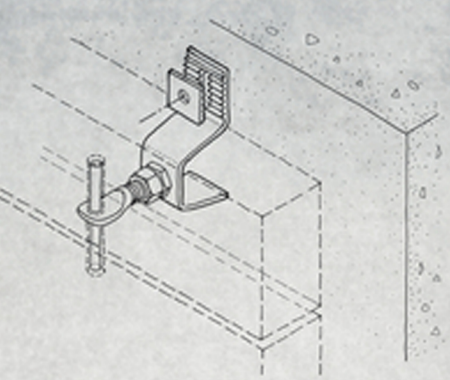
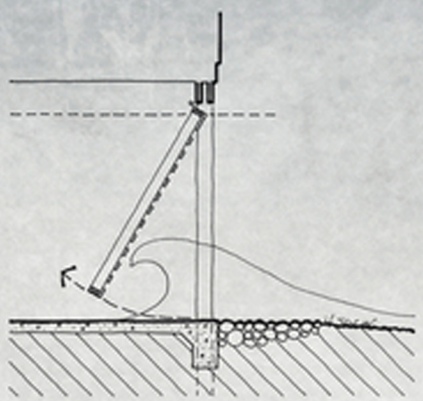
ARCHITECTURAL DETAILING

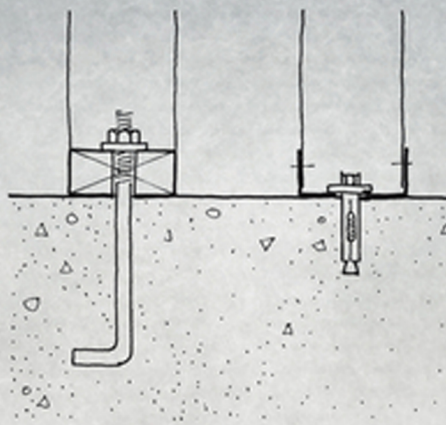
FUNCTION | CONSTRUCTIBILITY | AESTHETICS

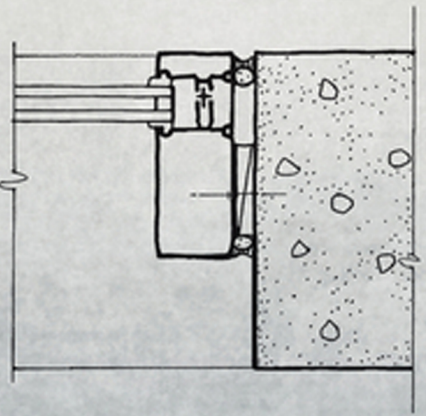
EDWARD ALLEN · PATRICK RAND

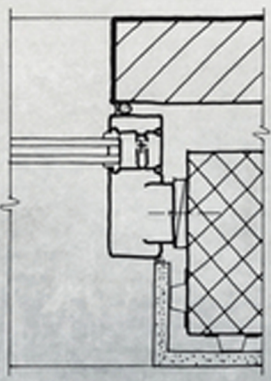
THIRD EDITION

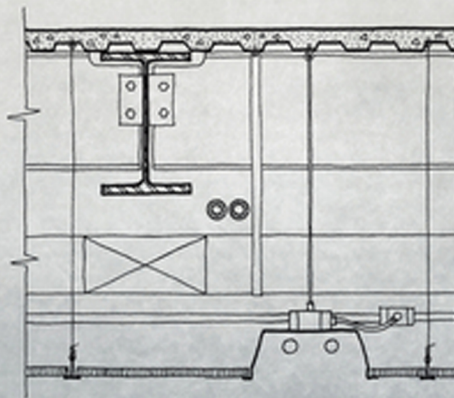












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Architectural Detailing

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Function • Constructibility • Aesthetics

Third Edition

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CONTENTS

CHAPTER 11 Ease of Assembly 171

CHAPTER 12 Forgiving Details 191

CHAPTER 13 Efficient Use of Construction Resources 215

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Edward Allen
South Natick, MA

Patrick Rand thanks Edward Allen, generous mentor to a generation of architectural educators, for this opportunity to collaborate again. Ed shows us all how to make the most important aspects of our craft vivid and accessible, empowering countless young designers to make architecture that is functional, constructible, and aesthetically pleasing.

Pat is also grateful to his many students, whose ambitious designs and probing questions helped him grow. Students in his graduate detailing seminars probed the breadth and depth of the principles in this book as they used them to analyze existing buildings and to design their own new projects. Work by these students provoked revisions of nearly all of the patterns in this edition, and the creation of several new patterns. He also thanks Christine Nalepa for her patience, support, and candid critiques of word and image.

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Patrick Rand
Raleigh, NC

INTRODUCTION

The transition from architectural idea to built reality is composed of countless decisions that are made amid a landscape of ever-changing circumstances. Architects design and draw for each building a set of details that show how it will be put together. Architects have primary responsibility for the detailing in buildings, a fact that architectural curricula often underappreciate. Detailing should be at least as prominent in architecture curricula as structures and mechanical systems: two areas in which consulting engineers often have primary responsibility. This book is intended to help students and young professionals become proficient with architectural detailing.

How does the architect know if these details will achieve the desired result? Will the building that they represent go together easily and economically? Will it shed water? Will it be easy to heat and cool? Will the details look good with one another and with the overall form and space of the building? Will the building grow old gracefully, and will it last for the requisite period of time? There are many more questions of similar importance.

The experienced architect does not leave the answers to chance. Each detail, no matter how special or unprecedented, is designed in conformance with universal, timeless patterns that, given competent execution on the construction site, virtually guarantee satisfactory building performance. These detail patterns are the subject of this book.

Detail patterns are elemental principles that are present in all successful building details. They represent an accumulation of centuries of wisdom about what works in building construction and what does not. Many of the patterns are firmly grounded in scientific fact. Others are based just as solidly on common sense and the realities of human performance. The experienced architect employs all these patterns automatically, as if by instinct, when designing details.

Good detailing is an opportunity to advance the concepts and aesthetic themes of the basic design. The detail patterns can be used to edit the schematic design, celebrating its strengths and eliminating features that are not contributing to the central ideas.

