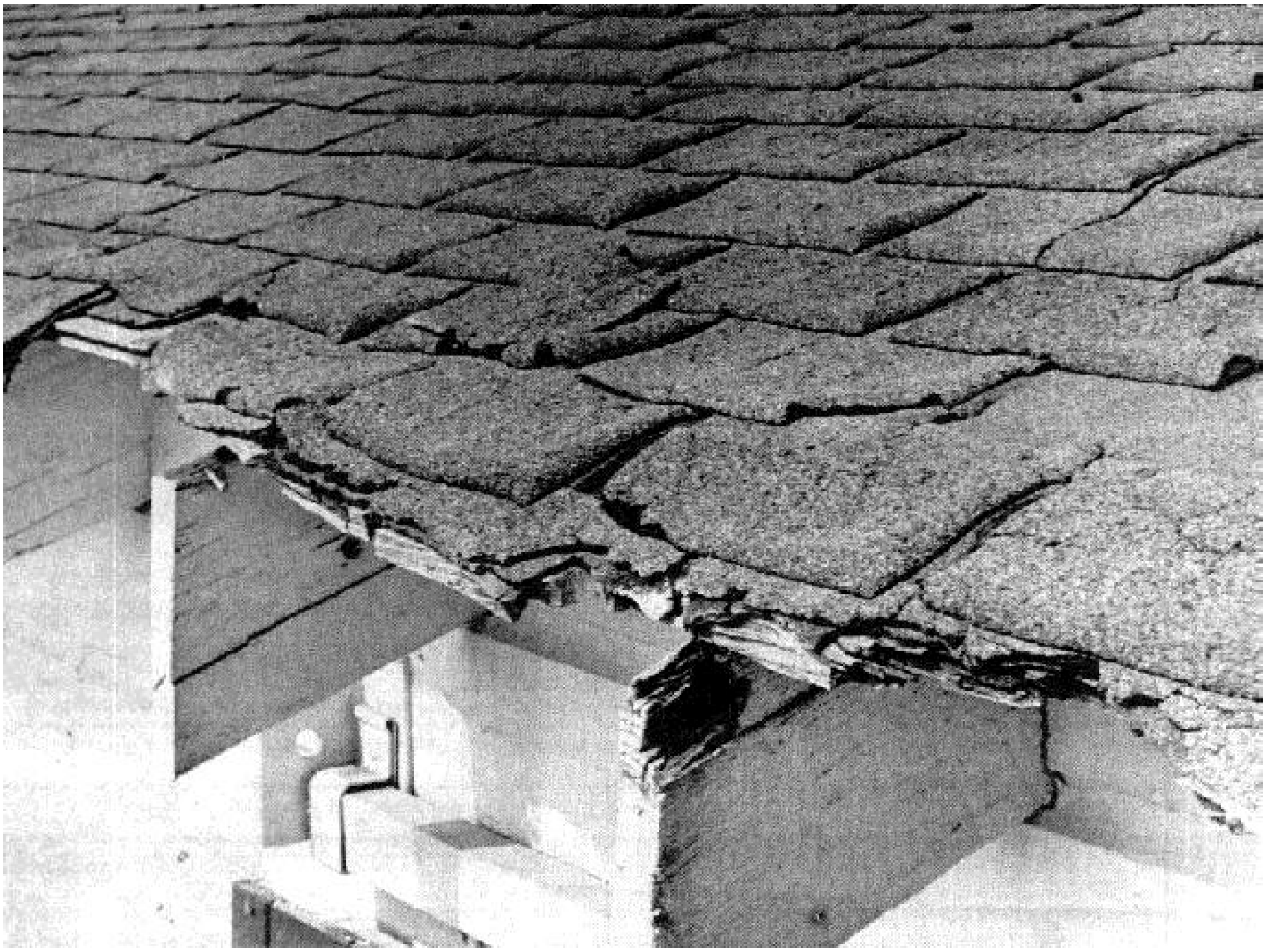

Figure 5. Inadequate provision for drip at eave — note damage to roof deck.

