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PARK TECHNIQUES

1983.

Trail Construction

In most national parks it is generally impractical and undesirable to develop extensive foot trails of an elaborate nature. Simple but well marked tracks through wild country, or hardened paths for routine occasional use by men and horses normally will serve their purposes quite adequately.

There are, however, certain trail locations where development to a fairly high uniform standard should be considered. Park managers will quickly identify these locations as those where heavy and usually short-distance use is normal—as between an auto parking area and a popular overlook, for example. Well constructed trails will be safer to use, and usable by more people. They will provide better protection of the areas crossed and require less maintenance. Ideally, these trails should look as if they had always been there, an integral part of the landscape.

It is always a wise precaution to review proposals for any development where excavation and construction are involved with experts who can assess the possible effects of the planned work on the environment. Where damage may occur to wildlife and its habitat, to historical or archaeological areas, to special botanical values, or to other irreplaceable resources, the planned project should, of course, be cancelled or modified to preclude such unacceptable impacts.

The following notes, drawings and guidelines on the design and construction of trails were adapted by the editors for PARKS Magazine from the Park Practice Program publication, *Design,* issued for the last quarter of 1975. These remarks apply primarily to temperate regions.

A basic step in constructing a trail is to "line out" or mark the width along the path from start to finish. See sketch 1. Both sides of the planned trail should be staked, the distance between them depending on the steepness of the land and anticipated uses. On hillsides with one-to-one slopes, or slopes of steeper grades, a good width on solid earth would be about 1.25 m (4 feet). See sketch 2. Where no slope exists, line out in accordance with sketch 3.

Stakes should be well-placed so that there is no question about where the trail is to be cleared and excavated. This is particularly important on curves. When the entire trail has been staked you can begin to clear the area of brush and small trees, but remove only those which absolutely must be sacrificed for the minimum recommended trail width.

As for the linear grade of the trail, about 15 percent should be regarded as the maximum.

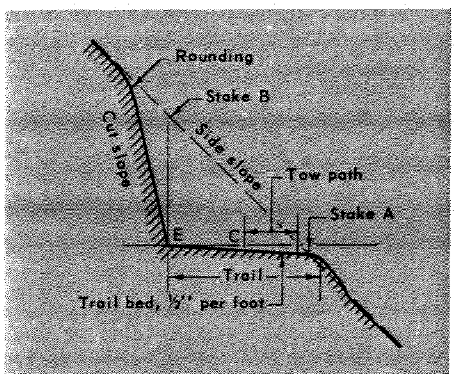
If handicapped or elderly people are expected to use the trail, gentler grades of no more than 5 percent should be used, and there should be no obstacles such as stairs, stumps or other impediments. Rest areas with places to sit should also be installed at intervals.

Excavation

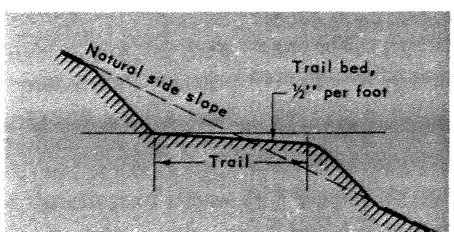
A narrow work path is cleared along the line formed by the outside stakes and excavated back about 50 cm (18 inches). See sketch 1. This path establishes the line for excavation of the remainder of the trail and its grade. If alterations need to be made, less time is lost and less damage done than if the entire trail were graded. The next step is to excavate to the full width.

The slope of the banks must then be considered. See sketch 4. The top of the slope, point "E," should be marked or staked on the ground and the slope cut straight from "E" to "G." The slope below the trail is then finished with fill and feathered down to the natural grade.

