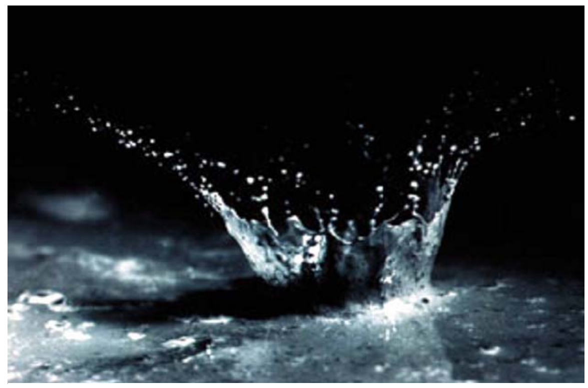
Environmentally Sensitive Maintenance
for
Dirt and Gravel Roads

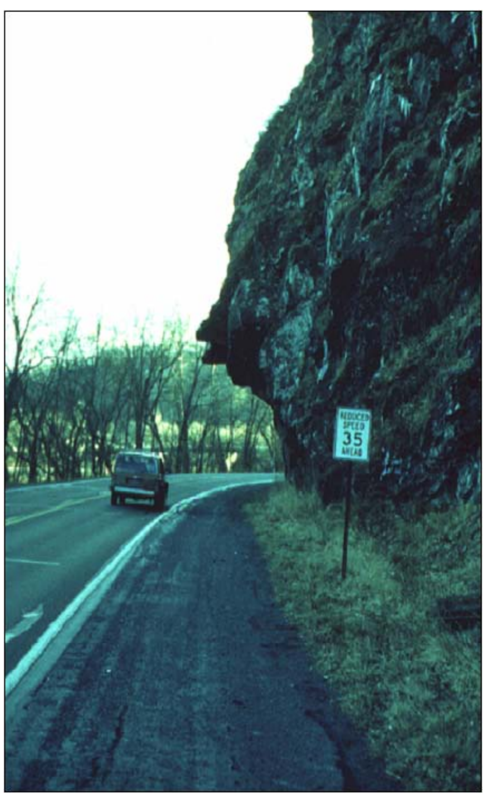
Chapter 3: Water, Erosion, Drainage and Road Basics

3.1 Introduction

Water is essential for all life on earth. Water, however, can also cause devastation through erosion and flooding. In the first chapter, we detailed the historical relationship between roads and streams, the interrelationship of our roads and the environment, and the importance of good roads and a good environment for a good municipality. In Chapter 2, we discussed the relentless forces shaping the earth, specifically gravity and water. Now we need to discuss water, accelerated erosion and the importance of proper drainage in maintaining our roads and the environment.



3-01 Never underestimate the force of water.



3-02 Stability depends on percentages of rock, sand, silt, and clay.

We will cover basic road maintenance materials and techniques to ensure an understanding of accepted and proven practices in maintaining dirt and gravel roads and establish a basis for our environmentally sensitive maintenance practices.

3.2 Water and Erosion

3.2.1 Principles of Erosion. Never underestimate the force of a drop of rainwater. To recap what was discussed in Chapter 2, it is that water drop exploding when it impacts bare soil that starts the erosion process. Water's eroding force increases with its volume and flow velocity (how fast it is flowing).

How resistant soil is to erosion depends on several factors. First, soil type and particle size are important. Soil stability will depend on the percentages of rock, sand, silt, and clay in the soil. A rock bank such as seen in the photo is stable with little erosion taking place.

A second factor is soil cover, specifically vegetation. Vegetation breaks the raindrop's fall, dissipating its destructive energy before it hits the soil. Vegetation also slows down surface water flow, keeping velocities low and minimizing erosion.

3-03 Vegetation provides many advantages in erosion control.

Plant roots constitute the third factor. Never underestimate the value of root systems as soil reinforcement. Plant roots provide additional stability by removing water from the soil. The importance of plant roots and root systems will be discussed more thoroughly in Chapter 4.

3-04 Roads interfere with natural systems, causing accelerated erosion

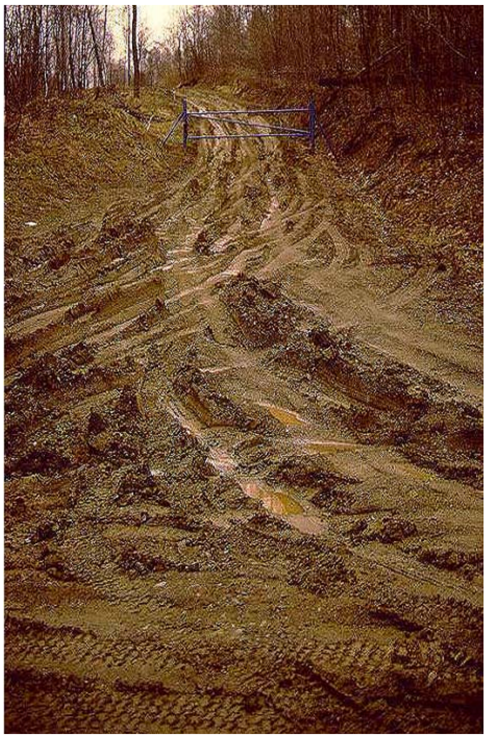
3.2.2 Accelerated Erosion. Remember, the greater the velocity, the greater the erosive force. Erosion is a natural occurrence in nature. When roads are constructed, however, they interfere with natural systems and concentrate water, increasing its volume and velocity, causing **accelerated erosion**. It is this accelerated erosion that causes severe problems for both our roads and the environment.

3.3 Water and the Importance of Road Drainage

3.3.1 The Importance of Drainage. Although water may be the life-giving liquid of our planet, it has long been recognized as the archenemy of our roads. Road literature provides a rich history of the disastrous effect water has on roads.

In 1820, the great Scottish road builder of the 19th Century, John Loudon McAdam, stated "…experience having shown that if water passes through a road and fills the native soil, the road, whatever may be its thickness, loses its support and goes to pieces." In 1909, Connecticut State Highway Commissioner, James H. MacDonald, remarked, "If there is no drainage, there will be no road, no matter what the material may be." In 1912, John Nathaniel Mackall in his Drainage, the Fundamental Principle of Road Construction discussed his conclusion after a seven-year study by stating, "Lay out your road with the object of draining it and never lose sight of this point. It is the ABC of road building and maintenance." A New Hampshire Highway Department Handbook in 1916 stated it this way: "Always remember and apply this most important rule: Keep water OFF your road, OUT of your road, and AWAY from your road."

