Trail Grade

If the grade of the trail surface is too steep, there is little that can be put on the tread to eliminate slipperiness. A wooden surface that has been installed at an 8-percent grade will be slippery with only a heavy dew. Pedestrians will find a wooden surface built at 5-percent grade slippery with frost or light rain. Shaded and north-facing sites aggravate the problem. The maximum grade for a trail with a wooden surface should be 2 percent (¼ inch per foot).

Cross Slope

Another cause of a slippery tread is a cross slope that is too steep. To prevent excessive cross slope use, use a simple carpenters, masons, or torpedo level to identify any difference in elevation between parallel stringers, the notch in sleepers, and ledgers attached to the piles. To eliminate or reduce cross slope, shim up the stringers or ledgers, excavate the high end of the sleepers, redrill the bolt holes, or replace the ledgers (figure 99).

It is much cheaper to build the foundation correctly than to try to correct problems later through maintenance.

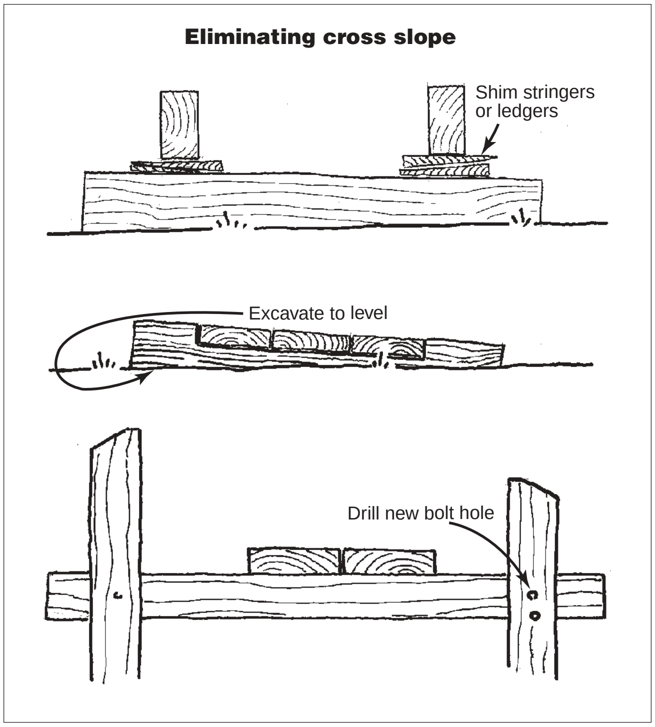


Figure 99—Eliminate cross slope with shims, by excavating the high side of sleepers, or by drilling new bolt holes on the ledgers.

Soil Conditions

Another factor that can create a slippery tread is settlement, a problem that occurs when soil settles after a trail has been constructed. The trail may have been built properly, but all or part of the trail may have settled over time. Perhaps sleepers or a bent on end-bearing piles were used instead of a bent on friction piles. That part of the foundation settled over time, causing the trail to sag. The result is that one or both sections of trail on each side of the sag are steeper than intended.

One part of a trail support may settle. For example, one end of a sleeper may settle and the other end may not, or one pile in a bent may settle and the other may not. Both piles may settle, but one may settle more than the other. This type of settling will affect cross slope.

Cross slope of ¼ inch per foot (2 percent) is common for concrete and asphalt surfaces, but is excessive for wood. The cross slope should be level or ⅛ inch or less per foot (0 to 1 percent). Settlement can be corrected by shimming the low side, notching the high side, or a little of each. This is extremely difficult to do after construction and can be avoided to a degree by taking ample rod soundings and digging a number of test holes during the design phase. During construction, the crew should be alert for changes in soil conditions and should take remedial actions when necessary.

Surface Treatments

If the hazard of a slippery tread cannot be corrected by shimming, notching, or adding steps, a few surface treatments can be applied. These treatments will require maintenance.

Latex Paint

A nonskid latex paint is made for boat decks. This paint is opaque, unlike a clear wood stain, but it can be tinted. As with all painted surfaces, peeling, scraping, and periodic repainting must be expected.

Walnut Chips

Walnut chips are a hard, angular material produced in various sizes. The number 4 size is suitable for nonslip surfaces. Walnut chips can be applied to a wooden surface by sand painting (using chips and paint mixed at the factory), using chips mixed into the paint at the site, or by painting the wood and sprinkling on chips while the paint is wet.