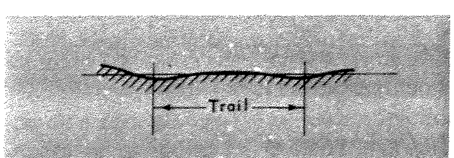
There are two primary objects in sloping banks: (1) it is a particular aid to the control of erosion in that it establishes slopes that are more nearly natural, thus enabling vegetation to catch quickly and cover the new cut and fill surfaces; (2) it reduces the possibility of damage through the action of frost and rain. Sketch 5 shows the action of frost on a poorly constructed trail. The combined action of water and frost at "A" and "B" loosens the material which drops to the trail, in some cases to such an extent that the trail becomes impassable.



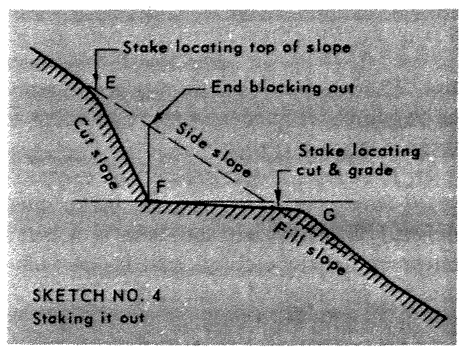
SKETCH NO. 1
A good cross section in heavy cut



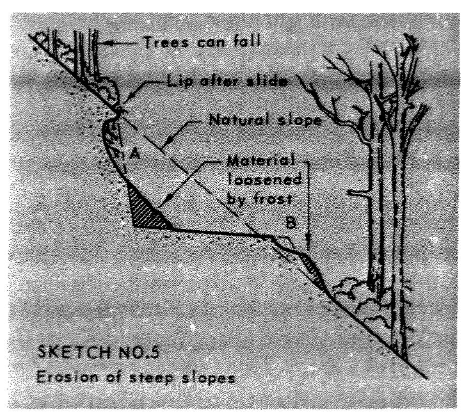
SKETCH NO. 2
For easy slopes



SKETCH NO. 3
For flat ground



SKETCH NO. 4
Staking it out

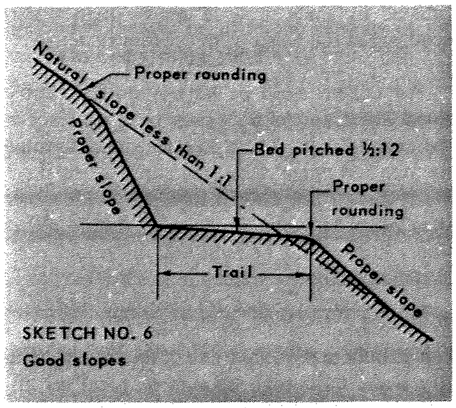


SKETCH NO.5
Erosion of steep slopes

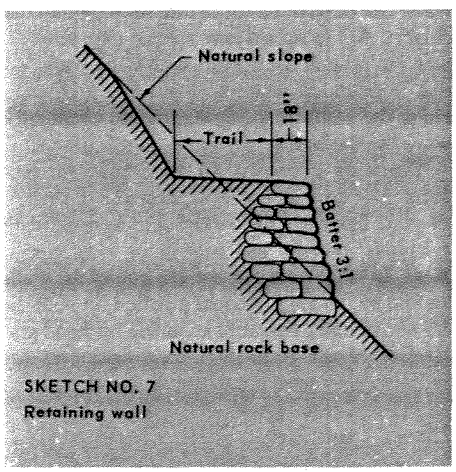
Sketch 6 illustrates an ideal trail section, well finished, with banks and trail surfaces properly sloped and corners of cuts and fills properly rounded.

The question of how far to cut back a slope (or bank) is often a problem. Where the trail crosses a gently sloping hillside the bank may be taken back on a 2-to-1 slope, that is, 60 cm back for each 30 cm in height. A 1.5-to-1 slope is good, and a 1-to-1 slope should be regarded as the maximum, although there may be exceptions. Care should be taken not to remove too much established plant growth by grading too far up steep banks.