These statements are just as true today! Good road drainage and proper maintenance is the best way to combat water's damaging influence – keeping water off, out of, and away from the road. Proper drainage cannot be over-emphasized in road maintenance and construction. Water affects all aspects of road serviceability.



3-05 Water acts as a lubricant, allowing material to move more freely.

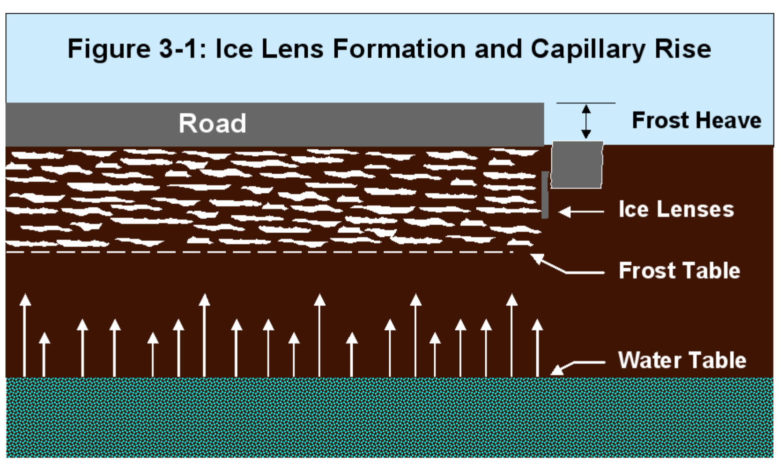
3.3.2 Characteristics of Water. To understand water and its effects, we must understand water's three key characteristics that concern us in road maintenance:

1. Water acts as a lubricant
2. Water expands upon freezing
3. Water runs downhill

Remember these factors as related to those relentless physical forces back in Chapter 2. A more detailed discussion of these characteristics is required to determine the concern for roads.

Water acts as a lubricant. Water's presence allows materials to move more freely by decreasing the friction between particles. Photo 3-05 shows a well-lubricated road. When a road gets wet, aggregates are more likely to move or become displaced under traffic loads. This in turn causes surface depressions that collect more water and result in even more weakened areas and soft spots.

If water is within the road structure and freezes, it expands and forms ice lenses as shown in Figure 3-1. This freezing process starts at the road surface and moves downward into the road structure. As the freezing takes place, more water is drawn up from the soils below. Thus, the road structure becomes supersaturated. The ice lenses formed from the expanded frozen water causes pressure in limited spaces – a pressure that is usually transmitted



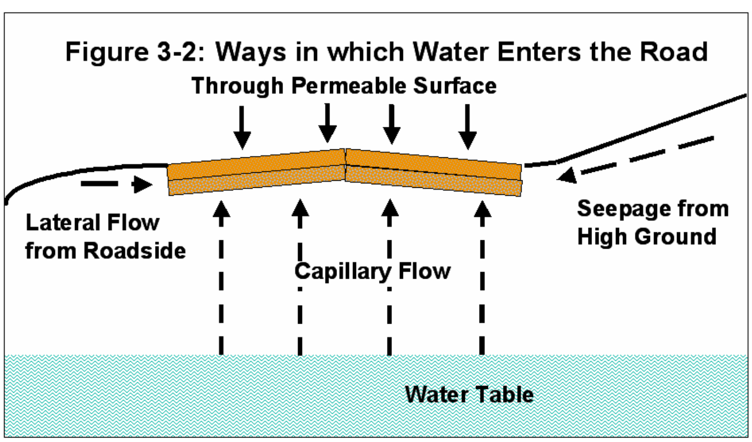
upwards, deflecting the road surface, causing frost heaves or frost boils. As the first step in controlling this frost damage, we must recognize the three conditions required for frost damage to occur: freezing temperatures, frost-susceptible soils, and water. The elimination of any one of these three conditions will prevent frost damage.

Since the power to control temperature is beyond us, we can concentrate on the remaining two. Some soils are more susceptible to frost heave, such as fine-grained clay soils, as was described in Chapter 2, Geology and Soils. It may not be feasible to remove frost-susceptible soils depending on the extent of the problem. Small localized areas can be considered for removal while larger areas may use alternate treatments with geosynthetics. Geosynthetics, their properties and uses will be discussed in Chapter 7. A combined strategy of proper drainage and the use of geosynthetics is usually the most feasible and cost effective method.

Springtime and thawing brings additional problems. During the spring thaw, ice lenses melt, releasing excess water to the base and subgrade. The problem is compounded since melting will occur from the top down, trapping water from draining downward. This excess water, if it cannot drain off laterally, acts as a lubricant, softening our roads and killing their load-bearing capacity. Springtime, often referred to as "mud season," can be a very trying for road maintenance crews.

3-06 Spring, "Mud Season," can be a trying time for road maintenance crews.

The simplest and most obvious characteristic of water is that it runs down-hill, subject to the relentless force of gravity. But we do not maintain our roads with this in mind. How many roads have ponding problems on the surface? We ignore this obvious characteristic at our roads' peril. Like gravity, water's devastating effects are relentless.



3.3.3 How Water Enters Our Roads. Figure 3-2 shows the many ways water can seep into our road structure. Road surfaces are not impervious to water, so water can seep through the surface. The longer water lays on the surface, the more seepage takes place. Water may enter as lateral flow from the roadside or high ground. The water table may rise and enter the road base. If the water table is at a level higher than the road base, then we have to look at ways to lower the water table in the vicinity of the roadway structure using underdrain systems (discussed in a later section). Even if the water table is low, you may still get water into your road by "capillary flow" through the soil. The soil acts like a wick in a kerosene heater, drawing the water upward and into the road. This capillary flow also aids the freezing process as additional water is drawn up from below. Capillary rise can be quite substantial depending on soil type, as the following table illustrates.

Height of Capillary Rise through Soils	
Soil Type	**Height of Rise (feet)**
Small Gravel	0.1 - 0.4
Coarse Sand	0.5
Fine Sand	1 – 3
Silt	3 - 30
Clay	30 - 90

Given water's destructive effect on our roads, good drainage must be our highest priority. Further, unless drainage issues are addressed first, all other maintenance work will not last as long as it should, resulting in a waste of time and money.