Mineral Products

Nonslip products are also made from pumice and aluminum oxide. Some are premixed. Others are sold as a gritty powder that is mixed with paint.

Nonslip Gratings and Grit-Treated Mats

Another method for correcting a slippery trail tread is to replace a wooden plank tread with nonslip gratings or to apply grit-treated fiberglass mats to the planks.

Working With Rock, Stone, and Gravel

The construction industry recognizes differences between rock, stone, and gravel. It helps to understand the differences in the materials so you will know what to specify or order.

Rock

Rock is the parent material in and under the ground. Sometimes it is called bedrock or ledgerock. Moving rock usually requires drilling and the use of explosives.

Stone

When rock is broken or crushed, the pieces are referred to as stone. Stone, when used in construction, describes usable pieces of what once had been rock. Stone may be large enough to use for walls, or it may be small pieces that have been through a rock crusher for use as aggregate in concrete or as a base course in a road. Stone is angular on all sides.

Among the byproducts of rock-crushing operations are "crusher fines," screened material smaller than $\frac{1}{4}$ inch that is not suitable for most crushed stone contracts. This material is often sold at a discount at crusher operations and makes a fine trail surface when it is wetted and compacted.

Gravel

Small pieces of rock that have broken naturally and have been subject to glacial action or tumbled in a river or creek are called gravel. The glacial action or the effect of water has rounded and removed all the corners of the original piece of rock.

Uses of Stone and Gravel

Rock is rarely found in a wetland. Stone can be brought to the site for use as riprap. Crushed stone can be used for walking surfaces. Because crushed stone is angular, when it is compacted it will knit together to form a solid mass. Gravel cannot be compacted to produce a solid mass. Gravel's rounded shape is useful because water can move through the spaces between the gravel particles. Crushed stone should not be used for drainage (around perforated pipe or to carry water from one point to another). Use gravel for drainage (figure 100).

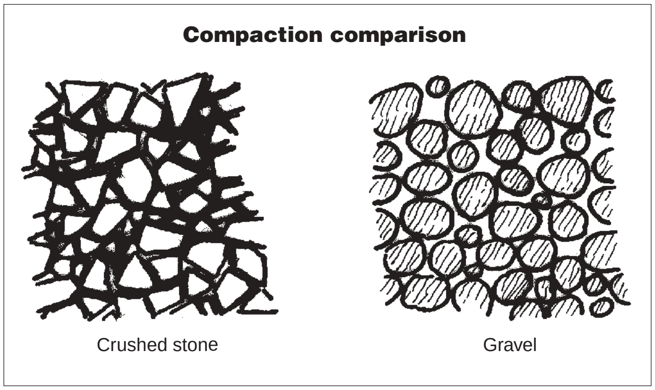
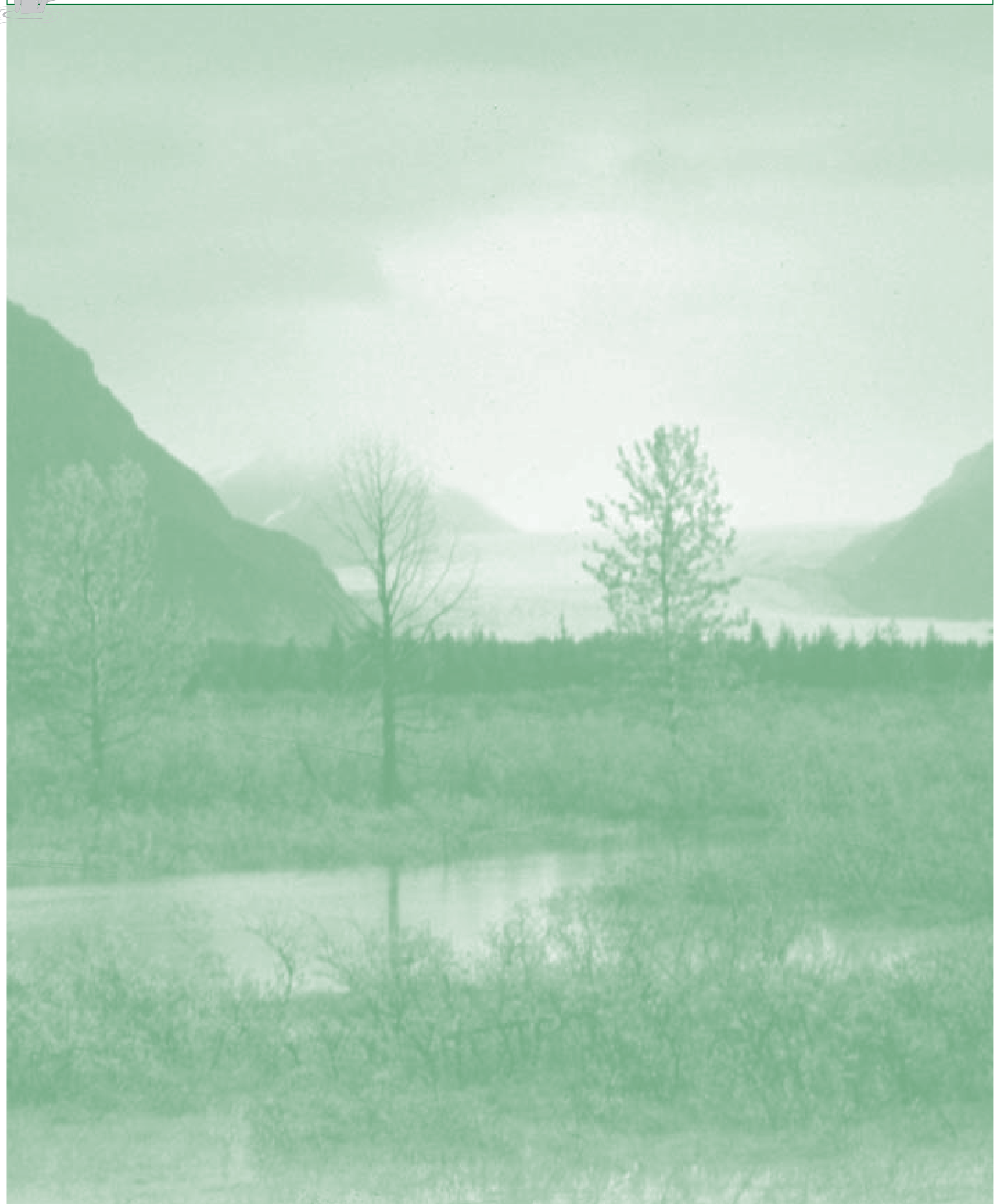