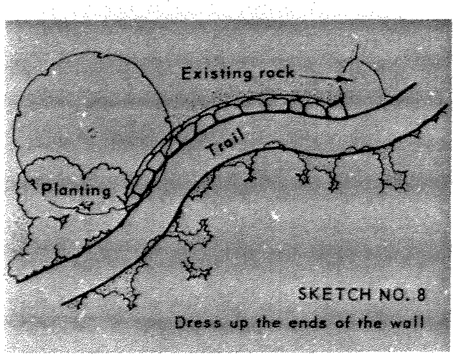
It is sometimes difficult to keep a slope uniform along the trail when the bank varies in height. If the slope is to be 2-to-1, measure the height of the bank, then measure back twice this distance from the vertical face of the cut, and set your slope stake. These stakes should be set from 1.5 to 3 metres apart to maintain a smooth, uniform slope.



SKETCH NO. 6
Good slopes



SKETCH NO. 7
Retaining wall



SKETCH NO. 8
Dress up the ends of the wall

Wall Construction

A natural slope is preferable to wall construction but walls are necessary in many situations. Great care should be taken in their construction. See sketch 7. To assure solid construction and good appearance the following rules should be followed in the selection and setting of rock. Start the construction with proportionately larger rock at the bottom of the wall; grade the size to smaller rock in the center section and again increase the size toward the top of the wall. The top course of the wall should be of rock sufficiently large to be solid. The following method of wall construction has been used with good results.

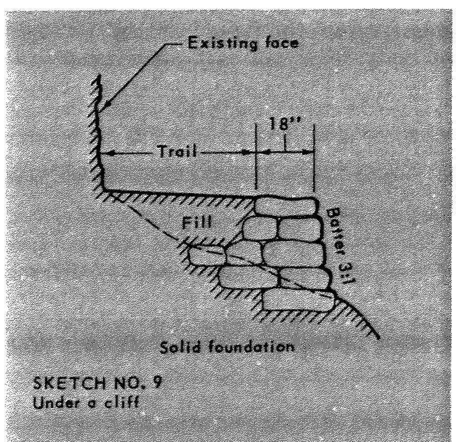
1. The outside edge of the base of the wall is carefully staked along the route of the trail.

2. Vertical batter boards as a guide to the slope of the wall during construction are set at intervals along this line at the proper slope. It has been found advisable to allow about 5 cm (2 inches) of clearance between the batter board and the wall surface. Care should be taken in placing the batter boards to see that the top of the wall is located to give the proper width of trail when the job is finished.

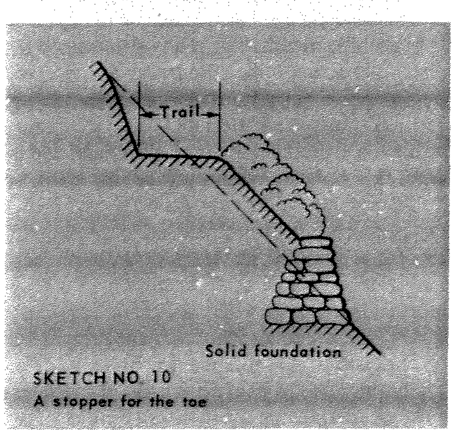
3. After the batter boards are set, excavation is started. Wherever possible, walls should be built on a natural rock foundation; if this is not present, excavation should be made to solid earth, below the frost line, before any wall construction is begun. Never build walls on filled earth bases.

4. Where the trail is built on earth-fill back of the rock wall, the wall should be built to the following dimensions: the base of the wall should equal one-half of the height. The front face of the wall should be battered about 23 cm (9 inches) to the metre (39 inches) in all cases. The back of the wall should be built in steps starting at the bottom and finishing at the last course with a width of wall at least 45 cm (18 inches). See sketch 7.

5. Particular care should be given to locating the beginning and ending of the wall. Wherever possible the wall should begin and end in some natural formation, leaving no sharp ends exposed above the natural surface. Where this is not possible, arrangements should be made for planting with native materials to obliterate the ends of the wall, as in sketch 8.