The patterns clarify the issues relevant to a particular detail but avoid stating what the solution should be. They are meant to provoke the designer to discover many possible solutions and to provide a clear process through which each can be assessed.

Details are rarely designed from scratch, as a pure response to a situation, as if it had never existed before. More often, we build upon precedents. The architect uses the detail patterns as a reliable means of analyzing and understanding existing details. They are helpful in reviewing one's own work, in checking the work of other detailers in the office, in judging the quality of manufactured building components, and in diagnosing problems in existing buildings. The absence of attention to a particular detail pattern, or the presence of a feature that contradicts a pattern, usually indicates a problem or a potential problem that should be corrected.

The detail patterns are straightforward and easy to learn. There are slightly more than 100 of them. Each is irreducibly simple.

The first portion of this book introduces each of the patterns in turn, explains it, and illustrates several instances of its use. Each pattern is given a simple descriptive name and a graphical icon to assist in the memorization of it.

The patterns are arranged in three main groups: Function, Constructibility, and Aesthetics, corresponding to the three major concerns of the detailer. The order of presentation of these groups is not intended to imply their hierarchy or their sequence in the design process. Under each of these groupings, the patterns are further categorized by similarity of intent. The first category of patterns under Function, for example, is Controlling Water Leakage, comprising 13 detail patterns that offer a complete strategy for accomplishing this important task.

The second portion of the book demonstrates the use of the detail patterns during the process of designing the details of three different hypothetical buildings: one in wood, one in architectural concrete, and one in brick veneer over a reinforced concrete frame.

The book closes with an annotated listing of publications recommended for the detailer's own reference shelf and a list of websites of particular interest. Exercises for self-study or classroom use are also provided.

The almost 500 original sketches and drawings by the authors are intended to be illustrative of the building elements and natural phenomena being addressed. They are not working drawings. Almost all are freehand sketches, because this remains the primary means that designers use to begin creating details. Some information has been intentionally deleted or added to make the drawings effective instructional tools. For instance, anchors securing a masonry veneer to the backup are drawn in these sections, whereas they might be identified only in specifications or in a large-scale detail in a set of working drawings produced in an office. By including them in the sketches, readers will engage the visual reality in more complete terms.

It is assumed that the reader has a general background in the materials and methods of building construction and is familiar with the conventions of architectural drawing. In the detail drawings throughout the book, outdoors is always to the left or top of the drawing.

PART

I

DETAIL PATTERNS

SECTION 1

FUNCTION

For a building to function well, its details must function well. When designing details for a building, the detailer has countless choices to make and no prescribed path toward the best solution. This portion of the book guides the detailer along this path by describing factors that affect the functional performance of details.

In architecture, function certainly includes the technical performance of the details that contribute to making a building safe and secure for its occupants. But function also includes features that affect the *qualities* of the forms, surfaces, and spaces that compose the building. A space that is firm and dry but that has an aggravating echo or glaring light does not function as well as it could.

The detailer is challenged to address the function needs of the building when it is new, but also long into the future and sometimes beyond the lifetime of those who designed or constructed it. Buildings constantly change in response to natural forces, such as the daily cycles of temperature and light, as well as in response to seasonal changes. A basic grasp of physics and of biological and chemical processes is part of the detailing process. Other functions concern the people who engage with the building every day, altering it internally and externally through countless actions.

The detail patterns that relate to function address the breadth of these topics. They are organized into thematic groups to focus the detailer's attention on each topic individually. Each pattern builds awareness of the issue and includes directions toward possible solutions. The patterns describe the natural processes involved, as well as the codes, standards, and conventional practices that are relevant to discovering appropriate detailing solutions.

CHAPTER 1

Controlling Water

INTRODUCTION

Water must be controlled in order to prevent **leakage**, which is the penetration of water through a building assembly. For water to penetrate through a building assembly, three conditions must all occur at the same time:

1. There must be an opening through the assembly.
2. There must be water present at the opening.
3. There must be a force to move the water through the opening.

If any one of these three conditions is not met, water will not penetrate the assembly. In designing any exterior detail, therefore, we can pursue one or more of three strategies:

1. We can try to eliminate openings in building assemblies.
2. We can try to keep water away from openings in building assemblies.
3. We can try to neutralize forces that move water through openings in building assemblies.

Complete success in any one of these three strategies will result in the complete elimination of water leaks, but sometimes in detailing we pursue two of these strategies or even all three of them at the same time. This approach gives added security in case one of the strategies fails as a result of poor workmanship or building deterioration. Let us consider each of these strategies briefly and list the detail patterns that relate to each. All of the patterns listed will be further explained later in this chapter.

1. Eliminating openings in building assemblies

Every building is full of openings. A shingled roof has an opening under each shingle. A wall has cracks around windows and doors, and around joints between the units of material from which the wall is made. Additional cracks and holes may form as the building ages and deteriorates. We can attempt to eliminate all these openings by using preformed gaskets and sealants. As the sole strategy, this is unreliable, however. Gaskets may not seal securely if they are the wrong size or resiliency, or if the surfaces they touch are rough or unclean. Sealants may fail to adhere properly if the materials to which they are applied are not scrupulously clean and properly primed, or if the installer does not compress the sealant fully into the seam. Both sealants and gaskets can deteriorate from weathering and from the flexing and stretching they may undergo as the building ages. A building skin that relies on sealants and gaskets alone for watertightness will leak sooner or later. Furthermore, even a small defect in a sealant or gasket that is exposed to the weather can leak very large amounts of water, just as a small hole in a bathtub can create a very large puddle.

Sealants and preformed gaskets are extremely useful, however, as components of an overall strategy for making a building skin watertight. Therefore, it is important to know how to detail sealant joints and gasket joints correctly and how to incorporate them into more complex schemes for controlling water penetration. The detail pattern that relates to eliminating openings in building assemblies is:

Sealant Joints and Gaskets (p. 36)

2. Keeping water away from openings in building assemblies

There are a number of effective ways to keep water away from openings. Often it is useful to keep most water away from an opening simply to reduce the volume of water that must be dealt with at the opening itself. In many cases we can easily and securely keep all water away from an opening.