Figure 100—Crushed stone has angular edges and compacts well. It is good for tread surfacing. Gravel does not make good surfacing because it has rounded edges. Gravel is good for subsurface drainage because water flows freely through it.

Appendix A—Field Note Sheets



Part 7 of 8

Station/ district	Tread width	Sideslope (percent)	Gradient (percent)	Notes

Station/ district	Tread width	Sideslope (percent)	Gradient (percent)	Notes

Appendix B—Slope Conversion Table

Slope Conversion Table		
Percent grade	**[1]Slope**	**[2]Pitch**
0.5	1 ft per 200 ft	1/16 in per 1 ft
1	1 ft per 100 ft	1/8 in per 1 ft
2	1 ft per 50 ft	1/4 in per 1 ft
2.5	1 ft per 40 ft	5/16 in per 1 ft
3	1 ft per 33 ft	3/8 in per 1 ft
3.3	1 ft per 30 ft	7/16 in per 1 ft
4	1 ft per 25 ft	1/2 in per 1 ft
5	1 ft per 20 ft	5/8 in per 1 ft
6	1 ft per 16.5 ft	3/4 in per 1 ft
7	1 ft per 14.3 ft	7/8 in per 1 ft
8	1 ft per 12.5 ft	1 in per 1 ft
8.33	1 ft per 12 ft	1 in per 1 ft

[1] One unit of climb or descent per 100 units of horizontal distance.
[2] Number of vertical inches per horizontal foot. Vertical inches shown are rounded off to the nearest 1/16 of an inch.

- Maximum grade recommended for wood surface trails = 2 percent.
- Maximum grade for accessible trails = 5 percent.
- Maximum grade for accessible ramps = 8.33 percent.

Appendix C—Comparison of Round and Rectangular Culverts

These tables show the open-end area of round culvert pipe and the open-end area of rectangular timber culverts.