SKETCH NO. 9
Under a cliff



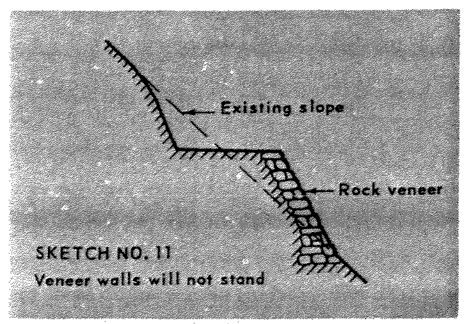
SKETCH NO. 10
A stopper for the toe

Sketch 9 shows a typical walled section where the entire trail width is obtained without going into the side slope and creating a large scar. This is particularly useful in very steep hillsides and in places where outcroppings of rock must be avoided.

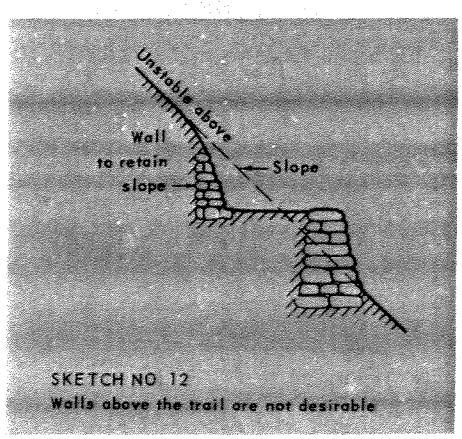
Sketch 10 illustrates a type of wall used where it is necessary to drop below the line of the trail to find firm foundations for wall construction. The slope between the top of the wall and the trail grade is built similar to the fill slope on the trail in ordinary circumstances. Care should be taken to provide for drainage above the wall.

Sketch 11 indicates a type of wall that is not practical as it can be washed out or turned over by frost action. It is merely a rock veneer and cannot be depended upon to retain a fill where there is pressure against it.

Sketch 12 indicates a wall on the cut side of the trail serving to retain loose earth and rock above the trail floor. This may be justified in a few exceptional cases. As a rule, however, wall construction above the bed of the trail should be avoided, as well as any laid-up work above a



SKETCH NO. 11
Veneer walls will not stand



SKETCH NO. 12
Walls above the trail are not desirable

trail such as veneer construction to eliminate a hole in the upper bank where a stump has been removed. Where it is necessary to stabilize a bank above a trail it may be done by placing the rock in such a manner that it gives the appearance of a natural outcropping. This area should be planted in a natural manner, using native plant materials, down to the trail edge.

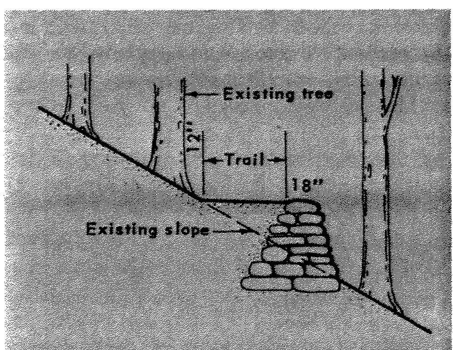
Where trails pass close to large trees and the location is kept below the tree, the type of construction shown in Sketch 13 should be adopted. This will make it possible to build the trail to the proper grade and location without injury to the tree roots.