3.4 Road Drainage

3.4.1 Drainage Systems. There are two major road drainage systems: surface drainage and subsurface drainage. The surface drainage system controls surface water caused by direct rainfall, melted snow, or surface runoff. The subsurface drainage system drains subsurface water from in our roads or from the subsurface areas surrounding our roads.

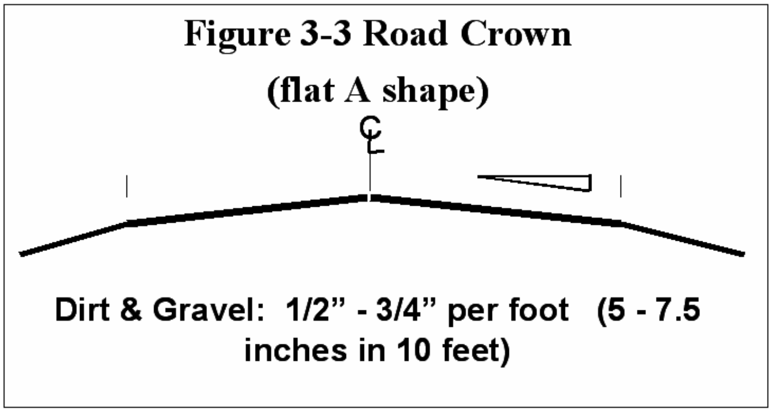
3.4.2 Surface Drainage. Surface drainage involves collecting the water from the road surface, road shoulders or berms, side slopes and adjacent areas and carrying it away via downhill slopes, roadside ditches and pipes. More complex surface drainage practices will be presented in later chapters; here we concentrate on road basics emphasizing the road and shoulder profile and the road cross-section or actual structure of the road.

3.4.2.1 Road Crown and Cross Slope. The road surface acts as our first line of defense against water, and the first component of a good surface drainage system is the road crown. The road crown means the center of the road is higher than the outer edges of the road, as shown in

3-07A good road crown is our first line of defense against water.

Figure 3-3. The crown should be a flat “A” shape with a cross slope or drop from the center to the edge of ½” to ¾” per foot or a 4-inch to 6-inch drop for an 8-foot lane.

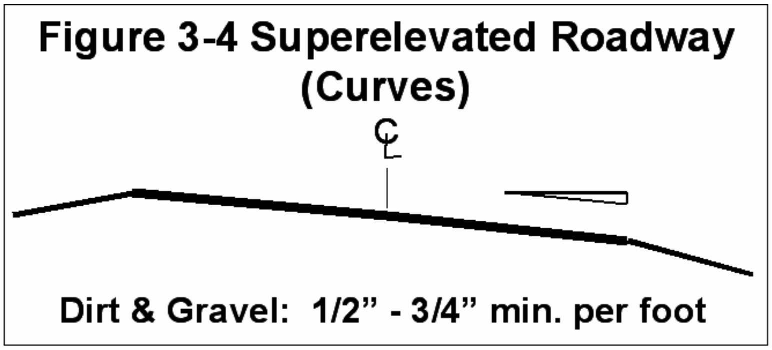
The crown must be maintained to allow water to flow off the road. Problems develop quickly when a gravel road has no crown, as evident in photo 3-08. Water will quickly collect on the road surface during a rain, softening the surface crust. This will lead to rutting, which can become severe if the subgrade also begins to soften. Even if the subgrade remains firm, traffic will quickly pound out smaller depressions in the road where water collects, and the road will develop potholes. A dirt and gravel road must have crown.



3-08 Water quickly collects when the road crown is lost.

A crown’s ideal shape is a straight line from the centerline down to each road edge, the flat “A” shape already mentioned. This shape can sometimes become rounded. The term for this is “parabolic crown,” and it is virtually always a problem. The middle portion of the road will have considerably less crown than the outer portions. This center area is somewhat flat, and water will collect and not drain from the middle adequately. Traffic will form potholes and ruts. A parabolic crown is often caused by a worn grader blade. Grader blades, which are worn down through the center portion of the blade, should be replaced or cut straight with a torch.

With curves, we need to slope the road from one side to the other to “bank” the curve. This banking of the curve, called superelevation, provides for vehicle safety in traveling around the curve, as shown in Figure 3-4.



The sloped surface still provides for proper drainage, getting the water off the road. The cross slope of the superelevated section should be a minimum of ¼" to ¾" per foot. Sharper curves may demand steeper cross slopes for safety. Of course, the steeper we bank the curve, the faster the vehicles will go.

3-09 Banked (superelevated) curve.

3.4.2.2 Road Shoulders. Most of our dirt and gravel roads do not have defined shoulders. But shoulders provide some key advantages.

If you have shoulders or a berm area, keep it flush with the road edge with a slightly steeper cross slope, avoiding "shoulder drop-off," which becomes a safety hazard for the motorist. A vertical drop-off can cause a serious accident. The errant driver leaves the road's travel way and drops to the shoulder area. When he attempts to return the wheel will catch on this "lip," and the driver will end up over-steering, allowing the vehicle to jump the lip, taking the vehicle into the adjacent lane of oncoming traffic.

3-10 When water cannot drain off the road, the result is a "secondary ditch."

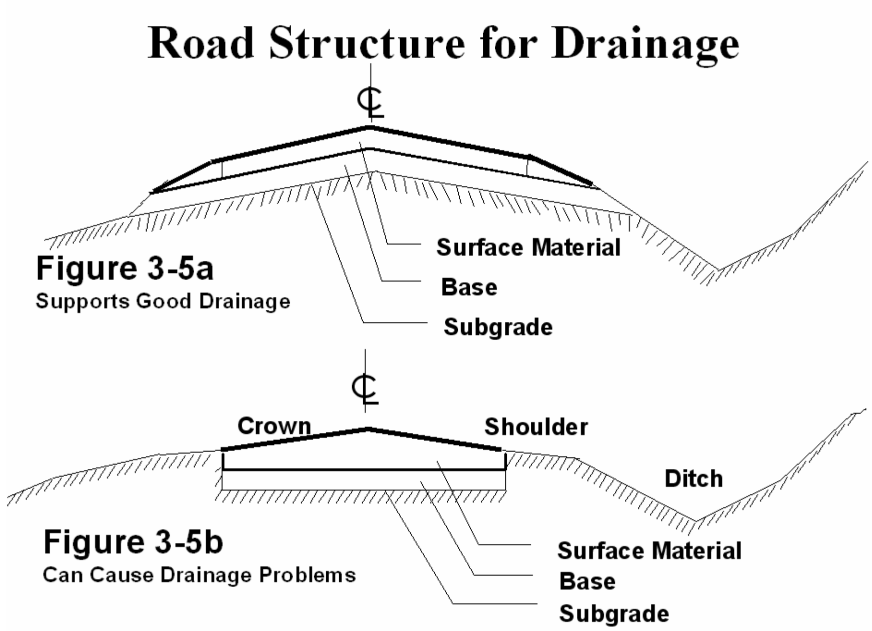
Roads without a properly sloped shoulder or berm area often develop a "secondary ditch" that will not allow the water to drain off and away from the road. This secondary ditch develops when road material moves toward the edge of the road and catches in the vegetation, forming a barrier to road drainage, as shown in Photo 3-10. Improper grading techniques can also leave a windrow of road material along the edge that acts as a dam, keeping water on the roadway.

