BITUMINOUS EMULSION STABILIZED ROADS

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The preliminary research on this subject, carried on during the development of the process, revealed certain theories and laboratory design tests which have remained throughout the later field development, without appreciable change. There are numerous published articles discussing these phases of the process, so they will be only briefly discussed here.

In general, it was found that a small amount of asphalt in the form of a properly manufactured emulsion, when mixed with clay bearing soils or aggregates, and allowed to dry, entirely changed the former characteristics of the materials. Otherwise unstable soils were found to become stable in the presence of water to the extent that they could safely be used as a pavement foundation, where normally they would have been discarded in favor of imported aggregates. Treated soils were found to have lost their great affinity for water and to remain stable against displacement under the most adverse conditions. Even some materials which, after treatment, took up considerable moisture, were found to retain a large portion of their dry strength.

A careful laboratory study of the phenomena disclosed that the minute asphalt particles dispersed in the emulsion, were intermingled with the soil colloids during the mixing process, and that when the water evaporated these particles were pulled out into thin asphaltic films which, by coating the soil grain surfaces, caused them to become water repellent. In other words, soil colloids which had a cementing value, due to the presence of an adsorbed film of water, were caused to retain, instead, an absorbed coating of asphalt which resisted water infiltration. When attempts were made to remove the asphalt coating from the soil grains, it was found that the asphalt, under the tremendous force of adsorption, had become almost a part of the soil itself, to such an extent that only a small portion of the asphalt could be recovered with the usual solvents.

As research continued, it became apparent that the amount of asphalt required by this process was rather critical. Too small an amount did not render the soil sufficiently water resistant, and too great an amount, still much below the usual binding quantities, lubricated the soil so that it began to lose natural stability. Tests were, therefore, devised for measuring the efficiency of the treatment: one, called the capillary absorption test, which measured the resistance to capillary absorption of water; and the other, the so-called "stability test," which measured the resistance to plastic flow within the treated material after it had absorbed as much water as it would.

It was first thought that soils gained stability in the treatment only because they remained substantially dry, but the stability test developed that the presence of the asphalt had increased the stability, even where water contents were equal. These two tests proved both simple and dependable, so they have been used since their development, for the control of most of the emulsified asphalt stabilization work which has so far been constructed.

In designing mixtures, an amount of emulsified asphalt is selected which, in the tests, shows the greatest benefit in furnishing both waterproofness and stability. This amount is kept between the minimum required for water resistance and the maximum allowed before loss of stability occurs. The range between these two points is broad enough so that field operations are not too sensitive and it is possible to construct very satisfactory work with only sufficient control to assure that the quantities fall within this range.

Typical results of tests on treated and untreated soils and aggregates indicated a wet strength usually many times greater in the treated than in the untreated material. Materials which normally lost practically all of their bearing strength when they became wet were found, after treatment, to maintain a large portion of their dry strength under identical conditions. Selected blanket materials of the clay bearing gravel, or crusher run rock variety are definitely improved by stabilizing. Field practice has indicated in numerous cases that 6-in., 8-in., or 10-in. stabilized blankets may be safely substituted for 12-in., 18-in. and even 24-in. untreated blankets over bad subsoils, because they can be depended upon to maintain a satisfactory load distributing power at all seasons of the year.

WHERE TO USE

To date, the greatest use of soil stabilization with emulsified asphalt has been in the stabilization of existing soils or soil gravel blends to make them suitable for a foundation for light wearing surfaces on highways, streets and airports. This use proved economical, as otherwise the existing soils would have had to be replaced with more suitable materials.

The next greatest use has been in the treatment of cementitious quarry fines and clay gravels of better quality to improve their dependable load supporting power, thereby making a lesser thickness of the imported material necessary.

DESIGN

Mixtures can be very satisfactorily designed by using the aforementioned tests for capillary absorption and stability. The amount of emulsion required to properly treat a material usually varies in about direct proportion to the amount of fines present in the soil. Naturally, the fines have a far greater surface area than the coarser materials, and require the greater percentage of asphalt if it is to act as a continuous coating. For this reason, it is sometimes cheaper to add imported gravel, sand or crusher run rock to the existing soil in order to reduce the amount of fines, thereby reducing the amount of emulsion required. This is usually good practice, also, because it improves the workability of the mixture, making it necessary to use less water in the mixing process, and allowing the mixture to be more readily handled with normal construction equipment.

A careful preliminary survey of the available materials, therefore, sometimes allows savings to be made and also improves the quality of the mixture.