The detail patterns that relate to keeping water away from openings in building assemblies are the following:

Wash (p. 7)
Overlap (p. 12)
Overhang and Drip (p. 15)
Drain and Weep (p. 19)
Ventilated Cold Roof (p. 22)
Foundation Drainage (p. 24)

3. Neutralizing forces that move water through openings in building assemblies

There are five forces that can move water through an opening in a wall or a roof: (1) gravity, (2) surface tension, (3) capillary action, (4) momentum, and (5) air pressure differentials. In most cases, it is surprisingly easy to detail a building assembly so that all five of these forces are neutralized, and the most secure strategies for keeping water out of a building are based on this approach.

We have already encountered the detail patterns for neutralizing two of these forces, because these same patterns are useful in keeping water away from openings in buildings. The force of gravity is neutralized by the following:

Wash (p. 7)
Overlap (p. 12)

Surface tension, a force that causes water to cling to the underside of a surface where it can run into an opening, is neutralized by:

Overhang and Drip (p. 15)

The patterns for neutralizing the other three forces are the following:

Moisture Break (p. 25)
Capillary Break (p. 26)
Labyrinth (p. 28)
Rainscreen Assembly and Pressure Equalization (p. 29)
Upstand (p. 34)

The capillary break neutralizes capillary action. The labyrinth neutralizes momentum, and the rainscreen assembly and the upstand neutralize air pressure differentials. By combining these seven patterns in each exterior joint of a building, we can make a building entirely waterproof.

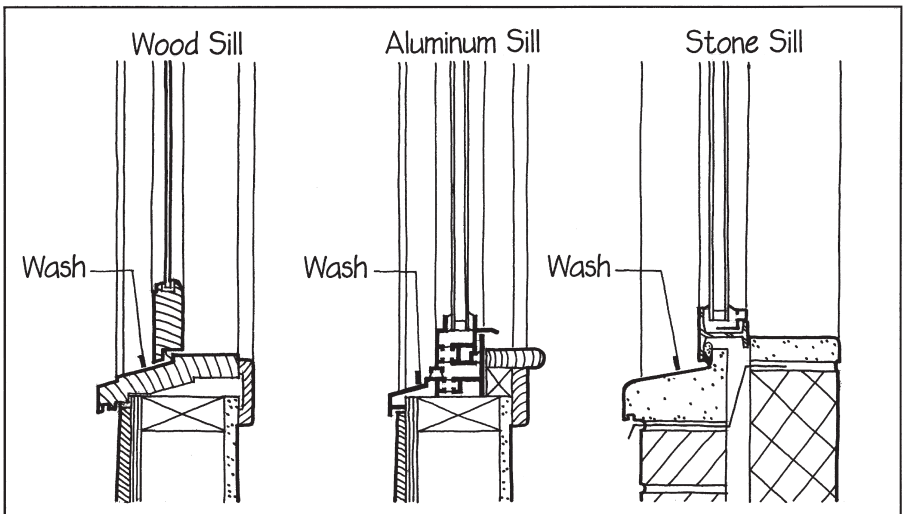
When conceived as a well-coordinated group, these features combine to form the water control layer of the building envelope. The designer should be able to draw an uninterrupted line in plan and section representing the water control layer. A building with a continuous water control layer is entirely waterproof.

Wash

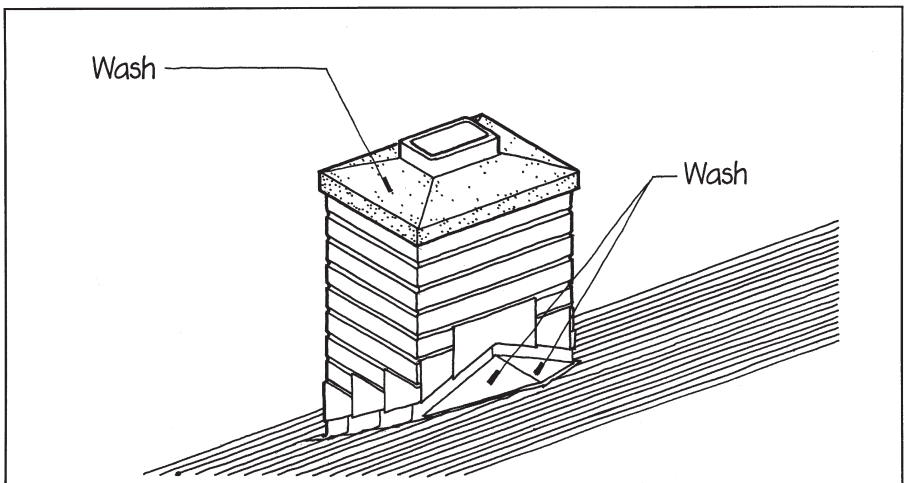
A WASH is a slope given to a horizontal surface to drain water away from vulnerable areas of a building. In general, every external horizontal surface of a building should have a wash. More permeable materials should have a steeper slope to shed water more quickly.

1. A window or door sill, whether made of stone, concrete, wood, or metal, always has a wash to keep water from accumulating next to the door or sash. A minimum slope for this type of wash is about 1 in. per foot (1:10 or 1:12). A steeper slope drains water faster and is more secure, because the more quickly water is removed from a surface, the less time it has to leak through. It is also more difficult for wind to drive water up a steeper slope.

2. The wash on this concrete chimney cap keeps water away from the vulnerable crack between the clay flue tile and the concrete. The slope should be at least 1:12. The outer edge of the cap should have a thickness of at least 3 in. (75 mm) to discourage cracking of the concrete, not the feather edge that is commonly used (see ***Clean Edge***, Chapter 12). The cricket on the upslope side of the chimney consists of two washes that divert water around the shaft of the chimney. ▷