Round Pipe Culverts

Diameter (inches)	8	10	12	15	18	24	30	36
End area (sq. ft)	0.4	0.6	0.8	1.2	1.8	3.1	5.0	7.1

Rectangular Timber Culverts

Height (inches)	**Clear width (inches)**							
	20	24	30	36	48	60	72	84
	End area (sq. ft)							
5	0.7	0.8	1.1	1.3	1.7	2.1	2.5	2.9
11	1.4	1.8	2.3	2.8	3.7	4.5	5.5	6.4
17	2.1	2.9	3.6	4.3	5.0	7.1	8.5	9.9
23	2.9	3.8	4.8	5.8	7.7	9.6	11.5	13.4

Appendix D—Sizes of Hot-Dipped Galvanized Nail Sizes

Penny[1] (d)	Length (inches)	Penetration[2] required (inches)	Nails per pound	Gauge (inches)	Bit size for pilot holes (inches)
10	3	2	75	10	NA
12	3¼	2⅛	69	10	NA
16	3½	2¼	54	9	3/32
20	4	2⅝	33	7	⅛
30	4½	3	29	7	⅛
40	5	3¼	22	5½	⅛
50	5½	3⅝	20	5½	⅛
60	6	4	18	5½	3/16

[1] Nails are sold by the old English system of pennyweight. The value of the penny has changed since the system was devised, and today there seems to be no relation to the size and weight of the nail to the penny. The standard symbol for penny is "d."

[2] The "penetration required" column shows the minimum depth the nail must penetrate into the second piece of wood to make a sound connection. The penetration must be increased by one-third when nailing into the end of the piece of wood (end nailing).

Appendix E—*Table of Board Feet*

The most common sizes of boards used for boardwalk and bog bridge construction.

Size of board	Length of board (ft)						Finished size (inches)
	6	8	10	12	14	16	
	Yield (board ft)						
1 x 6	3	4	5	6	7	8	¾ x 5½
2 x 4	4	5.33	6.67	8	97	11	1½ x 3½
2 x 6	6	8	10	12	14	16	1½ x 5½
2 x 8	8	10.67	13.33	16	19	21	Normally rough sawn
2 x 10	10	13.33	16.67	20	23	27	Normally rough sawn
2 x 12	12	16	20	24	28	32	Normally rough sawn
3 x 4	6	8	10	12	14	16	Normally rough sawn
3 x 6	9	12	15	18	21	24	Normally rough sawn
3 x 8	12	16	20	24	28	32	Normally rough sawn
3 x 10	15	20	25	30	35	40	Normally rough sawn
3 x 12	18	24	30	36	42	48	Normally rough sawn
4 x 4	8	10.67	13.33	16	19	21	3½ x 3½
4 x 6	12	16	20	24	28	32	Normally rough sawn
6 x 6	18	24	30	36	42	48	Normally rough sawn

Appendix F—*Metric Conversions*

METRIC CONVERSIONS

To convert from this unit	To this unit	Multiply by
inch	millimeter	25.4*
inch	centimeter	2.54*
foot	meter	0.3048*
yard	meter	0.9144*
mile	kilometer	1.6
millimeter	inch	0.039
centimeter	inch	0.394
centimeter	foot	0.0328
meter	foot	3.28
meter	yard	1.09
kilometer	mile	0.62
acre	hectare (square hectometer)	0.405
square kilometer	square mile	0.386*
hectare (square hectometer)	acre	2.47
ounce (avoirdupois)	gram	28.35
pound (avoirdupois)	kilogram	0.45
ton (2,000 pounds)	kilogram	907.18
ton (2,000 pounds)	megagram (metric ton)	0.9
gram	ounce (avoirdupois)	0.035
kilogram	pound (avoirdupois)	2.2
megagram	ton (2,000 pounds)	1.102
ounce (U.S. liquid)	milliliter	30
cup (inch-pound system)	milliliter	247
cup (inch-pound system)	liter	0.24
gallon (inch-pound system)	liter	3.8
quart (inch-pound system)	liter	0.95
pint (inch-pound system)	liter	0.47
milliliter	ounce (U.S. liquid)	0.034
liter	gallon	0.264
liter	quart	1.057
degrees Fahrenheit	degrees Celsius	(° F – 32) ÷ 1.8
degrees Celsius	degrees Fahrenheit	(° C x 1.8) + 32

*These items are exact conversion factors for the units—the others give approximate conversions.