A shoulder or berm area also supports the road structure, preventing road edge breakdown. Look at a road where the roadside slope drops immediately from the road edge into the adjacent road ditch, and you will probably find road edge deterioration. Shoulders also allow the water to flow further away from the road, maintaining better drainage, getting the water off and away more effectively.

And finally, shoulders make the road safer by providing a more defined visible roadway for the motorist and more room for erratic vehicle maneuvers or pull-offs. With all these advantages, developing and maintaining shoulders along our dirt and gravel roads, where feasible, should become a high priority in our road maintenance program.

3.4.2.3 Road Structure (Cross Section). The crown and cross slope are not only important for the road surface and shoulders, but also are important for the road base and subgrade, or the soil on which the road is built. The configuration in Figure 3-5a supports good drainage.

The old "trench construction" method for building a road consisted of digging a trench with a flat bottom and then building your road, depicted in Figure 3-5b. Depending on geology and soil types, this procedure could actually trap water within the road structure.



Proper construction maintains a cross slope for each layer including the subgrade and also carries the base materials through to the ditch slope to provide proper drainage of the road structure.

Notice in the figure that the bottom, or flow line, of the ditch is below the subgrade of the road. If a roadside ditch is required, this configuration with a 4:1 foreslope from the road into the ditch is the ideal ditch to drain the road surface and base properly and provide a safety factor for errant vehicles leaving the road. This construction, however, is not always feasible because of roadside terrain and right-of-way limitations often found on our dirt and gravel roads. Ditches will be discussed more thoroughly in Chapter 5 where we address ditch shapes and slopes and look at a variety of practices that can help us in maintaining our roads and ditches.

3.4.3 Subsurface Drainage. Surface drainage is only part of the overall drainage picture. We must drain the road subsurface as well. The free draining base of the road with a proper cross slope is a major component of the subsurface drainage system to drain the road structure, either into the roadside ditch or subdrain system. The ideal road structure would have a free draining base material topped with a good wearing course material, particularly in those areas where subsurface water is a concern.

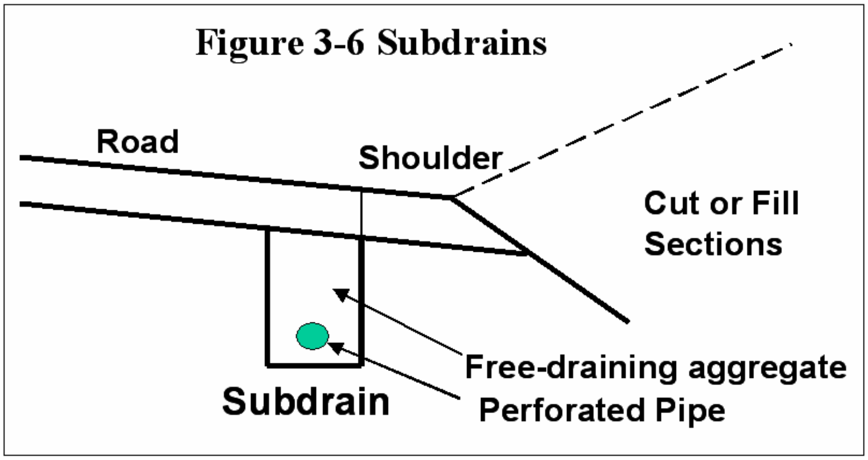


Figure 3-6 Subdrains

The second major component of a subsurface drainage system is an underground collector system, usually referred to as a subdrain. A typical subdrain, as shown in the Figure 3-6, consists of a trench parallel to the road with a free draining aggregate and a perforated pipe to carry the water to an outlet and away from the road. All subdrains should have an outlet. Whether or not adequate ditching exists, subdrains may be necessary to remove the water from the road structure and the surrounding area and/or to lower the water table.

But subdrains are subject to clogging over time. Soil fines, carried into the perforated pipe, can build up sediment, eventually blocking water flow and causing the system to malfunction. Some perforated pipes have perforations halfway around the pipe. These pipes should be installed with the perforations on the down side to prevent fine particles from falling through the holes and clogging the system. Water will find its way into the pipe (the path of least resistance) and keep the bottom flushed more effectively, prolonging the life of the system. Traditionally, roofing paper has been placed over the free draining aggregate in the trench to reduce the amount of fine particles migrating into the pipe.

Chapter 7 will discuss the use of geotextiles and geosynthetic pre-fabricated subdrains as cost effective alternatives that prolong system life.

3.5 Road Materials

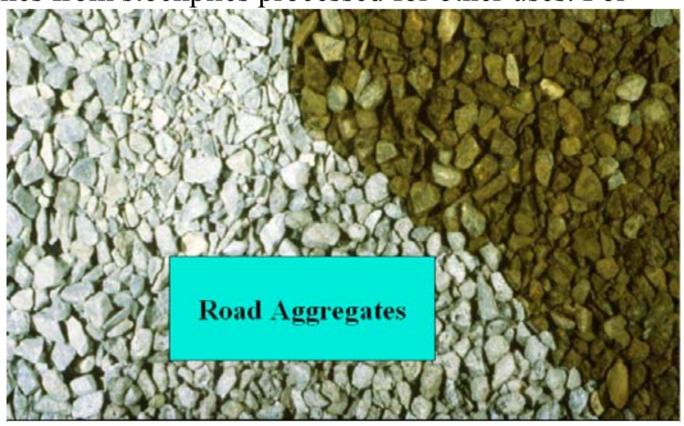
Road materials play an important part in a road's structural stability. Additionally, good quality road materials reduce erosion, sediment, and dust pollution. Road material is normally sorted by type, size, shape, and gradation. In addition, as discussed in Chapter 2, we need to be concerned about other factors such as hardness, soundness, pH, and plasticity (cohesiveness/stickiness) to adequately protect both the road and the environment.