1. Washes on Window Sills



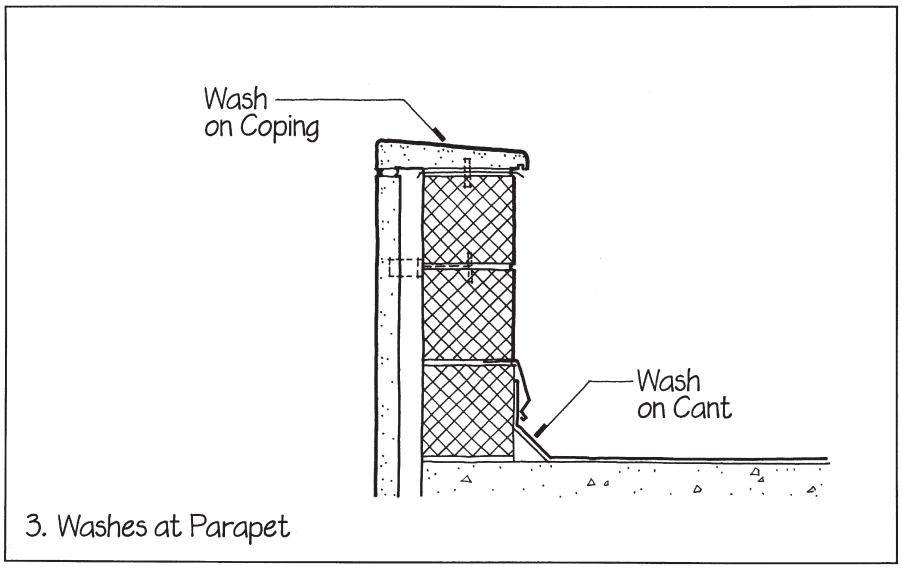
2. Wash on Chimney Cap and Cricket

3. The coping on a building parapet has a wash to keep standing water away from the seams in the parapet. Usually the wash drains toward the roof, to minimize water staining of the building faces. The cant strip at the base of the parapet slopes steeply toward the roof membrane to direct water away from the joint between the parapet and the roof deck.

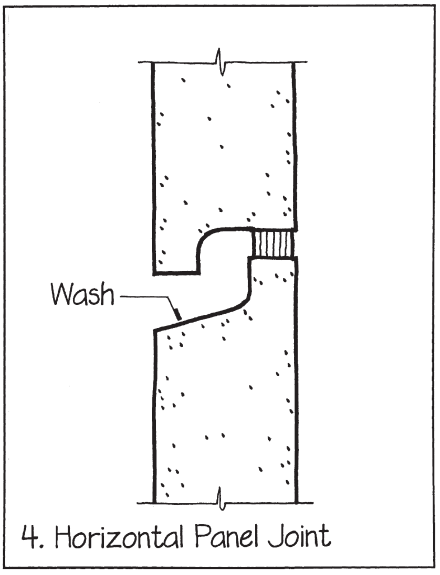
4. The bottom surface in a horizontal joint between wall panels should have a wash to drain water to the outside. Even if the joint will be closed at the outside face with sealant, the wash should be provided to discourage leaking if the sealant should fail.

5. The sloping roof is a special case of the wash. A shingled roof will not shed water unless it has a considerable slope. If the slope were too shallow, water would linger on the roof, flow around and under the shingles, and penetrate the gaps beneath. Each type of shingle material has its own recommended minimum slope. A slope steeper than the minimum is advisable on exposed sites where rain is often driven against the building by wind. A good rule of thumb is to avoid roof slopes less than 4:12. Wood shingles, asphalt shingles, and unsoldered metal roofing can go as flat as 3:12 with a special underlayment (consult the appropriate literature from trade associations or manufacturers for more information). Steeper slopes shed water faster and thus are less prone to problems. However, they may be more costly because the roof area is increased, and workers will have greater difficulty moving about the steeper surface. Many roofing materials can be installed at a very steep slope, even on vertical surfaces.

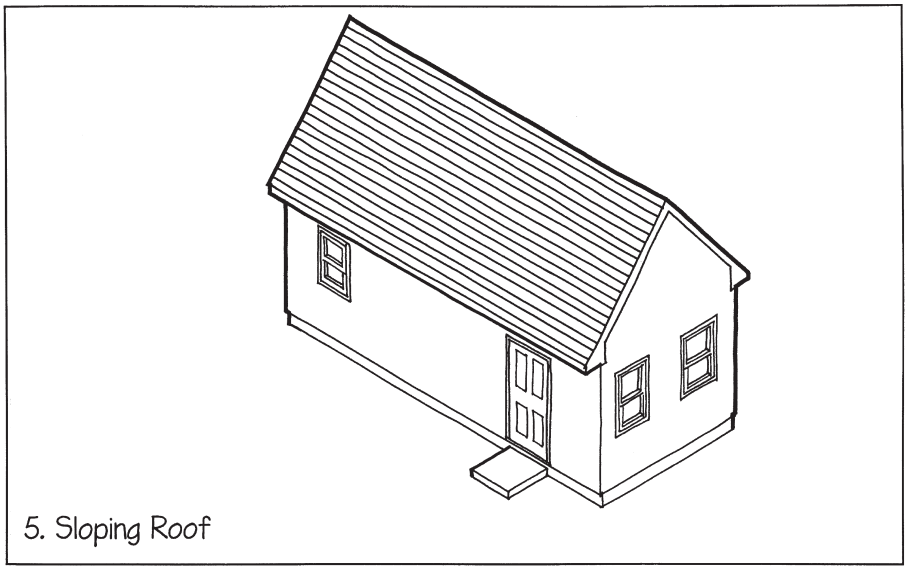
6. So-called flat roofs are seldom flat. They are given a positive slope toward points where water is removed by roof drains or scuppers, because standing water on a roof can cause deterioration of the roof membrane and even structural collapse. The correct name for "flat" roofs, in fact, is "low-slope" roofs. Drains in a low-slope roof should be located either at points of maximum structural deflection (usually the midspan of a beam or joist) or at low points purposely created by sloping the structure that supports the roof.



