Soil Stabilizers On Universally Accessible Trails

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INTRODUCTION

The Americans with Disabilities Act Accessibility Guidelines (ADAAG) state that ground and floor surfaces should be firm, stable, and slip-resistant. These three terms are not well defined and may be interpreted differently by many people. Not all ground surfaces need to be constructed for universal access, however when constructing a universally accessible trail, keep in mind that these three terms—firm, stable, and slip-resistant—are being used to define a trail surface that is easily traveled by individuals using canes, walkers, crutches, wheelchairs, or other mobility aids.

BACKGROUND

For the past several years, national forests around the country have been looking for ways to make areas more universally accessible, while maintaining a natural appearance that is not as distracting as concrete, asphalt, boardwalks, and other obviously manmade pathways. There are a number of products available on the market that claim to stabilize native materials used for trail surfacing without impacting the visual appearance of the surrounding area. Many of these products have been used all across the country with results that varied from extremely poor to very satisfactory stabilization. This report presents the results of the multi-year study, including the products and construction methods used.

In the summer of 1994, San Dimas Technology and Development Center (SDTDC) began the process of comparing stabilization products to determine their benefit under similar conditions. The Wood River Accessible Fishing Site and Day Use Area on the Winema National Forest was selected as the initial study site. The work took place during the summers of 1994 and 1995. The trail site is approximately 45 miles (72.4 kilometers) northwest of Klamath Falls, OR, and 15 miles (24.1 kilometers) from Crater Lake National Park. Summer high temperatures are 80 °F (32 °C) and the winter temperatures drop to below freezing (<0 °C), with up to 4 feet (1.2 meters) of snow covering the trail.

In December 1997 and May 1998, work was done on the Bell Rock Pathway on the Coconino National Forest. (See figure 1).

Figure 1. Equipment working on the Bell Rock Pathway on the Coconino NF.

The site is near Sedona, AZ, which is approximately 35 miles (56 kilometers) south of Flagstaff. The temperature during the summer months can reach 100 °F (38 °C), and in the winter months the temperature may drop to 15 °F (-9 °C), with only occasional snow cover.

The following products were applied to the trail surface:

Product Type	Product Brand Name
Pine Tree Resin	Road Oyl®
Enzyme	EMC Squared (EMC^2)™
Sulfuric Acid	Roadbond (EN-1)®
Latex Polymer	Soil Sement®
Ground Seed Hulls	Stabilizer®
Clay	Central Oregon Bentonite
Flyash	Class C Flyash

The products listed above were placed in sections constructed with coarse aggregate materials (3/4-inch minus; 19.05-millimeters minus) and sections constructed with fine aggregate materials (3/8-inch minus; 9.525-millimeters minus). Test sections were located in shaded areas as well as areas with full sun exposure. The various stabilizer products were added to the aggregate in place and mixed in with a rear-tined rototiller. The compaction was done by use of a vibratory plate compactor. Because the trail was only 48-inches (1.2-meters) wide and lined with timbers, it was not possible to use large equipment on the project.

A portion of the study project trail was also constructed using the macadam method. This method consists of placing geotextile fabric, covering with 1/2-inch (12.7-millimeters) pea-size gravel or chips, coating with oil emulsion, and a layer of blotter sand over the surface of the trail. Four control sections were also constructed, where water was added to optimum moisture levels and then compacted.

One of the concerns expressed by trail managers on the forests is that trail stabilization work needs to be easy enough that one supervisor may be able to direct the work of a volunteer group. The Wood River project took place over two summers and involved several groups of workers. The majority of the work was performed by 16- to 19-year-old youths through a cooperative agreement with Integral Youth Services, an Oregon non-profit organization. Some of the work was completed by members of the Winema National Forest road crew and some of the work by members of a Forest Service seasonal resource crew. The work at the Bell Rock Pathway was completed by a Forest Service seasonal work crew. It needs to be noted that none of the workers had ever worked with these products or done any soil stabilization work previously.

CONTROL SECTIONS

Four control sections were constructed during the summer of 1995 to provide a baseline for determining if the stabilizer products were of any benefit. Two sections were constructed using coarse aggregate and two with fine aggregate. One section of each size aggregate was located in the sun and one in the shade. Water was added to bring the aggregate to optimum moisture and the sections were then compacted. Within a few days, the sections located in the sun began to have surface raveling and as the moisture evaporated, the aggregate lost all evidence of compaction. The sections located in the shade also began to deteriorate as the moisture evaporated, but those sections lasted for a longer time. The shaded sections were located under a canopy of aspen trees. The following summer it was noted the leaves that had fallen on the trail helped to hold moisture in the soil and the leaves also provided a surface mat that was more stable than walking directly on the aggregate.