Recommended minimum roof slopes for various roofings are listed in table 1. Asphalt roll roofings, including wide-selvage roofing, may be used on slopes of two inches or more per foot. Wide-selvage roofing may be used on slopes of 1 inch or more per foot; however, it will not resist weathering as well because of poor roof drainage. Built-up roofs are best suited to roof decks that range from ½ inch to 2 inches per foot, though they may be used on slopes from dead-level to 3 inches per foot. Metal roofing in sheet form and corrugated asbestos-cement roofing are not generally used on slopes lower than 3 inches per foot. These include special shapes of galvanized and aluminum sheets, protected metal sheets and all batten and standing seam metal roofings. Corrugated or V-beam metal roofing may be used on lower slopes if the depth of corrugations is increased or if the sheets extend in one piece from eave to ridge. Soldered seam metal roofs (Copper, terne) may be used on flat or nearly flat decks. Information regarding the slope on which it is intended that various roofing materials be used may often be found in the applicable Federal, Military or ASTM specifications.

Table 1. Recommended Minimum Roof Slopes for Various Roofings

Type of roofing	Recommended minimum slope	Remarks
Built-up, coal-tar	½ inch per foot	May be applied on existing roofs having slopes less than ½ inch per foot. 2 inches per foot slope maximum.
Built-up, asphalt	½ inch per foot	For Alaska, 1 inch per foot minimum slope. May be applied on existing roofs having slope less than ½ inch per foot, providing low-slope type asphalt is used. Types of asphalt (softening point) suitable for use on various slopes are specified in ASTM D312. Three inches per foot maximum.
Asphalt roll roofing (application parallel to eave):		
a. Wide selvage	2 inches per foot	1 inch per foot slope for emergency construction.
b. Concealed nailing	3 inches per foot	Lap should be 3 inch. Slope of 2 inch per foot for emergency construction.
c. Exposed nailing	4 inches per foot	For 2 inch lap. Use exposed nailing method on emergency construction only.
Asphalt strip shingles	4 inches per foot	Over single layer of underlayment felt.
	3 inches per foot	For wind-resistant shingles over double layer of underlayment felt.
Asbestos-cement shingles	5 inches per foot	
Slate shingles	5 inches per foot	3 inches minimum headlap.
Tile shingles	4 inches per foot	Except promenade tile on flat decks.
Wood shingles	5 inches per foot	Depends on coverage (para 10.6.3).
Corrugated asbestos-cement	3 inches per foot	Increase end and side laps for localities subject to hurricanes, torrential or driving rains, or snow, and for roofs having slopes of from 3 to 4 inches per foot.
Metal roofings:		
a. Batten-seam	3 inches per foot	
b. Standing-seam	3 inches per foot	
c. Flat (soldered)-seam	½ inch per foot	Slope should be sufficient to prevent water from standing.
d. Corrugated sheets	3 inches per foot	May be used on slopes down to 2 inches per foot if depth of corrugations is increased. Increase end and side laps for localities subject to hurricanes, torrential, driving rains or snow, and for roofs having slopes less than 4 inches per foot.
e. Ribbed or V-beam sheets	3 inches per foot	