3. Washes at Parapet



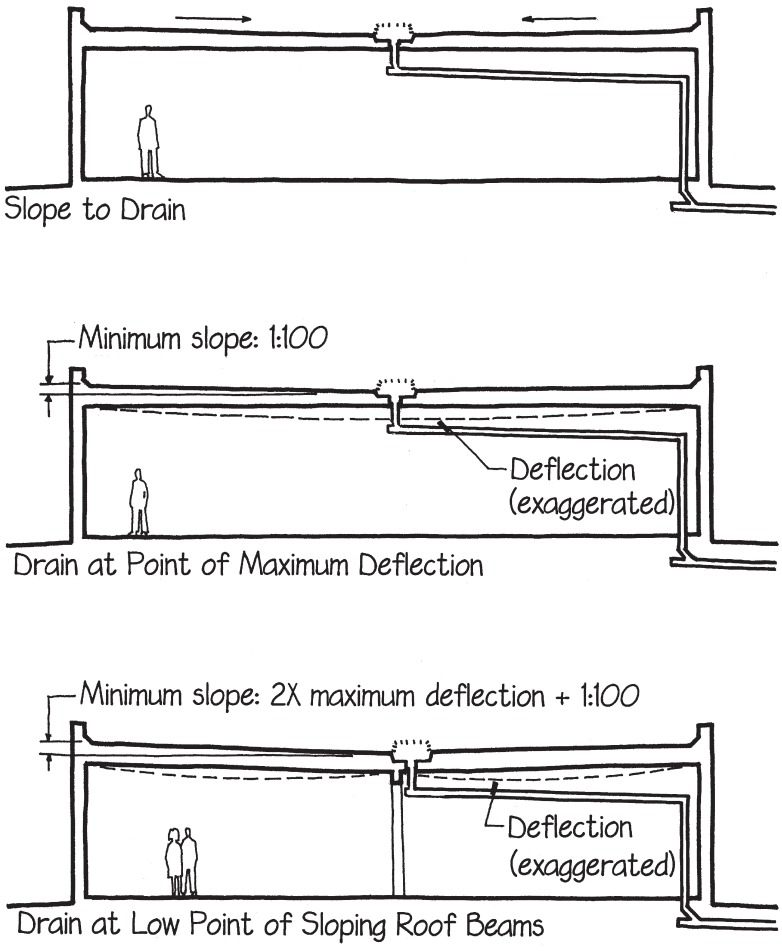
4. Horizontal Panel Joint


5. Sloping Roof

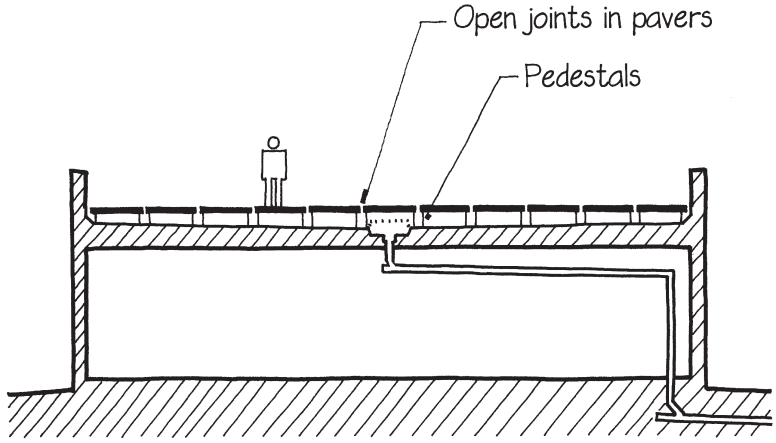
Tapered insulation or roof fill should be used if necessary to create an additional slope that will cause water to drain properly from a roof. If a drain is located at a point of maximum structural deflection, the minimum recommended slope is ⅛ in. per foot (1:100), and more slope than this is desirable. If a drain is located at a low point created by sloping a beam, the overall rise along the length of the beam should be at least twice the expected maximum deflection in the beam, plus another ⅛ in. per foot (1:100) of the length of the beam, to be sure water cannot be trapped by the curvature of the beam. The detailer should work closely with the structural engineer to design a system of roof drainage that complies with these guidelines. This is especially important if the roof is composed of cambered elements such as precast concrete planks or beams.

It is desirable (and mandatory under some building codes) to provide a complete, independent set of auxiliary roof drains or scuppers to take over in case the primary drains become clogged with debris. The auxiliary drains or scuppers are usually located 2 in. (51 mm) higher in elevation than the primary drains and must be served by their own network of piping.

7. A rooftop terrace is usually drained through open joints between its dead-level paving stones or tiles. The water drops through the joints and is funneled to a system of roof drains by the low-slope roof membrane below. The same recommended slopes apply to this membrane as to any low-slope roof. The terrace paving is held level by small, adjustable-height pedestals that stand on the roof membrane and support the paving units at each intersection. These pedestals are marketed in several proprietary designs and are usually made of plastic. ▷



6. Low-Slope Roofs



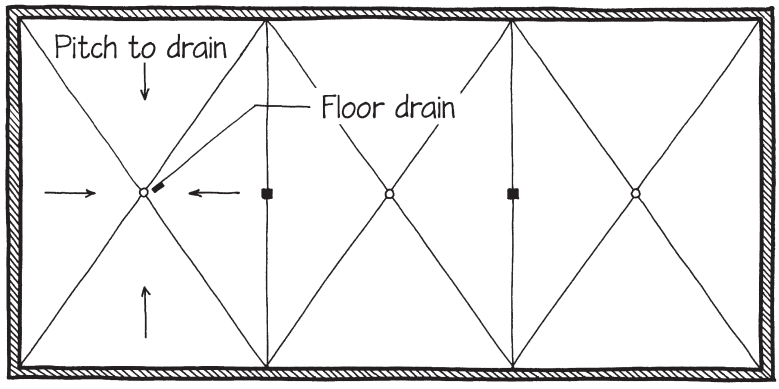
7. Rooftop Terrace

8. Another special case of the wash is indicated on architectural drawings by the note "pitch to drain." The rain gutter at the eave of a roof is usually pitched (sloped) to drain water toward the nearest downspout. Common slopes used for gutters are ⅛ in. or ¼ in. per foot (1:100 or 1:50). A steeper slope gives a greater capacity to handle water in a heavy rainstorm. Rainwater collected by gutters can continue to flow by gravity toward cisterns, planters, or vegetated surfaces, or it can be discharged into a stormwater collection system.