In August 1998, John Parker of Klamath Falls, OR (see figure 2) volunteered to assist the Forest Service by evaluating the various stabilized trail surfaces from the viewpoint of a wheelchair user. This evaluation was strictly a subjective determination of how one user perceived the trail. He used a medium weight chair with wider wheels than he would use in an urban area. The surfaces of the control sections located in the sun were soft, making it difficult to push the wheels of the chair. The chair did not continue to glide after each push on the wheels, and Mr. Parker found it difficult to turn the chair in these trail sections. The control sections located in the shade were firmer because of the mat of leaves covering the surface. Although the material did not appear to be stabilized (it was possible to use the edge of a boot to easily scrape away the aggregate), he found the shaded control sections to be very good surfaces for maneuvering the wheelchair.

Figure 2. John Parker evaluating stabilized trail surfaces.

PRODUCTS TESTED

Flyash

Flyash is a by-product obtained from the stacks of coal-burning power plants. The percentages of quicklime in the flyash depend on the type of coal that is burned at the power plant. Class C flyash was used on this project because it was expected to contain sufficient lime to provide some benefit. The flyash was mixed with both fine and coarse aggregates and in constructed sections of 3 percent, 5 percent, 8 percent, and 10 percent by dry weight. All of the sections were smooth and well compacted at the end of construction in September 1995. In April 1996, the trail was visually inspected immediately after the snow had melted. The surface was no longer firm and stable. It appeared that frost heave had lifted all of the surface material and created many air pockets under the surface. Walking on the trail was like walking on cotton, as each step was cushioned as body weight compressed the material. Foot traffic gradually recompacted the trail while there was still moisture in the surface, but as the summer dried out the soil the trail surface material was very loose and easily scraped away with the edge of a boot. The flyash was no better than the control sections, and it was decided at that time to do no further study with flyash because of the apparent difficulty in obtaining a uniform consistency of lime within the flyash.

The 1998 wheelchair evaluation of the trail surfaces found the sections constructed with flyash to be similar to the control sections. Those areas located in the shade under trees provided good traveling surfaces because of the leaves covering the trail. The areas located in the sun were dry and soft creating a difficult surface for maneuvering the wheelchair.

Bentonite Clay

The imported aggregate for construction of the trail had essentially no clay content. Bentonite clay has been used successfully for stabilization of timber hauling roads on the Deschutes National Forest near Bend, OR. In stabilizing these roads, it was determined that the best results occurred by adding between 3 percent to 5 percent bentonite clay into the surfacing material. If the material exceeded 5 percent bentonite the logging trucks lost traction when the surface became wet.

To avoid the possibility of a slick trail surface during wet weather, it was decided to add 3 percent bentonite by dry weight to the trail surfacing material. The bentonite was ground to a very fine texture and was shipped to the site in bags. The measured amount of bentonite was spread over the surface of the aggregate and mixed in with a rototiller. After the surface had been compacted it was firm and stable. The trail received very little use prior to being under snow for the winter.

After the first winter, the trail was visually inspected shortly after the snow had melted. The trail surface appeared similar to the sections constructed with flyash. Apparently, frost heave had lifted all of the surface material and created many air pockets under the surface. The surface recompacted somewhat under foot traffic, but the material was always uneven and loose during the dry summer months.

When John Parker evaluated the trail surfaces, he found the bentonite clay surface was soft, which made it difficult to push the wheels of the chair. The chair did not continue to glide after each push on the wheels, and he found it difficult to turn the chair in these trail sections.

It is possible that 10 to 15 percent bentonite clay for the trail surface may have been a better ratio. The 5 percent limitation on timber hauling roads is mainly because the heavy weight of the trucks forces the clay materials to the surface causing the slick roads. On a trail without steep grades or heavy vehicle traffic a larger percentage of clay may help to hold moisture longer and help to stabilize the other aggregate material.