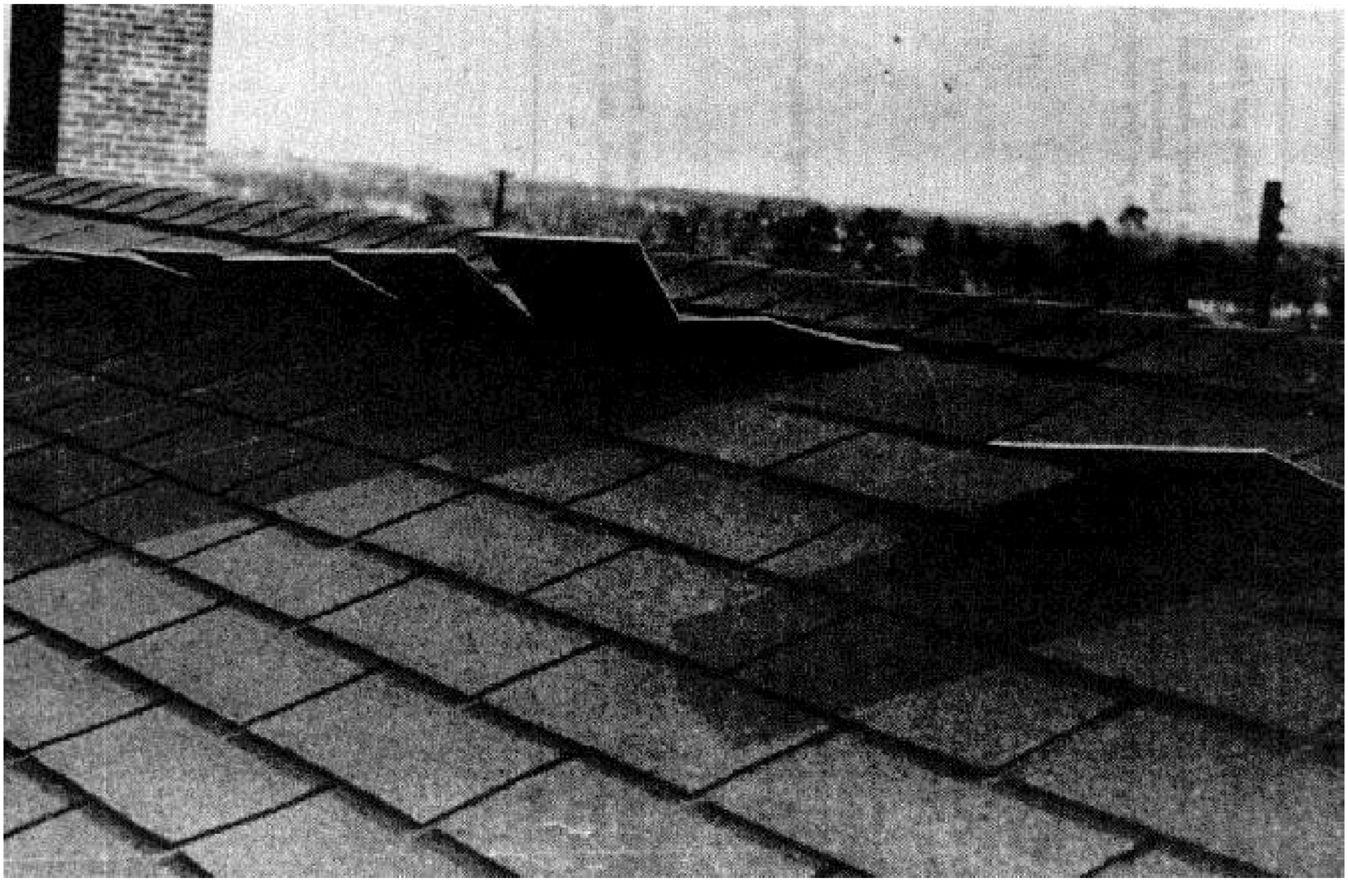

Figure 6. Action of wind on shingles nailed too high — can be eliminated by proper nailing and using wind-resistant shingles.

3.1.7. Wind Damage

All roofings are subject to damage from strong winds and flying debris. Roofs, generally, are not designed to withstand winds of hurricane and tornado intensity. However, the greatest damage to roofs is not necessarily from hurricanes but, rather, from winds of moderate intensity and the gusts that may reach 50 to 75 miles per hour that accompany them. Asphalt roofings, particularly free-tab asphalt shingles, improperly applied arc probably most susceptible to wind damage. Figure 6 illustrates the effect of a gust of wind on free-tab shingles that were nailed too high. Continued flexing of these shingles weakens them and after a number of gusts the shingle tab is blown off. The same is true if these shingles are nailed correctly, but the free tabs are not cemented down and account for the many cases where only the exposed tab of a shingle is blown loose. Free-tab asphalt strip shingles nailed correctly have been shown to resist less than 100 gusts in a simulated test. In a similar test with the tabs cemented down the shingles have resisted more than 2,000 gusts. Another cause of wind damage to roofs is the partial vacuum caused by wind blowing perpendicularly over the ridge of a roof and causing the roll roofing to tug at its fastenings. This same effect is apparent when wind blows against the side of a building with a flat roof and is one of the important reasons for the adequate fastening of built-up roofing felts and for providing a properly fastened gravel stop. In the case of built-up roofs it is the constant pull from relatively mild winds that loosen the nails and make the roof susceptible to the first strong wind to which it is subjected.

3.1.8 Exposed Nails

The tendency of exposed (uncovered) nails to work loose has probably caused most trouble with asphalt roll roofings which have been applied by the exposed nail method. However, exposed nails are always a potential source of trouble with roofings of any type. Nails used to hold down curled wood shingles invariably come loose as do nails in the battens used to deflect water away from the entrances to buildings.