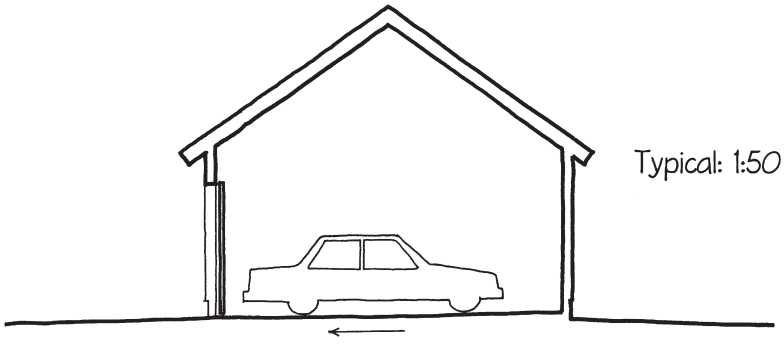
9. An industrial or basement floor slab is often pitched toward floor drains to eliminate puddles of standing water. A rule-of-thumb pitch for slab drainage is ¼ in. per foot (1:50), but to prevent puddles, this should be increased for surfaces that are not very flat, and can be decreased for very smooth surfaces. In the case of a floor or paving, however, pitches should not become too steep, or they will be awkward for pedestrians and vehicles to navigate.

10. If there is no interior floor drain, a residential garage floor is usually pitched so water dripping off a car will run under the garage door and out. Minimum pitch recommendations are the same as for industrial and basement slabs.

8. Pitched Gutter



9. Floor Slab Pitched to Drain

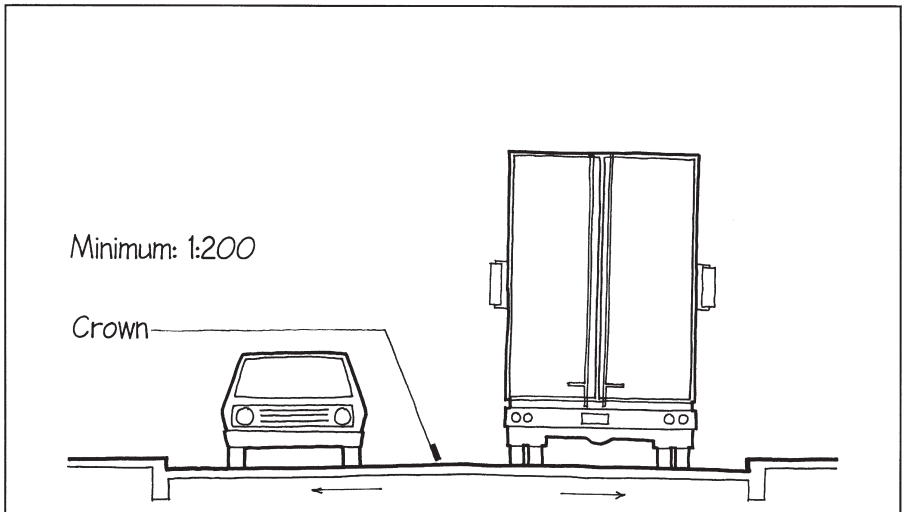


10. Slab Pitched to Drain

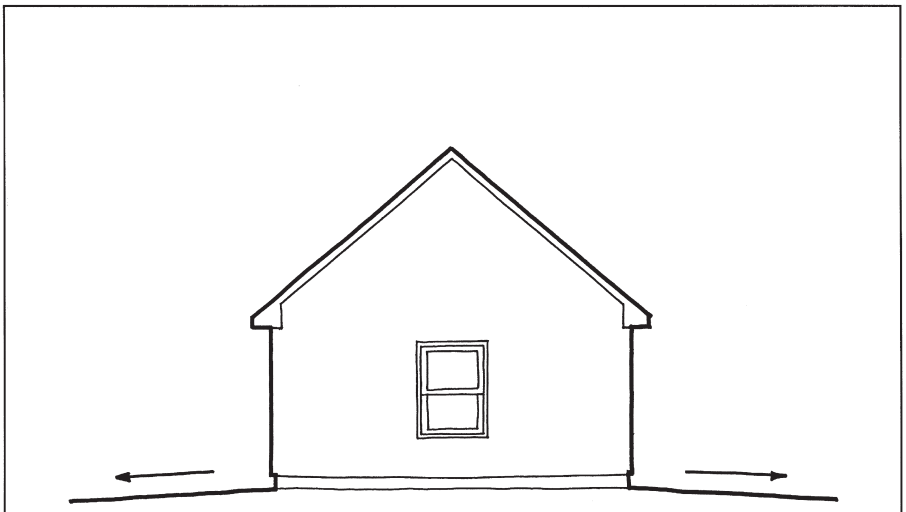
11. Roads, driveways, and walks are usually crowned, to shed water in both directions and to avoid puddling. The slope on each side of the crown should be at least 1:200. Parking lots should slope at least 1:100 to shed water, but not more than 5:100.

12. The ground surrounding a building should slope away from the building at a rate of at least 2:100 for at least 6 ft. (1.83 m). This helps keep water from puddling against the foundation and leaking into basements and crawl spaces.

A wash ensures that gravity will act to keep water away from an opening, but its action can be overcome by strong wind currents. Thus, a wash that is contained within a joint is often combined with an air barrier and a pressure equalization chamber to form a rainscreen joint (see ***Rainscreen Assembly and Pressure Equalization***, later in this chapter). ■



11. Crowned Roadway


12. Slope Away From Building

Overlap

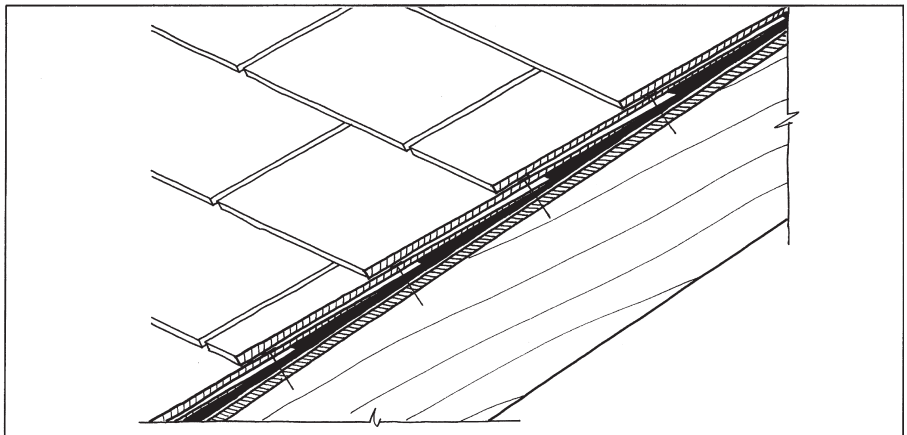
In an overlap, a higher surface is extended over a lower surface so water moved by the force of gravity cannot run behind or beneath them. For an overlap to work, the surfaces must be sloping or vertical. Porous materials need a greater overlap and steeper slope to be effective.