Bentonite Clay With EMC Squared (EMC^2)

Earth Materials Catalyst (EMC), is a proprietary formula that contains biocatalytic proteins. EMC SQUARED (EMC^2) and Earth Materials Catalyst are trademarks of Soil Stabilization Products, Inc. There are several other companies that supply similar proprietary enzyme formulas for the stabilization of soils. Two other product names are Permazyme and Eco-Crete.

Bioenzymes require some clay content in the aggregate material in order to create the reaction that will strengthen the material. There are reports of successful stabilization with as little as 2 percent clay in the aggregate material, but best results seem to be achieved with 10 to 15 percent clay. For the project at Wood River Day Use Area, 3 percent bentonite clay was mixed into the aggregate prior to adding the enzyme product. Upon completion of construction, the trail looked very good, but like the other trail sections previously mentioned, it did not hold up over the first winter.

The trail was reviewed the first week of April 1996. There was still some snow remaining in the shaded areas, but the trail itself was free of snow. This section of trail was saturated with water, and it was apparent from the visible ruts that a wheelchair user had recently been on the trail. (See figure 3). Even though there were no obvious signs that a wheelchair had traveled from the parking area over the trail constructed with Road Oyl® (described later in this report), there were 1-inch (25.4-millimeters) deep ruts created by the chair wheels beginning at the start of the EMC^2 section and continuing through the entire length of the EMC^2 section. As the trail dried out through the spring and summer, the surface did not harden. Later in the summer, it was possible to easily scrape 2 inches (50.8 millimeters) through the surface with the edge of a boot. When John Parker did his trail evaluation, he found the trail to have a soft surface and it was not easy to push his wheelchair over. He felt that the surface was all right for a short distance, but he would not want to travel far on that type of surface.

Figure 3. Visible ruts on trail.

In December 1997, trail stabilization work was done at another Forest Service site. The Bell Rock Pathway is located near Sedona, AZ. Three enzyme products were used on this project which has greater than 50 percent clay in the aggregate. Though the nighttime temperatures were near freezing, it was decided to try these products because the winter rains were making the trail very muddy and slippery. The enzyme products used were Permazyme 11X, Eco-Crete, and EMC^2 used with Earth Materials Sealant (EMS), which is a latex polymer emulsion. All of the trail sections looked good after compaction, but they all became muddy and slippery with the first rain. It is possible that the products did not work because the nighttime temperature was near 25 °F (-3.9 °C).

Bentonite with Roadbond EN-1

Roadbond EN-1® is a patented liquid road base stabilizer that is mainly a diluted sulfuric acid that is labeled as a corrosive for shipping, storage, and handling. This product requires more personal protective equipment (PPE) than any of the other products used. A properly fitted respirator, goggles or face shield, elbow length rubber gloves, and a protective apron should be worn to protect from the fumes and possible splashing as you measure the product for dilution. (See figure 4). After the product has been further diluted prior to application, it is not considered a risk to work with or a risk to the environment.

Figure 4. Bentonite with Roadbond EN-1 being applied to trail. Note that the worker is wearing the required PPE.

This type of product has also been reported to work well with aggregate containing clay. Three percent bentonite clay was added to the aggregate at the Wood River project prior to application of the diluted Roadbond EN-1. The material was brought to optimum moisture levels and then compacted. As with all of the other products, the trail looked very good at completion of construction, but it did not hold up through the first winter. This trail section was adjacent to the bentonite with EMC^2, and had similar findings when reviewed in April 1996. The ruts caused by a wheelchair traveling across the EMC^2 surface continued through the length of the section constructed with Roadbond EN-1, and ended where the chair went onto a wooden platform built next to the river for fishing access. There was no visual evidence to show that the wheelchair user attempted to travel over any of the other trail sections. When John Parker reviewed the trail, he considered the section through the coarse aggregate to be extremely bumpy, with small rocks making it difficult to push the wheels. The section constructed with fine material was a good traveling surface for the chair, but it was still possible to easily scrape 2 inches (50.8 millimeters) through the surface.

In December 1997, Roadbond EN-1 was also used on the Bell Rock Pathway that had greater than 50 percent clay material. After completion of the construction, the trail looked very good, but it became very muddy and slippery with the first rain. It is possible that the product did not work at the Wood River site because of the low clay content, and that it did not work at the Bell Rock Pathway because of the below freezing temperatures.