Trail Width

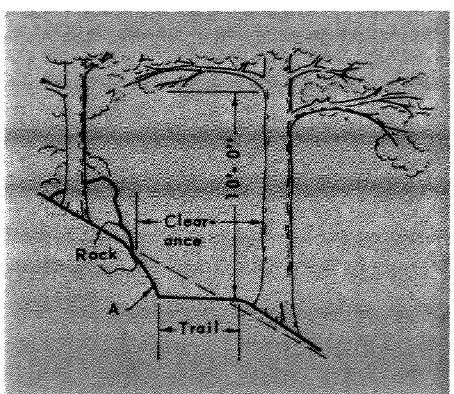
The anticipated intensity of use will determine the required trail width, of course, but 1.25 m (4 feet) is probably adequate for most trails. This width should not be measured out to a sharp edge which is not substantial. It should be measured from the outside of the trail where the fill slope starts to round over, to a point just out from the base of the cut slope, allowing for rounding out at point "A". See sketch 14.

Where there is a wall on the lower side of the trail, the width should be measured from the inside of the wall. The top of the wall should not be included in the width of trail.

Where there is a steep dangerous dropoff below the trail, the trail width should be increased to 2 or 2.5 m (7 or 8 feet), exclusive of wall width. If pack animals or horses are permitted on the trail there should be at least 30 cm (1 foot) clearance beyond each side of the trail. This distance may be increased where there is a dangerous condition below the trail. Tree branches that overhang the trail should be removed to permit passage of horseback riders. See sketch 14.



SKETCH NO. 13
Swing out around trees



SKETCH NO. 14
Clearance for trees

Drainage

No factor in trail construction is more important than proper drainage. Many sections of good trail are damaged and destroyed by erosion which could have been prevented. All drainage should be planned well ahead of construction. The method of carrying surface water off of each trail section should be determined, along with the location, type, size, and construction details of all drainage structures.

Three general drainage conditions are encountered in trail construction: **sheet water, water concentrating in natural basins, side drainage,** and **water in natural channels.**

Sheet water. Where water comes to a level section of the trail from an uphill slope it usually does not concentrate in drainage channels, but flows across in a sheet. In rare cases it is permissible to concentrate sheet water by cutting hidden ditches across the hillside, with an open ditch bringing the water to a culvert under the trail. *The approved practice is to pitch or tilt the trail bed* about 4 cm to the meter (½ inch per foot) so as to carry sheet water across the surface with the least concentration, and thus with the least danger of erosion.

Water concentrating in natural basins. Foot trails may go uphill and down, or cross ridges which shed water, and hollows which collect it. These hollows may concentrate water from a considerable area. The bottoms of these hollows, touching the trail, may be flat and wide, or steep and narrow. This topography calls for drainage structures, and the shape and area of a hollow dictate their location, type and size.

Surface water should not be forced to concentrate in channels to a greater extent than it does naturally. To compel it to back up behind culverts in new locations is to invite destructive erosion and unsightly ditches. Several small culverts should be used rather than one large one. The trail should also be raised enough to impound a rush of storm water until it can flow through the culverts, without cutting new channels in the drainage basin or across the trail.

In gullies, nature has already determined the type of structure to be employed, a culvert big enough to carry all the water that comes down. The gully has already established a temporary balance between the scour of the stream and its bed. This balance should not be disturbed, so the floor of the culvert should be at the level of the gully bed. Then the elevation of the trail, compared with the elevation of the gully bed, may dictate a wide, shallow culvert, or a deep, narrow one. But the wider the culvert the easier it will take water, and the less danger there will be of destructive cutting on the discharge side.

In many places where a small culvert seems to be needed it might be better to build a low-water crossing, which is merely a depressed section of the trail paved with flat stones.

Side drainage. Sometimes it is necessary to drain a trail surface to the inside, against a bank, providing a catch basin at the end of the culvert. Draining a surface in this way should be avoided if possible, but where it is necessary the side ditches should be paved with flat stones to prevent undermining. See sketch 15.