3.1.9 Failure of Flashings

Flashings should be designed to furnish at least as long service as the roofing. Many early roof failures are actually flashing failures. This is particularly true of built-up roofs on flat or low slope decks. Numerous cases have been observed where

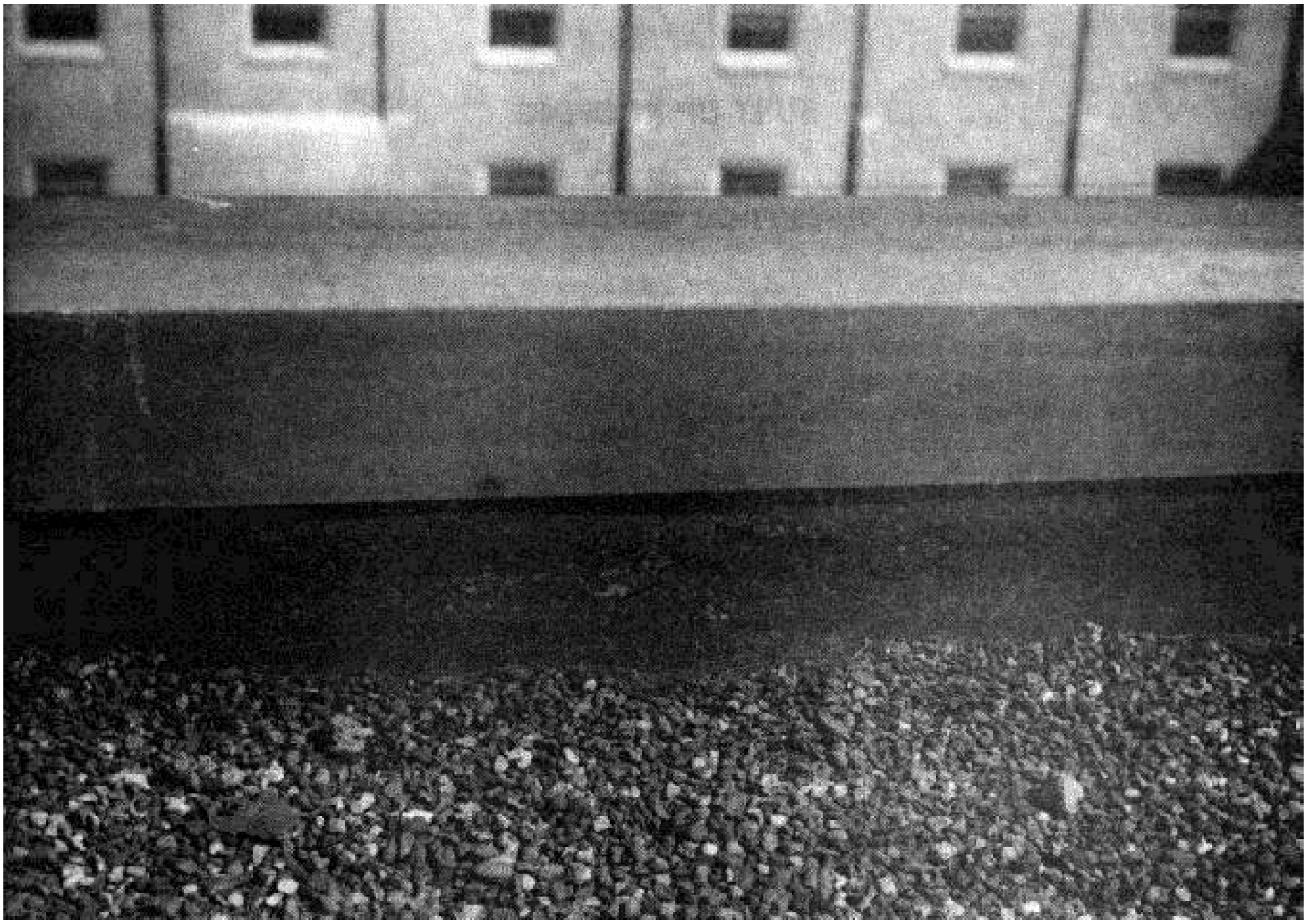

Figure 7. Defective flashings are frequently responsible for leaks attributed to failure of membrane.

reroofing has been requested when repair of the flashings or provision for new flashings was all that was required to make the roof leak-proof (fig. 7). When it is considered that the function of flashings is to provide a waterproof junction between the roof and other parts of the structure and between roof sections, their importance, and the importance of maintaining them properly cannot be over-emphasized. Flashings are discussed in detail in chapter 12.

3.1.10 Improper Design

Troublesome and costly roofing problems are often the result of faulty initial design of the roof system. Examples are: too flexible a roof structure causing cracking of the roof membrane; inadequate roof slope and insufficient number of drains; inadequate provision for expansion and contraction; sagged roof structures; omission of walkways for traffic; mopping directly to gypsum decks; poor flashing details. Action should be taken to determine the cause of the problem and, to the extent feasible, remedy the deficiency, particularly when reroofing.