1. Roof shingles and tiles keep water out by overlapping in such a way that there is no descending path through or between them. Each unit covers a joint between units in the course below. The overlap only works, however, if the roof surface slopes steeply enough so that water runs off before it can find its way around the backs of the shingles or tiles to the open cracks beneath.

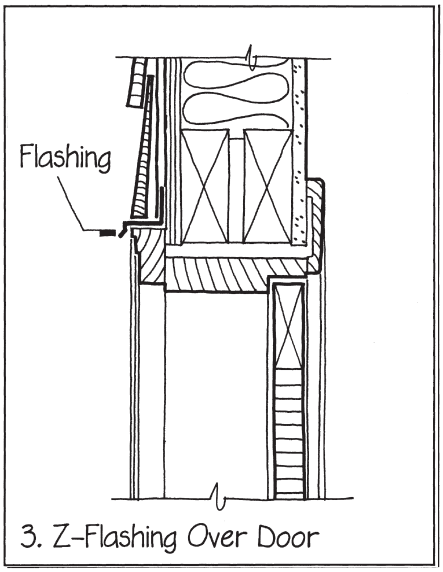
2. Wood bevel siding sheds water by overlapping each board over the one below. The weak spots in wood siding are the end joints, which should be caulked and flashed to prevent water penetration.

3. Flashings keep water out by overlapping. Flashing is used to create overlap wherever the overlap or slope of base materials is insufficient to prevent water intrusion. This simple Z-flashing of sheet metal or thin plastic keeps water from coming through the crack above a window or door frame.

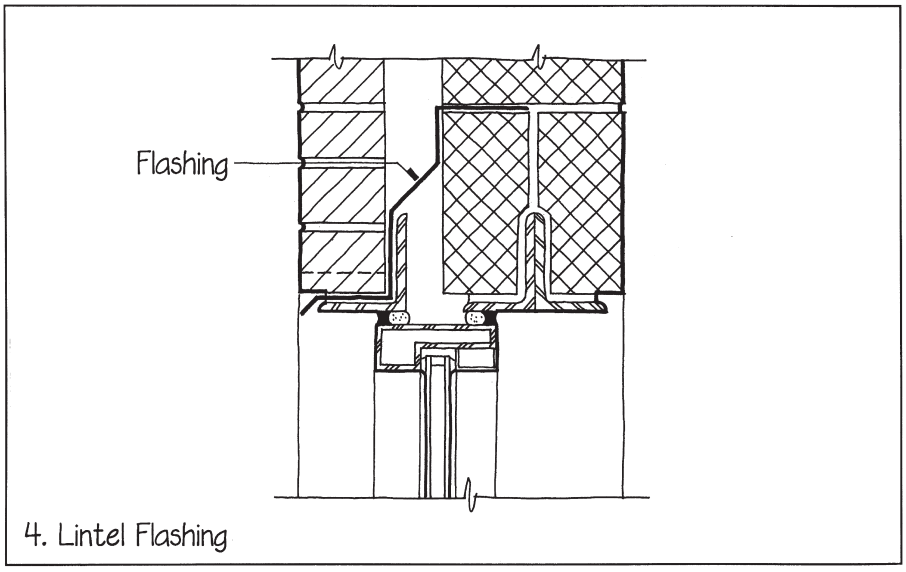
4. This lintel flashing in a masonry cavity wall is another example of overlapping. Any water that penetrates the outer brick facing is caught by the metal or synthetic flashing sheet and is conducted through weep holes to the outdoors. Notice the overhang and drip on the outside edge of the flashing. These keep water out of the crack between the flashing and the steel lintel (see ***Overhang and Drip***, later in this chapter).



1. Wood Shingle Roofing



3. Z-Flashing Over Door



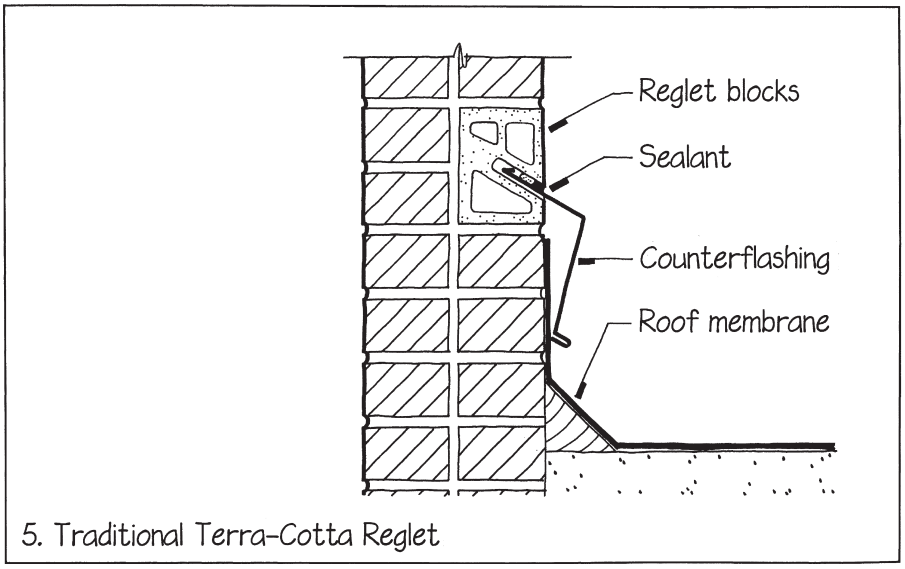
4. Lintel Flashing

5. A reglet is an upward-sloping slot in a vertical surface into which a flashing or the edge of a roof membrane may be inserted. The slope (wash) acts to prevent water from being forced into the vulnerable joint by gravity, and the overlap of the upper lip of the reglet over the flashing keeps water from reaching the joint between the two components. The reglet shown in this drawing is a traditional type that is largely obsolete, but it may still be encountered when older buildings are renovated. It is molded into glazed terra-cotta tiles that are built into a parapet wall by masons. Shims and/or a sealant bead must be inserted into the reglet to hold the flashing or membrane in place.