3.5.1 Quality Aggregates. What do we mean by quality road aggregates? The answer to this question will vary depending on location (remember geology and the physiographic provinces), aggregate availability, intended aggregate use, and other factors. Some regions do not have good aggregate sources. Common available materials may include:

- granite
- quartzite

- limestone
- sandstone
- shale
- glacial deposits of stone, sand, silt and clay or
- river run gravels. One thing to remember – using the best material available will prolong the road's life, decrease required maintenance work, and further protect the area's natural environment.

3.5.1.1 Surface Aggregate versus Other Uses. Many times surface aggregate used for our dirt and gravel roads comes from stockpiles processed for other uses. For example, the aggregate may have been produced for use as a base or subbase material beneath a paved road surface. But there are major differences between surface aggregates and base course aggregates. Base course aggregate is not designed to withstand traffic and the constant, direct grinding of wheels. A base aggregate may have larger sized stone and less fines than what is required for a good surface aggregate. Base aggregate may not be suited to developing a hard crust surface and remaining bound and stable under traffic. A free-draining fill aggregate may be great as fill material for building sites, but the high sand content that allows for good drainage will remain loose and unstable as a surface aggregate on an unpaved road. A good surface road aggregate needs a fine binding material having more plasticity or stickiness than subbase aggregate.



3-11 Road Aggregates

There are still many local governments that use their State Department of Transportation (DOT) specifications for their road aggregates. But many states only have base/subbase course aggregate specifications and do not have an actual unpaved road surface aggregate specification. Aggregate meeting base material specifications will probably not meet unpaved road surface requirements.

3-12 A good road surface aggregate will be well graded from fine to coarse.

3.5.1.2 Road Aggregate Specifications. Dirt and gravel road aggregate must be a granular, well-graded, crushed (irregular) material. Well-graded means the aggregate has a variety of sizes from a maximum coarse material down to a fine material and everything in between. The fine material (passing a #200 sieve) fills all the voids between the larger particles and locks everything together in place. The fines hold the road together, obtaining good density and a hard crust surface to shed water. Most specifications will have a required content of 8% to 15% fines.

Another characteristic of good road fines is their plasticity, or binding quality. Although fines are needed to fill the voids between the large aggregate, a percentage of good plastic fines, such as natural clay, is needed to bind the material together and maintain a tight surface to shed water and prevent dust. A plasticity index (PI) of 4 to 12 is a common specification requirement.

Please note that we are describing a gravel road “surface” material. The amount and plasticity of this fine material determines how effectively it locks in place to form a tight surface that will shed water and provide a smooth driving surface.

Road “base” material plays a different role in effective drainage. This role dictates that base material contain less fines and have a plasticity index of down to 0% to allow water to drain from the road structure. Large quantities of plastic fines in the road base will clog drainage channels in the base material and prevent proper drainage. A poorly drained road will lose strength and stability and ultimately fail.

We have discussed several times how common maintenance techniques can spell disaster for dirt and gravel roads. This is another example. Maintenance crews will commonly use only one type of material for both the road surface and the road base. But that results in either a weak road surface or a poorly drained road base. The best approach, particularly in those areas of poor drainage, would be to specify two types of road aggregates, one for the road surface and one for the road base.

The aggregate should also be angular or irregular in shape. In some regions, it is common to use material directly dredged from streams or by simply loading material from a site onto trucks without processing – hence the terms “river run” gravel or “bank run” gravel. These natural deposits will most likely not meet gradation requirements and will contain rounded natural shape material that will not lock up for stability. Have you ever tried to stabilize a hand full of marbles?

The benefits of processing the material by crushing cannot be overstated. Crushing insures that a good percentage of the stone will be fractured. This crushed, fractured material will lock together for better strength and stability under traffic loads. Quarried aggregates will be composed of virtually all fractured particles, resulting in the best specified road material.

The aggregate must be free of any other debris or contaminants such as soil, vegetation, or trash. Any contaminant material will only interfere in obtaining good consolidation and long-term stability.

The importance of additional material considerations of hardness, durability, and pH were discussed in Chapter 2, Section 2.3.3 in relation to not only the road’s structural stability, but also to the surrounding environment.

Quality road aggregate with good gradation, shape, plasticity, hardness, durability, and proper pH will compact well, developing a tightly bound surface to withstand traffic loads, and reduce washboarding, rutting, erosion, sediment, and dust for less maintenance and a better environment.

Appendix A for this chapter contains several state specifications for unpaved road surface aggregate material. Notice the great similarities and the relatively minor differences in the various parameters. Some titles such as Pennsylvania’s “Driving Surface Aggregate” say it all. In addition, the Pennsylvania specification reflects the environmental/structural combination qualities of hardness and pH.

3.5.1.3 Recycled Asphalt. As our paved roads wear out, the asphalt pavement materials can be recycled. Although there are various recycling methods to restore the asphalt paved road, this recycled material is many times used for gravel roads. Milling the old asphalt pavement is a common method used in the recycling process. The asphalt pavement can also be removed and then processed through crushing. This milled or crushed recycled asphalt material can create a good gravel road surface. The asphalt in this material, however, is still the binder, and depending on the age and oxidation (brittleness) of the material, can still form the characteristic asphalt pavement. This means that the road will be hard to maintain as a gravel road as far as blading or grading operations and may develop cracking, potholes and other typical asphalt pavement distresses. If the asphalt is still somewhat viscous and not hard and brittle, virgin aggregate can be mixed with the asphalt to overcome some of the asphalt binding quality and to provide a material that will still remain workable for blading and grading operations. A commonly used mix would have 50% virgin aggregate.

3.5.2 Sampling and Testing Aggregates. Aggregates can differ substantially from one area to another or from one quarry to another. Aggregates can also differ substantially within the same quarry and may depend on geology, or quarry operations and procedures in the handling and processing of the material.

Road maintenance managers need to understand the necessity of sampling and testing aggregates to insure that they are getting a road material that meets the specifications and makes for a well-structured road. A visual inspection can tell very little about the quality of the aggregate.