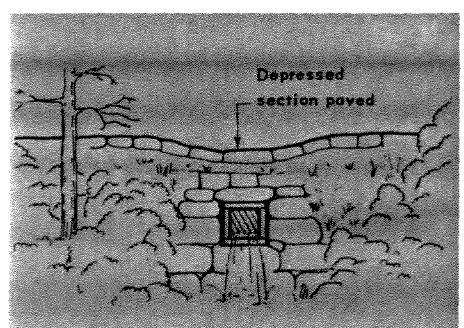
The only particular requirement for this type of culvert is to carry the catch basin well into the bank to keep it away from traffic. The back wall of the catch basin should be carried far enough up the slope to prevent erosion around it.

Water in natural channels. Established channels determine the location of culverts, and the amount of water to be moved can be estimated with reasonable accuracy. Any depression, even one coming from a small spring, is the established drainage channel in that area. This can be proved by the absence of erosion and the presence of cover on nearby surfaces. The amount of run-off at flood stage can be estimated by lines of drift left by high water, scouring at the bases of trees, root systems exposed by scouring, and other signs.

The culvert must be large enough to carry flood water, and its floor must be at the level of the channel bed. These two factors determine the size and shape of the structure. Where there is any choice, the culvert should be wide rather than deep. In some situations a bridge rather than a culvert will be required, but bridge construction cannot be treated in this brief article.

If the drained slopes are bare, and erosion is to be retarded until cover grows, a catch basin can be built at the intake end of the culvert, with dry walls built high enough to form an impounding basin behind them, where the flood water can deposit its silt before seeping into the culvert. But in such a case special care must be taken to protect the culvert with wing walls, so that impounded water will not find a passage along the walls of the structure and eventually wash out the trail.

Types of culverts. Culverts may be preformed of concrete or steel, or made of timber, or stone using dry or mortar joints as prescribed by plans, general instructions or local conditions. In stone construction the end of the walls should be flared, as a usual practice, to hold the fill above and to prevent scouring by flood water. Care should be taken to keep inside surfaces uniform and smooth to prevent debris from



SKETCH NO. 15

catching. A culvert should extend 50 cm or so (a foot or two) beyond the edge of the trail on each side, and the trail widened to the head walls of the culvert. The bottom level of the culvert should slope downward along its length not less than 1 cm in 30 (⅜ inch to the foot).

Waterbreaks

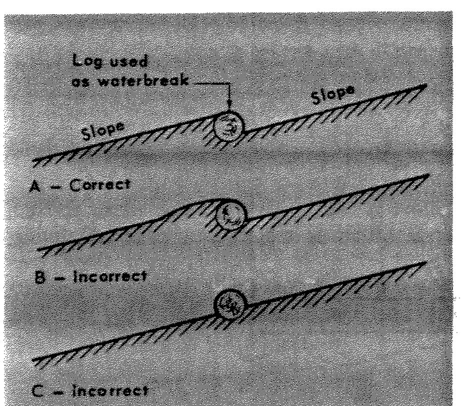
A waterbreak placed at intervals across trails should be extended far enough into the bank on the upper side of the trail to prevent water from cutting around it. It may be necessary to cut a notch into the bank to accomplish this, tamping the dirt back afterward. Both ends should be anchored behind rocks or trees, or firmly staked in place. See sketch 16.

The pitch of a waterbreak, or the angle at which it lies across the trail, is very important. A definite relation between the slope of the trail and the pitch of the waterbreak must be established by experience in each location. This relation depends upon the nature of the soil, and it may vary greatly on different sections of the trail. On one section there may be a stiff clay which does not wash. On another stretch there may be alluvial soil which will wash badly.

As one of two extremes, take a section in tough clay on a flat slope. Here there is very little danger of washing, and the breaker can lie on a steep pitch carrying off all of the water quickly. If it were laid on a flatter pitch, there would be danger of silt depositing behind the breaker which would put it out of use.