After the most suitable materials have been selected, and the mixture properly designed, it becomes necessary to design the pavement so that there is some assurance that no loads will be transmitted to the sub-soils which cannot be properly supported by them. In practical stabilization work, as in most of the other types of pavement design, too much guess work has been resorted to when more scientific means should have been developed. There is not nearly enough known about how to design pavements for thickness and load-bearing properties. The lack of this knowledge has resulted in failures of all types of pavements, and this has also been the case with pavements in which soil stabilization with emulsified asphalt has been used. There is considerable room for further research in the field of pavement design.

A well stabilized foundation course seldom requires more than a thin asphaltic wearing surface to withstand the ordinary types of traffic. An adequate thickness of stabilized material satisfactorily distributes the wheel loads to the sub-soil, and because it remains firm and unyielding at all seasons of the year, it can be depended upon to support relatively thin wearing surfaces.

EMULSIFIED ASPHALT

The type of emulsified asphalt used in soil stabilization is very important. This type of soil stabilization could not have been developed had it not been for the improvement in emulsified asphalt design and manufacture in the last six or eight years. Prior to that time, the mixing type of emulsion consisted of asphalt suspended in soap solution and was too unstable to mix with fine aggregates without coagulation, thus causing poor results. The quick-breaking type of emulsion, while perfectly satisfactory for penetration macadams and similar work, was not stable enough to resist breakdown when mixed.

The emulsion used in soil stabilization work must be one which is stable enough to withstand any degree of mixing with the finest of aggregates, some of which even contain electrolytes. Another very important characteristic is that the emulsion must be such as to insure the asphalt being present in particles of microscopic and sub-microscopic size. Without this fineness, the asphalt particles would be too widely dispersed throughout the mixture to be of material benefit as only a portion of the soil colloids would be coated.

Emulsion must also have the property of allowing unrestricted loss of moisture from the mixture after it is laid, as otherwise the work would be greatly delayed in setting.

CONSTRUCTION

Probably the most important construction items are proper mixing, adequate compaction, thorough drying and proper surface protection. These will be taken up separately.

Although many types of mixing equipment and methods have been used successfully in emulsified asphalt stabilization work, the trend is now toward the use of traveling mechanical mixers (Figures 1, 2, 3) which, while traveling on the road, mix the aggregate thoroughly with water and emulsified asphalt, and lay it out ready for shaping and rolling. There are several reasons for the popularity of

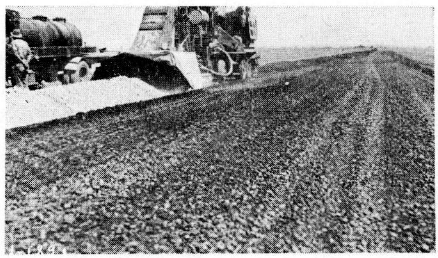

Figure 1. Traveling Road-mixing Plants Are Now Generally Used on Large Projects. They are very efficient and give very low costs. This machine picks up the material from a sized windrow, adds the diluted stabilizer and deposits the finished mixture.

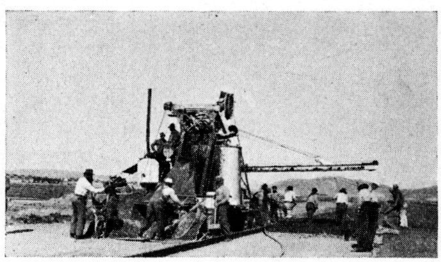

Figure 2. An Emulsified Asphalt Stabilized Runway Being Constructed with 27E Concrete Mixers. The base mixture is being spread between headers.

this type of equipment, namely: economy; speed; successful control; uniformity of results; and better mix consistency. Such equipment, because it furnishes powerful and positive agitation, makes it unnecessary to use the quantities of water formerly required by the less efficient mixing methods. Mixing can be carried out with very little water if the force exerted in the mixing is sufficient to handle the material in this form. The mixture must be lubricated with more water, however, if less powerful equipment is used. Stabilized mixtures require thorough drying, or removal of the water before they set up and become hard. By reducing the amount of water necessary to the formation of the mixture, drying is much more rapid and the road can therefore be finished much sooner. It is not unusual to find one of these machines able to mix thoroughly from 200 to 225 tons of material per hour, under normal operating conditions.

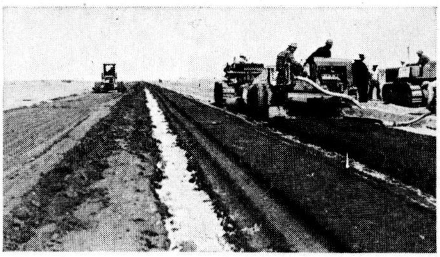

Figure 3. This Photograph Shows Another and Very Efficient Type of Road-mixing Machine.