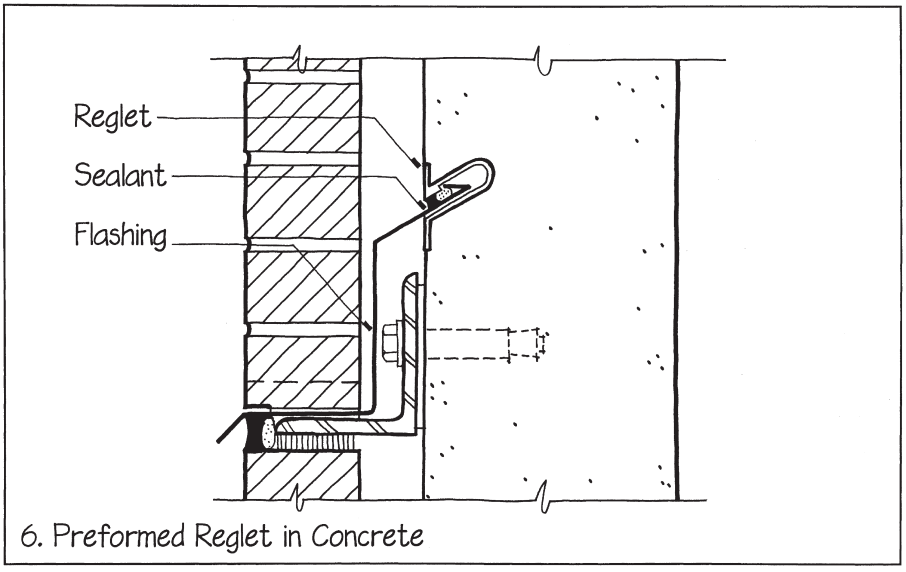
6. This contemporary type of reglet is created in a concrete wall or spandrel beam by using a preformed strip of metal or plastic that is nailed lightly to the formwork before the concrete is poured. The opening in the reglet is usually closed temporarily with an adhesive tape or a strip of plastic foam to prevent its being accidentally clogged with concrete. There are many patented profiles for this type of reglet that are intended to interlock securely with a folded edge on the top of the flashing. Diligent inspection is needed just prior to concrete pouring to be sure that the reglet is installed right side up.

If a reglet is wetted, water may find its way through by capillary action. A continuous bead of sealant between the flashing and the reglet can be helpful in preventing this.

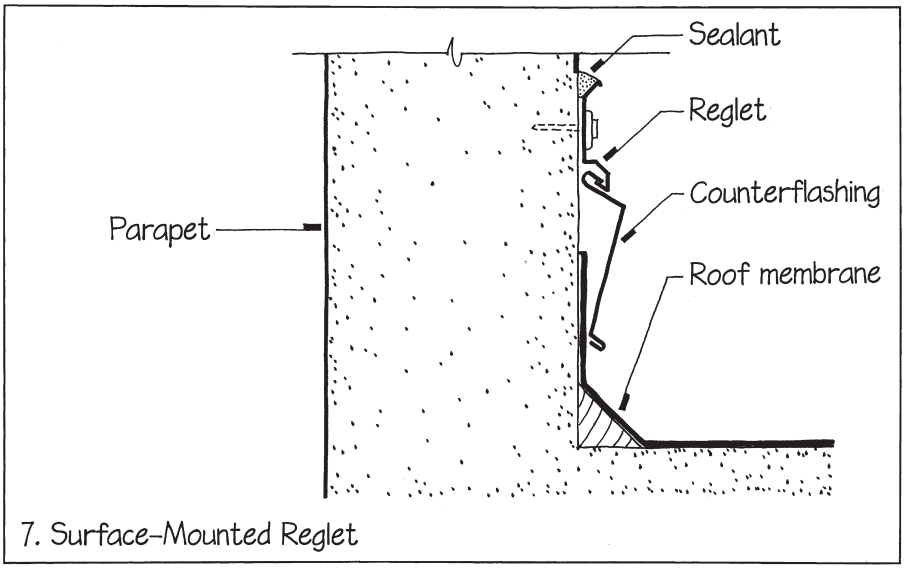
7. There are also a number of patented designs of surface-mounted reglets made of plastic or metal. A bead of sealant is intended to keep water from behind the reglet. This is somewhat risky, because the success of the detail is entirely dependent on perfect workmanship in installing the sealant and perfect adhesion of the sealant to the wall. ▷



5. Traditional Terra-Cotta Reglet



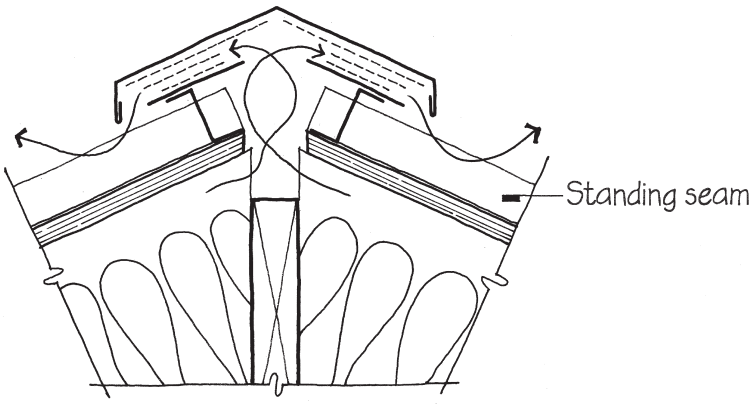
6. Preformed Reglet in Concrete



7. Surface-Mounted Reglet

8. The ridge of a standing seam metal roof uses a continuous cap assembly to overlap all of the standing seams, producing covered openings through which water cannot enter, but hot air can escape.

An overlap is generally very effective in preventing entry of water driven by the force of gravity. If wind is allowed to blow through an overlap, however, it may carry water with it. An overlap is useless against standing water, so it cannot be used on a level surface. ■



8. Continuous Ridge Vent with Standing Seam Metal Roof