3-13 Mechanical Sieves

National standards for aggregate sampling require a representative sample of the aggregate you intend to use. Using a representative sample helps to ensure reliable test results. A sieve analysis for the proper gradation blend along with other tests for the specified parameters (plasticity, hardness, pH) is essential to insure the quality of the aggregate.

Testing costs, when compared to the benefits of a structurally strong road, are nominal. Using quality aggregates greatly reduces overall maintenance costs and protects the environment.

3-14 Quarry Visit

Check parent material

3.5.3 Pit / Quarry Operations. As mentioned, handling and processing at the quarry has a significant influence on the aggregate quality. Road maintenance managers would be wise to visit the quarry and talk to the operator. Take a look at the parent material and check the pile. Observe the equipment operators as they remove the gravel from the face of the quarry pit, process the piles and mix and load the aggregate. As they remove material, are they getting a good blend? Is segregation of the aggregate visible on the belt loaders or on the surface of the piles?

3-15 Check Moisture Content And Fines

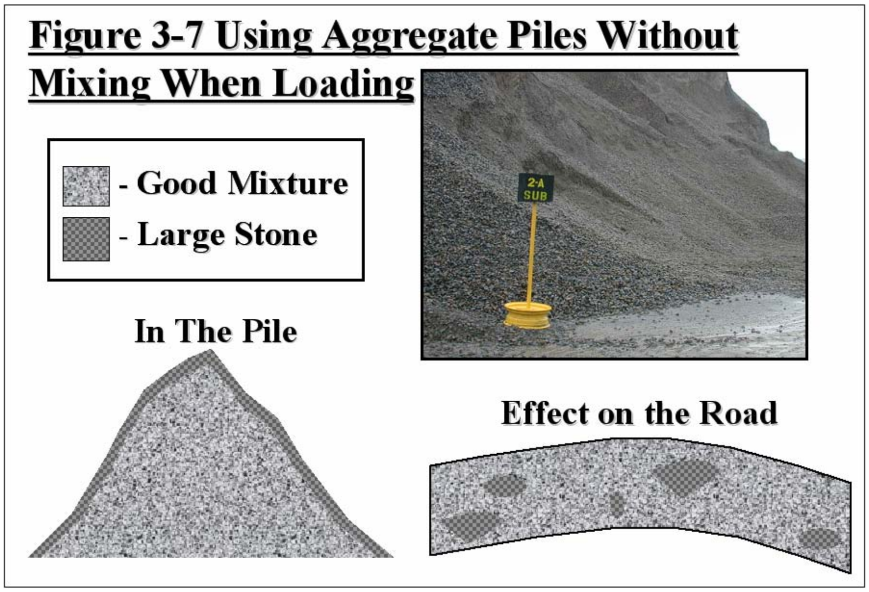
Check the moisture content of the material. Grab a handful and compress into a ball. If the material sticks together when you open your hand, you've got a good moisture level. If it falls apart, it's too dry. If water runs out between your fingers, it's too wet.

Some separation of aggregate in a pile is normal. Coarse material will tend to end up on the surface. A good loader operator will view the pile and then work it appropriately to obtain a good blend of aggregate.

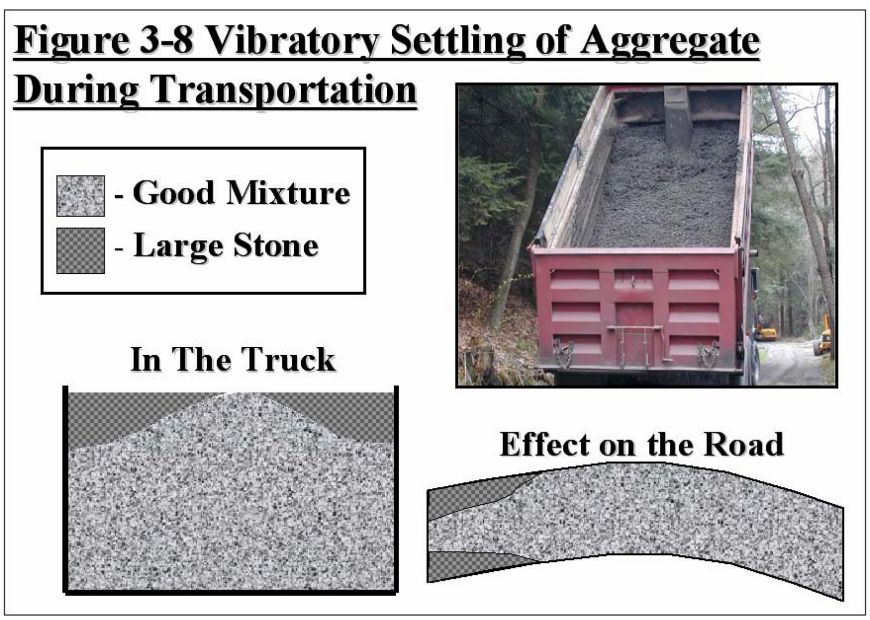
3-16 Aggregate Separation In A Pile Is Normal | Mix The Pile!

Contamination of the aggregate can also become a problem. Has all the topsoil and vegetation been cleared from the top of the removal site? Are the stockpile sites well maintained, with an uncontaminated level working area? Does the loader operator start with a lowered bucket too far in advance of the pile, picking up soil or other contaminate material?

Loading and hauling of the material, even a good gravel road material, can affect the quality of the road. If the loader operator does not work the pile and obtain a good mix of material from the pile, normal aggregate separation will produce undesirable results on the road. This is depicted in Figure 3-7.



Long distance hauls can also cause problems. The continual vibrations created by hauling, especially over longer haul times, can cause aggregate settling in the truck bed producing a surface of larger stones, as depicted in Figure 3-8.



3-17 Talk To The Quarry Operator
Establish The Spirit Of Cooperation

Quarry visits, including observations and discussions with the operators, can establish good working relationships with the proper spirit of cooperation and can result in quality aggregate, good handling practices, and a stronger, longer-lasting road.

3.6 Basic Road Maintenance Practices

We will primarily discuss the use of the motorgrader for dirt and gravel road maintenance. We recognize, however, that other equipment can work just as well. Front-or rear-mounted grading attachments for tractors, road rakes, and road drags of various designs are often used effectively. No matter what equipment is used, the principles of basic road maintenance remain the same.

3-18 Good road surfaces differ in appearance depending on aggregate type and gradation.