Stabilizer

Stabilizer® is a patented, organic, and non-toxic product manufactured from the seed hulls of the plantego plant. The product is a light brown color and is ground to a very fine texture. This product will not stabilize materials over 3/8-inch in diameter, and the material needs to consist mostly of fines. Therefore, this product was not mixed with any of the coarse aggregate material. This product does allow surface raveling to take place, but because the tread surface material is 3/8-inch minus there are no significant rock obstructions to be encountered by physically challenged trail users. Since water will penetrate the surface, trail surfaces that are stabilized with this product will soften somewhat when exposed to moisture. As the moisture evaporates the surface will again become firm.

The product was very easy to apply. The Stabilizer was weighed to determine the correct quantity for the number of square feet being stabilized. Water was sprayed on the surface; the product was rototilled in with the aggregate material; and the surface was leveled and compacted.

Approximately 400 square feet (37.16 square meters) of fine aggregate at the trailhead area were stabilized in August 1994. Another 2,740 square feet (254.55 square meters) of trail were treated during August and September 1995. All of the treated sections have had similar results.

After the first winter the surface was never as compacted as it was at initial construction. Because the surface was not impenetrable, it was easy for seeds to establish root in the trail. Sections of the trail treated with Stabilizer have had significantly more vegetation growing in the trail surface than sections treated with other products. Immediately after the snow melt in the spring and after heavy rains, the trail surface is noticeably softer.

John Parker’s evaluation indicated that the Stabilizer trail sections located in direct sunlight most of the day were not as firm as sections that were located in the shade. Though the wheelchair did not create any wheel ruts in sunny or shaded areas, he felt that he needed to use more energy to keep the chair moving across the surfaces that were dried out by the sun.

Soil Sement

Soil Sement® is a latex polymer that is a by-product of the paint industry. Latex polymers are not considered to be long term stabilizers. When used to stabilize a road with heavy vehicle traffic, it may be necessary to frequently spray a maintenance application coat over the road surface to help hold the fines on the surface and eliminate dust. Even with low use roads or trails it is necessary to do a maintenance application coat every two to three years because the product will breakdown because of environmental conditions.

Latex polymers do not work well in aggregate containing clays, therefore no bentonite clay was added to the Wood River materials. Sixty percent of the recommended product quantity was diluted with water and sprayed over the aggregate and mixed in with a rototiller. After compaction, the remaining 40 percent of the product was diluted with water and sprayed over the trail surface to provide a heavier concentration of the product near the surface. After the first winter, it was possible to easily scrape through the top 2 inches (50.8 millimeters) of material with the edge of a boot.

The trail was constructed in September 1995, and the surface did not receive any maintenance application coats. When John Parker traveled over this section, he rated it the number two surface throughout the project area. The chair would continue to glide after each push of the wheels, and he found it easy to turn the chair as well.

Road Oyl

Road Oyl® is an emulsion formulated with pine tree resin solids in suspension. Road Oyl does not have any petroleum products within the emulsion. It is designed to be a cold applied product that works best as a pavement binder when mixed with dense graded aggregate materials. As the water evaporates from the emulsion, the surface will become very hard and will resemble an asphalt surface except for the color, which will usually be a darker shade of brown than the aggregate with which it is mixed.

Road Oyl was the most difficult of the products to apply. The barrels of Road Oyl were placed intermittently along the side of the trail so the product would be near the sections where it would be applied. A fire hose was used to spray water over the trail surface to prewet the aggregate materials enough to assist with the dispersion of the Road Oyl when it was spread over the trail surface. A hand pump was placed into a barrel, and 4 gallons (15.1 liters) of Road Oyl was pumped into a bucket. A similar bucket with numerous holes drilled through the bottom was placed at the trail section where the Road Oyl was applied. When the Road Oyl was poured from the first bucket into the second bucket, the trail worker quickly moved the bucket back and forth over the trail surface as the product drained through the holes. As the work crew spread the Road Oyl down the trail, another worker began mixing the product into the aggregate materials using a rear-tined rototiller. After thorough mixing, another worker used a garden rake to smooth the surface materials and create a slight crown in the center of the trail. The trail was then left untouched until the color of the surface materials changed from a yellow-tan to brown, indicating that the emulsion was breaking. Breaking is the stage at which the evaporation of water from the emulsion allows the binder to begin to coalesce. At this point, a vibratory plate was used to begin the initial compaction of the surface. A cloth rag with diesel fuel was wiped over the bottom of the vibratory plate to help prevent the aggregate from sticking to the surface. If materials did stick to the surface of the vibratory plate, it was an indication that there was still too much moisture in the trail surface, and more evaporation would need to take place before further compaction. Any materials sticking to the surface of the vibratory plate would need to be removed by scraping it clean. After compaction, the trail surface was allowed to continue to cure for two to three weeks, and then a surface seal coat was applied using a 3-gallon (11.4 liter) backpack weed sprayer. Because of the solids in the emulsion, the spray tip would plug-up after about 2 gallons (7.8 liters) had been sprayed. It was necessary to remove the spray tip and unplug the main spray openings by pushing a wire or nail through the hole.

