Drainage. One-half the runoff from the pavement drains across the shoulder and sidewalk area and down the slope.

Composition of embankment. Sand and gravel, 97 percent. Clay, silt, colloids, 3 percent.

Treatment of surface. Topsoil was placed 4 inches thick in a 10-foot wide strip next to the shoulder. This was fertilized, limed, seeded, and mulched. The remaining slope area 50 to 60 feet wide was left untreated. There has been very little erosion on the untreated portion even though the runoff from half the roadway flows across its surface. There is no tidal or wave action along this fill except during extremely high tides which might occur during a storm. To date, no damage has resulted from this condition.

There has been some blowing of sand as evidenced by a layer about $\frac{1}{4}$ inch thick deposited evenly over the topsoiled areas. Since this process will eventually destroy the grass areas and create shoulder maintenance problems, it is felt that native vegetation consisting of bayberry, beach goldenrod, Baccharis, and beach grass should be planted further to stabilize the sand.

The above illustrations represent three general types of slope treatments involving extremely sandy conditions.

At Brielle, topsoil was readily available. Its use along with fertilizer, seed, and hay mulch was most successful.

At Toms River, the use of a soil supplement in the form of peat and muck also resulted in success. In this case, however, the need for additional fertilizer is now evident in some spots.

At Wildwood, the sand slopes were flattened to a ratio of 12:1 and left untreated. Erosion from water runoff has been negligible; however, there is a small amount of wind erosion which indicates the need for vegetation on the slopes.

SEEDING and EMULSIFIED-ASPHALT MULCHING on ROAD in NORTH CAROLINA

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● THIS section of US 421 runs from US 17, west of Wilmington, N. C., northerly approximately 15 miles. It was completed in the latter part of May, 1953. With the exception of 2 miles on the north end, it runs through pure white sand ridges, with the height of some of the cuts exceeding 20 feet.

It was realized during construction of this road that erosion of this sand, both by wind and water, would have to be controlled quickly if any shape was to be maintained on the shoulders, fill and cut slopes, and ditch lines. Not only would a heavy rain wash the sand away, but both natural wind and wind from traffic would move it around.

At first it was planned to seed all areas and then mulch cut slopes over 4 feet in height with straw, which is the standard procedure in North Carolina. After further study it was apparent that to use straw would be extremely dangerous from a fire-hazard standpoint as this road runs through an undeveloped wooded area. Also, the amount of straw necessary to do this job was not available. In seeking other means of controlling erosion on this job, a report from a project in South Carolina was found which told of using emulsified asphalt for mulch. It recommended using this material as mulch only in cool weather, over topsoil which had

Figure 1. Sand slopes on Negro Head Road in North Carolina.

Figure 2. A hydraulic seeder was used for seeding and fertilizing.

Figure 3. This type of weeder, pulled by a Ford tractor with crawler treads, was used to cover the seed.

been wet down with water to assure good penetration. This could not be done on this job because of the season of the year and the area involved, but it was felt that asphalt sprayed on the sand cuts would be worthwhile as it would stop the wind and water erosion.

Another problem encountered while planning this work was getting machinery to stand up on the sand cuts to get the seed and fertilizer in the ground. It was realized that regular seed drills, and lime distributors would only slide down the cut slopes and do a great deal of damage to the slopes. In studying other equipment with which to do this work, it was decided to try a hydraulic seeder developed and used by roadside crews in the western part of the state. The seeder mixes seed and fertilizer with water and sprays it over the area to be seeded, under high pressure. After talking about the problem with the men who developed this machine, they felt that it would seed the areas as well as spread the emulsified asphalt.

Seeding of this road was started on May 25, 1953, using the hydraulic seeder. Sudan grass at 1½ lb. Korean lespedeza at 1 lb., and 6-8-6 fertilizer at 20 lb. per 100 sq. yd. were applied to all areas. The hydraulic seeder spread this mixture of seed and fertilizer over the areas very evenly, and in wide areas, it was able to seed 100 feet from the edge of the pavement.

No seedbed preparation was necessary because of the sandy soil. The seed was covered by using a Ford tractor (with crawler treads) pulling a heavy section harrow, or weeder. After starting to apply the mulch, it was found that on the cut slopes the ridges left in the sand by the section harrow were undesirable, as the mulch covered the front side of the ridge but the back was not covered. Thereafter another crawler-type tractor was used to pull a heavy board drag to smooth the soil before applying the mulch.

Mulching was started on May 28, using AE-5 emulsified asphalt at the

Figure 4. A board drag smoothed the sandy area before asphalt emulsion was applied.

rate of 0.2 gal. per sq. yd., which was the rate recommended. To obtain better penetration, an equal amount of water was added to the asphalt, which made a total application of 0.4 gal. of the mixture per sq. yd. The Emulsified Asphalt Company of Wilmington, from whom the material was bought, and their representative, Mr. Davis, were very helpful throughout this job. They added the water to the asphalt at the plant, thus saving considerable time. It was found soon after starting to mulch that a crust was forming, because of the dryness of the sand and the temperature of the weather. There had been no rain on this section in several weeks and the temperature was between 85 and 90 F. Several cut slopes were sprayed with water before the asphalt application, but the sun dried up the water before the asphalt could be applied. The rate of application of the mulch was reduced 50 percent with the expectation of making a second application after it rained, but no rain came. The job was completed with the revised application, as it was planned to reseed in the fall and it was felt that the reduced application would hold the slopes until that time.