Basic road maintenance practices are designed to produce a structurally sound road capable of supporting traffic with a good hard crust surface and proper crown for good drainage. Good road surfaces vary in appearance depending on the type and gradation of the aggregate material being used, as can be seen in the photos. This manual is not a basic gravel road surface maintenance manual. However, it does discuss effective maintenance techniques that ensure road stability. Further, the manual emphasizes the importance of proper basic road surface maintenance in protecting the environment. One of the best resources for gravel road maintenance is the Gravel Roads Maintenance and Design Manual, developed by the South Dakota Local Transportation Assistance Program (SD LTAP) in conjunction with the Federal Highway Administration (FHWA), November 2000. This manual provides valuable information for road maintenance personnel on gravel road materials and routine maintenance operations. The following section, Section 3.6, will provide brief coverage of the basics with several references from the South Dakota manual.

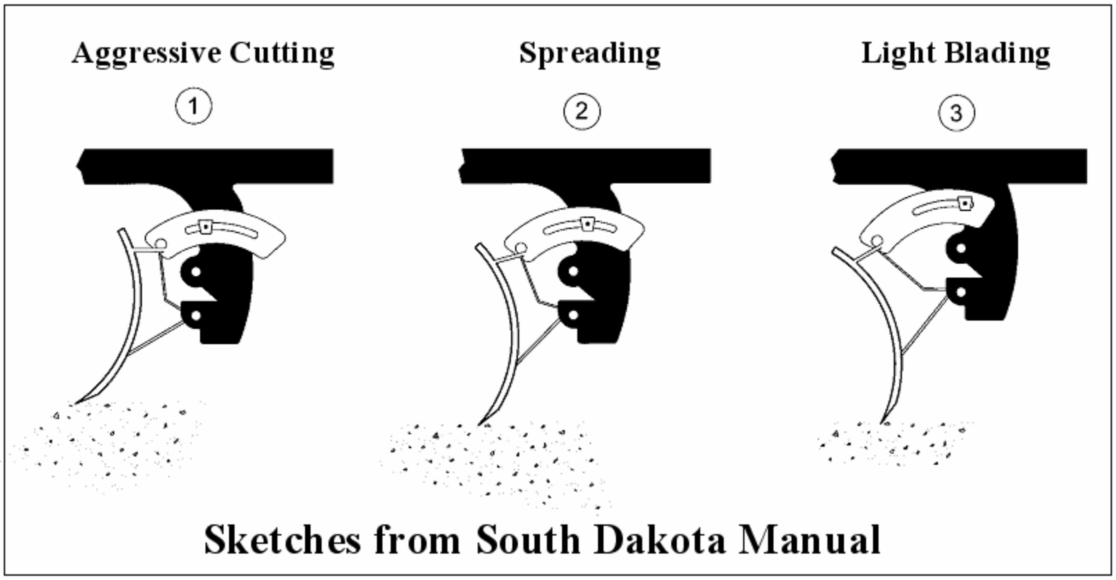
3.6.1 Basic Techniques. First, no matter what work is being done on the road, it should be planned when there is adequate moisture. This usually means that all work should be done after a rainfall unless there is an available water truck and water source. Adequate moisture is needed not only to achieve proper compaction for structural integrity and strength, but also to avoid dust.

Dirt and gravel roads are usually maintained through three basic practices: blading or smoothing, reshaping or regrading, and adding new material. Gravel road deterioration, like any paved road, will develop in stages. Low severity surface distresses such as roughness, loose gravel, and minor ripples appear first. ***Blading or smoothing the road surface frequently to correct these distresses will result in less intense efforts of reshaping or adding new material***. When the road loses crown and more severe distresses appear, a reshaping or regrading to re-establish proper crown is required. The more frequently we reshape using existing road material, the less often we will need to add new material. Sooner or later, however, the road loses crown and enough material has been lost off the roadside or by way of erosion and dust that there is not enough remaining material to simply regrade the road. Then we must add new material in order to re-establish the crown and have an effective road profile.

3.6.1.1 Blading or Smoothing. As described above, blading a road is needed when surface distresses appear but the road still has a good crown. We need to blade the road to smooth the rough surface to restore good rideability and prevent further more extensive distress.

3-19 Blading or smoothing a rough surface restores rideability and prevents further more extensive deterioration.

When using the motorgrader, the moldboard angle and pitch is critical to doing good maintenance. The moldboard should be angled somewhere between 30 and 45 degrees, tilted forward, with light down pressure. A 10 to 15 degree tilt on the front wheels will help oppose the resisting forces and stabilize the operations. A speed of 3 to 5 miles per hour is considered average, but there are many conditions or variables that may require slower speeds for effective operations. With the blading or reshaping operations, compaction of the material is often left to traffic.



Operating with proper pitch or tilt of the moldboard is important. Moldboard pitch or tilt refers to how much the moldboard is tipped forward or backward. The following excerpts and sketch are taken from the South Dakota LTAP Gravel Roads Maintenance and Design Manual:

3.6.1.2 Regrading or Reshaping. As stated above, when the road loses crown and more severe distresses appear, a reshaping or regrading to re-establish proper crown is required. With the moldboard tilted slightly backward and sufficient down pressure to produce a cutting action, the road is reshaped to restore proper crown and cross-slope for good drainage. A minimum of four passes may be required, with a first pass in each direction to cut and windrow the material to the road center and then a second pass in each direction to spread the material back across each lane. The cutting action should be deep enough to cut to the bottom of all existing distresses such as corrugations, ruts, and potholes or soft spots.

Since this operation is being performed to restore proper crown and cross slope, check the resulting cross slope to insure it meets the half inch to three quarters inch drop from the center of the road with the flat "A" shape.

This operation should include a compaction effort. Using rollers for proper compaction of the disturbed material will result in a stronger road for a longer period of time.

3-20 Checking Cross Slope to insure proper drainage.

3.6.1.3 Adding New Material. If there is not sufficient material remaining to regrade and restore proper crown and cross slope at the proper elevation, additional road material will have to be added. Prior to adding new material, the road should be in good shape with all other maintenance work performed. All distresses, such as corrugations and rutting, should be repaired and the road brought into the proper condition and shape to receive the new material. If the existing road surface is smooth or has a hard crust, the surface should be lightly scarified to loosen surface material to provide a good bond between the road surface and layer of new material. Compaction is again required to provide the proper density for structural strength and durability.

3-21 Adding new material.

3.6.2 Transitions. There are always those areas where we have to transition from our normal road crown to meet other profiles. Transitions are required at road intersections, driveways, road curves, railroad crossings, and bridges.