After 5 winters, there has been one small section about 1 square foot (0.1 square meters) in size that has cracked and begun to flake up on one edge. This crack shown in figure 5 developed over the second winter, and no attempt to repair it was done in order to see if the area would get worse over time. It did not develop into a more serious defect, and it is expected that a repair could be done fairly quickly by removing all of the loose surface material, wetting the surface, mixing the proper amount of ROAD OYL into a “fine” aggregate, placing it into the damaged area, and compacting.

Figure 5. Crack that developed in trail after second winter.

John Parker’s evaluation rated the Road Oyl section the best surface within the project area. The Road Oyl surface was smooth and similar to traveling on a good asphalt surface. The chair was very easy to turn on all of the Road Oyl sections, and the chair continued to glide easily after each hand turn of the wheels.

Macadam

The macadam method of stabilizing a trail surface consists of a layer of non-woven geotextile covered with a 1/2-inch to 1-inch (12.7-millimeters - 25.4-millimeters) layer of aggregate chips or pea gravel that is lightly compacted with a landscaping roller. The aggregate is then coated with an asphalt emulsion at the rate of approximately 1.5 gallons per square yard (4.75 liters per square meter). The asphalt emulsion bonds the aggregate together, as well as adheres to the geotextile, which helps to disburse the weight of the trail traffic over a larger area. A thin layer of blotter sand can be spread over the surface to hide the black appearance of the asphalt.

After compaction of the base material, the geotextile was placed over the width and length of trail to be treated. The geotextile was pulled tight by anchoring the edges with nails that were pounded into the ground. When all of the fabric had been anchored in position, wheelbarrows were used to move the pea gravel from stockpiles at the trailhead. Garden rakes were used to spread the pea gravel over the fabric to a uniform thickness of approximately 3/4-inch (19-millimeters), and the aggregate was then rolled with a landscape (lawn) roller. The asphalt emulsion was immediately sprayed over the aggregate to avoid the possibility of the surface being disturbed prior to application. The following morning sand was spread over the surface to help fill in any surface voids and to hide the shiny black color of the trail surface.

The macadam sections of this project were completed in late September 1994. Over the years, most of the blotter sand had been blown off of the trail surface. (See figure 6). In August 1998, John Parker rated most of this trail very low because the exposed pea gravel created a consistently bumpy ride in the wheelchair. There was also a distracting crunching sound as the wheels traveled over the surface. Structurally the surface was very firm and stable, and with maintenance of the sand surface the problems of noise and bumpy ride for a wheelchair user would probably be resolved.

Figure 6. Macadam surface with blotter sand blown away.

SUMMARY

The coarse and the fine aggregate control sections located in the sun both failed in a matter of days as the water used for compaction evaporated. These two sections never improved. Both the coarse and fine aggregate control sections in the shaded area failed when the water initially evaporated from the compacted surface. Three years after construction it was still possible to use the edge of a boot to easily scrape down 2 inches (50.8 millimeters) through the surface. However, John Parker's evaluation of these two sections indicated that they were very good from the perspective of a wheelchair user. The location of these sections under a canopy of aspen trees provided a mat of leaves over the trail which made it easier to travel across the surface, and the leaves also helped to retain moisture in the aggregate materials.

Three percent bentonite clay was not an effective stabilizer on any of the trail sections. Those sections that were in the shade were under a canopy of pine trees and did not get the benefit of fallen leaves to help hold in moisture.

The trail sections constructed with enzyme product EMC^2 and sulfuric acid product Roadbond EN-1 did not noticeably stabilize the aggregate materials at all. Both of these types of product claim to work very well when mixed in with clay. They did not work with 3 percent clay at the Wood River project and they did not work with greater than 50 percent clay at the Bell Rock Pathway. At the end of the first winter snowmelt, a wheelchair had left a 1-inch (25.4-millimeters) deep rut as it traveled across both of these sections at Wood River.