After the job was completed and all areas measured, it was found that 512,000 sq. yd. had been seeded and 134,000 sq. yd. mulched at a cost of $0.0143 per sq. yd. for seeding and $0.0155 per sq. yd. for mulching.

This job was checked regularly through the summer of 1953 to observe results. The shoulders, fills, and unmulched flat areas had a good germination, while on the mulched slopes there was poor germination. The reason for this, it was discovered, was that the layer of asphalt on the cuts absorbed the heat and held it in the cut slope, even at night, destroying viability of the seed or burning seedlings. The soil under the asphalt was checked several times with a thermometer on clear days and it was found to be 10 to 15 degrees hotter than the areas with no mulch.

It is felt by all persons interested in this job that, even though very little vegetation was obtained on the mulched areas, the application of mulch was well worthwhile as very little erosion by wind or water occurred in the mulched areas through the summer and autumn of 1953.

The reseeding and remulching with emulsified asphalt was started on December 7, 1953, slightly more than six months after the summer cover-crop seeding. It was decided not ro reseed the large cut slopes to their full width because it would disturb areas that were under control by the summer

Figure 5. The hydraulic seeding machine applied asphalt emulsion on distant areas.

application of mulch. This would also reduce the cost of the reseeding. It was felt that if an area 40 feet wide on each side of the road was stabilized with grass it would give a very pleasing appearance to the traveling public and that the areas beyond this point could be maintained by asphalt mulch alone.

Figure 6. Asphalt emulsion is applied to areas nearer the highway.

The only operation necessary for fall seeding, other than that done for summer seeding, was pulling a peg-tooth harrow over the areas that were previously mulched, in order to break up the crust formed by the summer application of asphalt mulch. Seeding and mulching were done with the same equipment as the summer seeding except that a seed drill was used to apply the seed and fertilizer on all areas on which it could operate, which included shoulders, slopes to ditch, flat areas, and cut and fill slopes 4:1 and flatter. The hydraulic seeder was used to seed the steeper cut and fill slopes and to apply asphalt mulch on the cut slopes and other areas subject to wind and water erosion. All areas were seeded with rye grain at 2 lb. Korean lespedeza at 1½ lb., and fertilizer at 20 lb. per 100 sq. yd.

Emulsified asphalt was obtained from the same source as during the summer, and the water was added at the plant. Mulching was started using a 50-50 mixture of water and AE-5 emulsion and applying 0.4 gal. of the mixture per sq. yd. It was found that this mixture was forming a crust, and so the mixture was cut to 25 percent asphalt emulsion and 75 percent water. The same rate of application of 0.4 gal. of mixture per sq. yd. was continued; the mixture penetrated 1 inch and did not crust. All seeded cut slopes were mulched, plus the areas of the unseeded cut slopes that look weak.

Figure 7. The rye cover obtained, following winter reseeding and remulching.

A weekly inspection of this work was made to observe results. Good germination was obtained on all areas, and it began to look as if a perfect cover was going to be obtained. During the second and third week after germination it was noticed that the rye on the cuts seeded by the hydraulic seeder was dying, while the rye seeded with the drill was doing fine. A study of this condition was made and it is believed that this was caused by the following conditions: Since these seed were planted in sterile sand, the only plant food obtainable was the fertilizer applied at time of seeding. This fertilizer was dissolved when applied by the hydraulic seeder and spread evenly over the ground. When harrowed in, it was scattered even more. Any rain that fell carried it deeper into the ground, thereby reducing the amount

available for the plant roots. After germination and before the roots developed enough to collect this scattered plant food, it is believed that the plants starved. The cover on the areas seeded with a drill, where the seed and fertilizer were placed together in the ground, continued to grow well for eight weeks, at which time it started browning. These areas were topdressed with 6-8-6 fertilizer at 20 lb. per 100 sq. yd. The grass started growing again and has gone through the following seven months in good condition. As of October 18, 1954, all areas seeded with a drill have practically a 100 percent cover.

It was noted during this time that on the mulched areas the grass was greener and grew faster than on the unmulched areas. No erosion has occurred on mulched areas, regardless of whether grass was obtained or not.

It is now felt that emulsified asphalt has a definite place in soil erosion-control work. No set rule can be given for amounts to be applied, as soil and weather conditions are the controlling factors. The 25 percent asphalt emulsion and 75 percent water mixture seems to be the best for sandy soils when applied during cold weather. During the months following this work, the asphalt has penetrated deeper into the soil and whitened on the surface as the rains leached it out. As of this date it has not leached enough to cause any movement of sand. This project came through "Hurricane Hazel," with its high winds and heavy rains on October 15, 1954, with no damage from either, except that some small areas of the crust formed by the initial application were torn off by the wind. The reseeded and remulched areas suffered no damage whereas similar jobs in the path of the hurricane on which straw mulch was used were severely damaged by the wind.