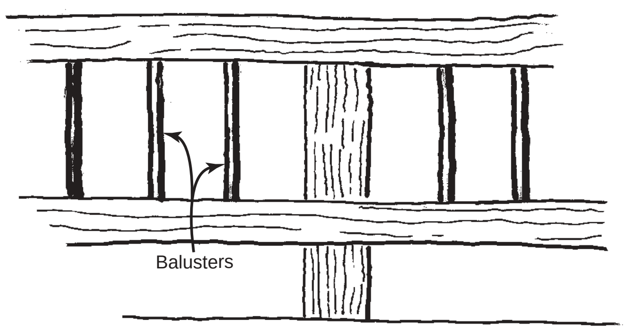
Glossary

Aggregate—Crushed stone or gravel used as a base course for riprap, asphalt, or concrete pavement. Aggregate is also used in asphalt and concrete mixes.

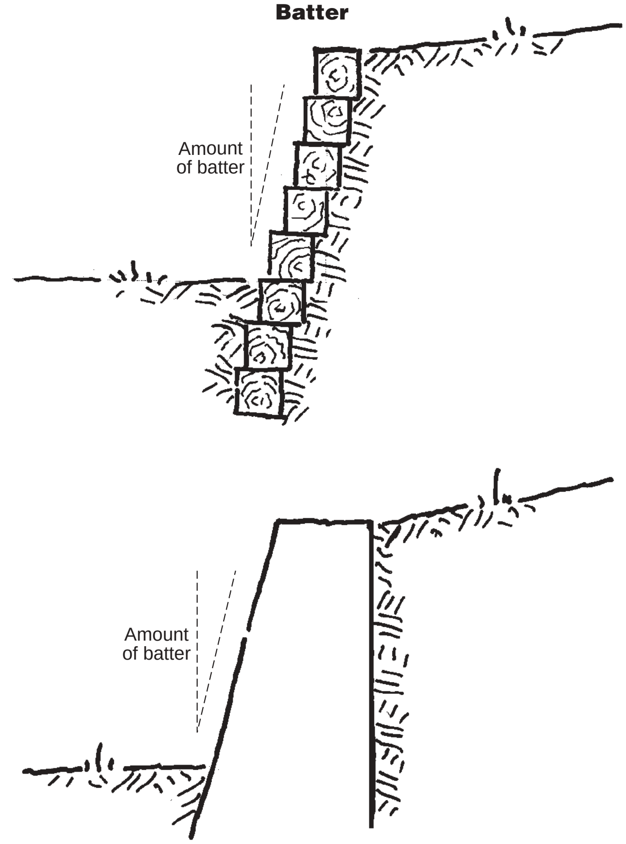
Asphalt—A mixture of aggregate and asphalt cement, correctly called asphaltic concrete.

Baluster—One of many vertical pieces between the top and bottom rails of a guardrail.

Balusters



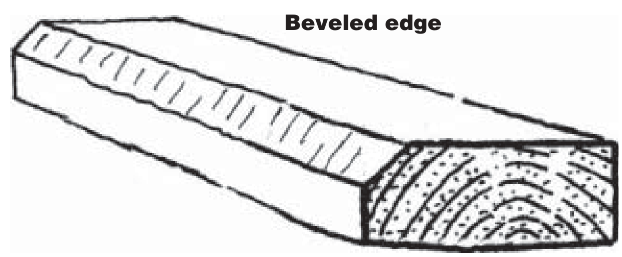
Batter



Batter, battering—Sloping the exposed face of a wall back either at a uniform angle, or stepping it back uniformly, the structurally sound way to build a timber wall (figure 102).

Bevel—Finishing the corner of a piece of lumber by removing a narrow portion of wood at a uniform angle to the edge and face. A bevel follows the grain of the wood (see chamfer) (figure 103).

Beveled edge



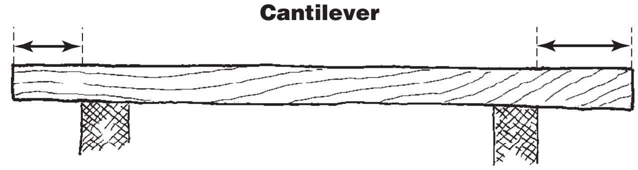
Borrow pit—An excavation used to obtain fill for a construction site.

Braided trails—Parallel trails around a low, wet spot. These trails are not constructed, but are worn in the ground by trail users who do not want to get their feet wet or walk in mud. Each new trail funnels water to a low point. Users repeat the process, producing a series of trails.

Camber—A slight bend in a timber.

Cantilever—The portion of a beam or plank extending beyond one or both of its supports.

Cantilever



Chamfer—Similar to a bevel but done at the end of the piece of wood and across the grain.