Flyash did not perform any better than the water/compaction treatment the control sections received. The 3 and 5 percent flyash sections were under an aspen canopy that helped improve the trail surface with a mat of fallen leaves. The 8 and 10 percent flyash sections were in the sun and had a very soft surface that was difficult to push a wheelchair over.

The product Stabilizer, which is made from ground seed hulls, stabilized marginally better than the water/compaction method for the control sections. This product allows water to permeate through the surface when it gets wet. The aggregate material will get firmer again as the material dries out. This product has worked well in very dry climates, such as Arizona and New Mexico, but it did not work well at the Wood River Day Use Area in Oregon.

The latex polymer product Soil Sement was applied in September 1995, and was considered to be the second best surface by John Parker in his wheelchair evaluation in August 1998. If this surface was to receive regular maintenance coatings it may hold up for a number of years.

The pine tree resin emulsion product Road Oyl was the most expensive and the most difficult to apply, but it provided the best surface for universal accessibility.

The macadam construction method did provide a firm surface though there was a considerable amount of surface raveling of the pea gravel. Regular maintenance of the blotter sand top surface may solve the problems of raveling, noise, and bumpy ride.

CONSTRUCTION TIPS

Reduced budgets for construction and maintenance of trails is an ongoing concern for all public agencies. Soil stabilizer products are not magic potions that will solve budget concerns. Do not think that the use of soil stabilizers will relieve the responsibility of doing a thorough engineering design. In October 1995, SDTDC published an initial report on the subject "Soil Stabilizer For Use on Universally Accessible Trails." That report discussed the importance of following good construction practices. The necessity of this cannot be over emphasized! A properly designed trail is essential, and is especially important regarding issues of water. Water can cause a great deal of damage to a trail in a number of ways: erosion across the trail or down the length of the trail; subsurface water causing the trail to fail from underneath; and surface water penetrating voids or cracks in the trail surface that will allow vegetation growth or may cause freeze/thaw damage.

Many people believe that the use of a soil stabilizer product will allow them to apply the product directly to the in-place native material; compact; and the trail is finished. This can be done, but it is NOT recommended for a number of reasons:

> If the native material is treated and compacted, it will often times create a trail that is lower than the surrounding ground. This will direct water onto the trail that can cause damage to the surface and possible erosion depending on the trail grade.

It is better to remove several inches of native material in order to compact the base material to help prevent the possibility of subsurface failure of the trail. After compacting the base, it is necessary to bring in enough aggregate to be sure that the finished compacted surface will not be lower than the surrounding ground.

If there is a concern about the possibility of vegetation growing up through the trail, a barrier of filter cloth or heavy black plastic should be installed below the trail surface. This can be done after removal of native surface material and compaction of base course and prior to importing the surface material.

Imported fine aggregate will be more consistent in its gradation and composition, which will allow for uniformity in the application of the stabilization product.

To achieve a firm and stable surface it is recommended that one use fine aggregate (3/8-inch minus; 9.53-millimeters minus), rather than coarser aggregate that can cause problems for individuals using mobility aids. If a surface with coarse materials has any raveling, the loose surface rocks can make it very difficult to turn the wheels on a chair or walker. Loose surface rocks can also make placement of canes or crutches very difficult. (See figure 7.) Two types of fine aggregate material that are not suitable for accessible trails are sand and pea-size gravel. Both of these materials create surfaces that are very difficult to move a wheelchair across. Sand does not have any large particles (1/2-inch, 12.7-millimeters) to help keep the wheels from sinking into the soft surface, and pea-size gravel does not have enough interlocking surfaces or any fine material to give the pea-size gravel stability. A well graded mixture from 3/8-inch (9.53-millimeters) down through the very fine material is what is needed.

Figure 7. Coarse materials and loose surface rocks make it difficult to turn the wheels on a chair or walker.

SOURCES OF INFORMATION

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FHWA-FLP-92-011; July, 1992
U.S. Dept. of Transportation, Federal Highway Administration
Office of Direct Federal Programs
Washington, D.C. 20590

Available to the public from:
National Technical Information Service
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Soil Stabilizer For Use On Universally Accessible Trails
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