3.6.2.1 Road Intersections. When two unpaved roads intersect, we need to gradually eliminate the crown as we approach the intersection. This transition from normal crown to a flat profile at the intersection should be made within approximately one hundred (100) feet, resulting in a smooth gradual transition. The shoulder or berm area of the road should still maintain a slope for proper drainage of the road.

3-22 Working parallel to a paved road has advantages.

When a gravel road meets a paved road, we need to transition the crown into the existing edge elevation of the paved road. As we grade out toward the paved road, backdragging may be required in order to avoid leaving aggregate on the paved road. Depending on traffic conditions and safety or operations, working parallel to the paved road can be an advantage in tying into the edge of the paved road.

3.6.2.2 Driveways. Driveways will also cause a need for transitioning. We will be discussing driveways in more detail in later chapters as we look at environmentally sensitive maintenance practices. For now, the basic rules are that we need to grade the driveway, keeping the low point at the ditchline and not leaving a windrow of material across the driveway. The low point at the ditch line insures drainage off of and away from the road.

3.6.2.3 Curves. Back in Section 3.4.2.1, we discussed superelevation or banking the curve, sloping the entire road surface from one side to the other for vehicle safety in transversing the curve. Here again, we need to transition from the normal crown to the banked slope of the curve and then transition from the banked slope of the curve back to the normal crown. This should be accomplished within about 100 feet on each end of the curve, as shown in Figure 3-9.

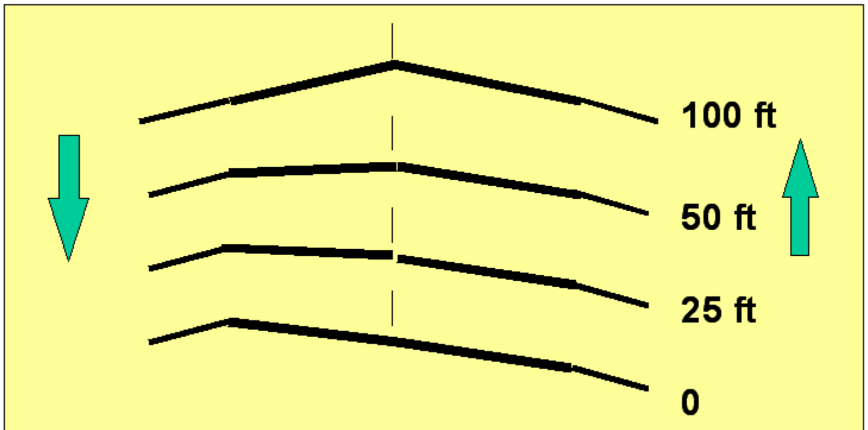


Figure 3-9 Transitioning into and out of a curve.

3.6.2.4 Railroad Crossings. Railroad crossings also require gradual elimination of the road crown as we approach the rails. It is important that our operations leave the rails clean, keeping aggregate off of the tracks and being careful not to damage the rails or the moldboard. Handwork could be required using a shovel and broom in order to insure a safe railroad crossing for both vehicles and trains.

3-23 Keeping rails clean of road material is essential for safety.

3.6.2.5 Bridges. At bridges, we need to transition into the existing bridge deck profile. Many bridges on unpaved roads have flat decks that will require the gradual elimination of the road crown. If the bridge deck is crowned, the task will be to transition the road crown gradually into the bridge crown.

3-24 Road crowns must transition into the existing bridge deck.

Although we will be discussing practices for better bridges in Chapter 5, good bridge maintenance dictates keeping all road material off the bridge and keeping the bridge drainage facilities clear and open. Road material buildup on the bridge deck will only retain water or moisture that is detrimental to the bridge deck and structure no matter whether the bridge is constructed of metal, concrete or wood.

3-25 Drainage openings (scuppers) in bridge decks must be kept cleaned.

Bridges need to have good drainage. Usually drainage openings are provided in the deck, called scuppers, which drain directly to the stream below. Keeping the deck clean is imperative not only for good drainage and longer bridge life, but also for prevention of sediment into the stream.

One of the more troublesome areas at bridges is the approach area where the road aggregate meets the deck. This approach area demands special attention and probably more maintenance. When traffic moves from a rigid bridge deck to a more flexible dirt and gravel road surface, the impact forces of those vehicles can cause problems, resulting in significantly more maintenance for the approach areas.

3-26 Bridge approach areas demand special attention and usually more maintenance.

3.6.3. Frequency of Maintenance Operations. No matter when operations are being performed, remember that the presence of moisture will avoid dust and aid in proper compaction. If a water truck or water source is not available, work should be planned after a rainfall if at all possible.

That brings us to the question of "how frequently do we blade or smooth the road?" We have already discussed the fact that the more we blade or smooth, the less often we will regrade or reshape, and the less often we will add new material. In other words, keeping the road in good condition by blading and smoothing prolongs the road's life while cutting maintenance costs.

So maintenance operations are performed "as needed" depending on a number of variables such as road type and condition, drainage conditions, the weather, and traffic volumes. How many storms have occurred since the last maintenance was performed? How severe was the storm? What's the traffic volume? Do we have a lot of truck traffic?

Special events may dictate needs, requiring maintenance work in preparation before the event to put the roads in good shape, or after the event to repair damage.

If we accept the “as needed” scenario, we must inspect the roads frequently. Routine inspections, supplemented by special inspections after major storm events, are essential to determining road needs and performing the required maintenance at the right time.

Equipment operators play key roles in road inspection. The operator can also take note of other existing problems on the road or roadside, such as damaged drainage pipes or broken delineators, while he is working on the roads. Operators should keep a notepad and jot down problems with location details so they can be taken care of later, but in a timely fashion to prevent any major problems or costs.

3-27 Operators should note existing problems.

Look at the photos in 3-27. These are samples of what an operator could notice and jot down a note so that maintenance repairs can be planned and the problems taken care of.

On a last note, Photo 3-28 depicts the “sign” of a professional equipment operator. He carries a shovel and is not afraid to use it.

3-28 Using a shovel is the sign of a “professional operator.”

3.7 Summary

We have seen how the dirt and gravel roads and their surrounding environment are deeply entangled with one another. We have also seen how poorly maintained roads contribute to erosion, pollution, and dust. By using appropriate materials and techniques, local governments can reduce pollution and maintenance costs at the same time.