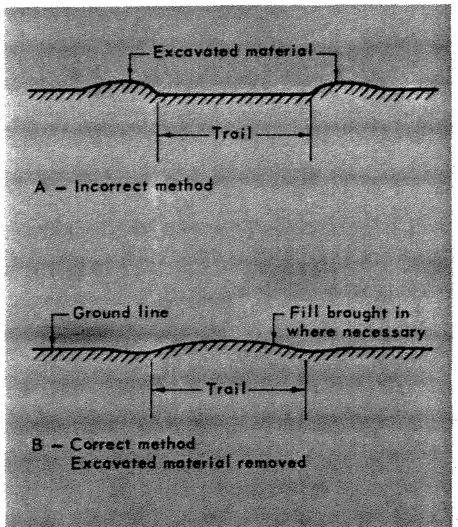
At the other extreme, consider a section in alluvial soil on a steep slope. Washing will occur here on the slightest incline, so the breaker must lie almost straight across the trail. If it is given a more pronounced pitch the water will hit the breaker, turn, and wash a cross-ditch. The breaker log may be washed out too, and the water will go on down the trail, making an additional load for the next breaker to carry off.

The spacing of breakers cannot be determined by any rule, but there are three particular locations where they should be placed: (1) where there is a depression or wash, the breaker should be set below; (2) on sharp curves, the breaker should be set at the uphill entrance of the curve; and (3) at changes in the trail grade, the breaker should be set just above the break in grade.

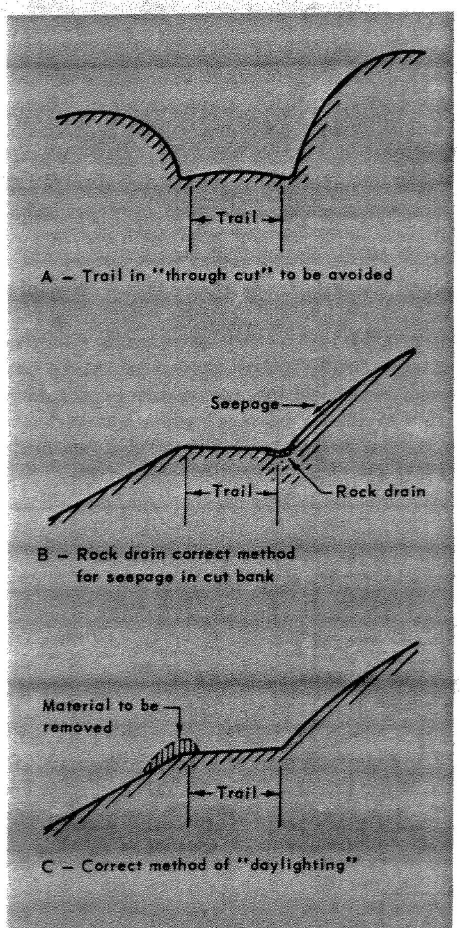


SKETCH NO. 16
Waterbreaks

No harm is done if some excess water goes over a breaker that is carrying a full load off to the side. It is better to set them so that this occurs in heavy downpours than to pitch the breakers so that excessive scouring occurs alongside the logs. If careful study is given to the behavior of breakers in different soils, and on different slopes, it will be possible to reach a reasonable balance between scouring, as one extreme, and silting up, as the other.



SKETCH NO. 17
Wrong & right construction on flat sections



SKETCH NO. 18
Trails on old road beds

In sketch 16, "A", "B", and "C" indicate three methods of setting breakers. "A" is the correct method with the grade below the breaker finishing flush with the top of the log. When setting, it is better to fill rather full back of the breaker and then tamp the soil well to prevent settling and the consequent exposure of the breaker. The grade above and below the breaker should feather nicely into the grade of the trail and not leave a "bump" as shown in "B". When breakers are set in this manner they are secure and not visible when one looks up the trail.

"C" indicates a method which is not desirable. It is not as secure, is more noticeable and creates an obstruction to stumble over.

The following are frequently encountered conditions that require careful study to secure proper drainage.

On ground where there is no appreciable cross slope, the trails often are incorrectly built as shown in "A" of sketch 17. Turf is cut from the trail floor and raked off to the sides, making piles that confine water to the trail and wash it out. On such locations, the proper method of construction will usually be to work out shallow, rounded depressions, not ditches, at the sides, and the good soil from these excavations used to slightly raise the level of the trail forming a dry, well drained surface in wet weather. In some cases it will be necessary to gather additional fill from another section to raise the trail floor. Drawing "B" in sketch 17 indicates the correct method of construction in this type of topography.

Water should be directed away from these drainage depressions wherever conditions will permit.

Sketch 18 indicates types of construction used when trails follow old road or railroad grades.

"A" — This sketch indicates the method used in "through cut" sections. It is not a desirable solution, however, and should be avoided wherever possible.

"B" —This shows a condition frequently encountered where there is a seepage of water for some distance from the bank above the trail which will keep the trail continually wet if the water is not disposed of satisfactorily. Here the trail is raised and the seepage caught in a rock fill which should extend along the trail for the distance that the seepage exists, and from there connect with one or more culverts.

Mounds of earth similar to those shown in "C" should be graded off.

Securing Firm Trail Foundation

Trails should not be built on top of peat or beds of leaf mold. When this condition is encountered the entire depth of soft material should be excavated to make a solid base that is well drained and will remain solid. The leaf mold and peat removed should be used as topsoil along other parts of the trail and for planting operations.

Trail Finishing

How far should one go on trail finishing? Generally, refined grading is not practical. Most trails will probably receive a relatively small amount of maintenance. The best answer to this question is that trail finishing should be carried to the point where erosion will be discouraged and natural plant growth will be encouraged. Such finishing can be justified from the practical standpoint. All trails will require occasional maintenance to keep them in good condition, and finishing them to hold upkeep to a minimum is one of the guiding factors in good trail construction. When banks are not properly sloped, walls not well built, and drainage not properly provided, constant maintenance will be necessary and the cost of upkeep will increase.

This article is based on an article by Guy E. Arthur, US Department of the Interior, which appeared in the Park Practice Program, Oct., 1975. It appeared previously in PARKS in 1976.

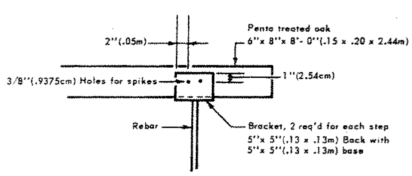
Steep Grade Trail Steps

If you're tired of the common "straight up the hill" trail steps, here's a flexible system, submitted by Dennis P. Fehler, landscape architect at Mark Twain National Forest in Missouri, USA. Using difficult topography to an advantage, Fehler's system follows the natural contour of the land and is constructed in a way that minimizes site disturbance. With this system, a designer can predict accurately the visual effect desired for a particular site and can prepare a technical drawing that can be understood easily.

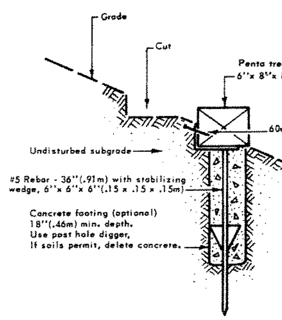
To show graphically the necessary curve for the steps, a "lime line" is drawn on the ground. Spacing of the 6′ x 8′ (15 x 20 cm) railroad tie steps varies according to the slope. To lessen site disturbance, brackets are used for step footings. Here they are welded to a 36′ (90 cm) piece of #5 rebar with stabilizing wedge. Other anchoring methods may be substituted depending upon local soil, topography, and codes.

Vegetation can be planted to soften or enhance the edge of the steps, and the vegetation can be manipulated to provide a variety of spatial effects. Erosion is reduced due to the serrated edge effect. If a step is damaged it can be replaced easily. The brackets preserve the correct horizontal and vertical alignment.

Reprinted from Design, a US National Park Service publication, Oct., 1980.



BACK VIEW OF FOOTING DETAIL



FOOTING DETAIL