Where the aggregates are to be imported a stationary mixing plant of the pug type or rotary drum type can be used to advantage. The use of such a setup makes road mixing unnecessary as the completed mixture can be delivered ready for spreading and finishing.

Some jobs are still being constructed by the older methods of using blades and harrows, and some are still being constructed by the even more primitive method of hand mixing and laying. The process is equally workable under all of these conditions, but where possible, the more up-to-date mixing equipment is preferable.

Spreading of the stabilized mixtures is still largely done by blades, although some of it has been done through mechanical spreaders. It has been found advisable to limit the thickness of spread so that drying is rapid. Two lifts of 4 in. each will dry much more rapidly than will one 8-in. layer. For this reason, it is well to place a heavy stabilized pavement in two or more layers (Figure 4), and allow each to dry before placing the next one. Materials mixed by mechanical mixers are usually spread out and rolling started immediately behind the mixing operation. Rolling with sheepsfoot rollers has proven advisable, as it not only insures maximum compaction, but also assists in drying the materials. After the sheepsfoot roller rides to the surface (Figure 5), the rubber-tired roller is substituted, and rolling is continued with possible watering until a dense, smooth surface is obtained.

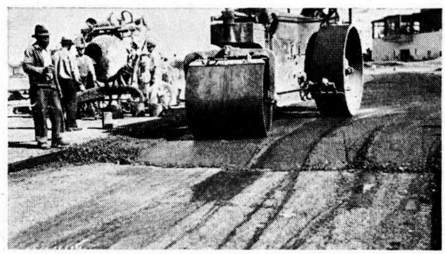

Figure 4. Lakeside Drive in Oakland, California, Is Built over Unstable Subgrade Dredged from Lake Merritt. In 1937 the City constructed a 12-in. quarry waste base, stabilized with emulsified asphalt. The base was mixed in the concrete mixer here shown. This picture shows the last layer being compacted by rolling and the previous layer in the foreground.

Drying of the stabilized materials is of extreme importance. As mentioned previously, it is the loss of water from the mixture which pulls the asphalt out into the form of a coating for the soil particles. Without this drying, stabilization never becomes fully effective, the process merely remaining quiescent until drying eventually does occur. It is, therefore, necessary that great care be given to the final drying of the stabilized pavement, and to assist this drying, several methods of construction have been devised and have proven very successful. The surface of the work usually dries very rapidly, and it is not with this portion that delays occur. It is the bottom of the stabilized slab which usually rests on a moist, or sometimes wet, subgrade

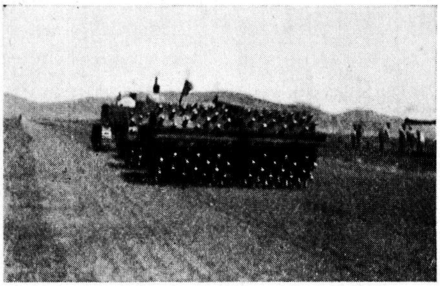

Figure 5. March Field, California. After the base mixture is spread it is compacted with the sheepsfoot roller here shown until the roller rides out on the surface. It is then finished with a flat roller, and is ready for the dense-graded emulsified asphalt surfacing which is similarly mixed in concrete mixers and spread by hand.

that requires considerable time to dry and harden. Most subgrades contain so much moisture that they supply water to the mixtures almost as rapidly as it can be evaporated through the surface. Under conditions of this kind, it is naturally advisable to prevent as much of this capillary movement of water from taking place as possible. One of the best means for doing this is to spread a thin layer of stabilized mixture on the subgrade, first, and allow it several hours to harden and dry. The other material can then be spread over this layer, with the assurance that the dried material is already stabilized to the point of acting as a water cut-off at the bottom of the slab.

This method cannot always be used, particularly in regions where rains may occur at any time, as such construction is usually carried on by the trench method and it would provide a fine reservoir for water in case of rain. For this reason, the surface of the subgrade is sometimes primed with emulsified asphalt, cutback, road oils or tars immediately before spreading the stabilized mixtures. Materials are generally used which will almost immediately penetrate into the surface of the subgrade, thereby making protection from the construction traffic unnecessary.

When these methods have been used, it has been found that the pavement is not only dried more thoroughly and is therefore more thoroughly stabilized, but that the drying has also been found to take place in much less time than is necessary when moisture is allowed to enter the bottom of the mix. The use of this method insures the complete stabilization of the entire thickness of the stabilized blanket layer, and thereby assures the development of as much foundation as possible.

Stabilized foundation courses are not designed to carry traffic without surface protection. The mixtures have only the amount of asphalt necessary to develop their highest stability, and this amount of asphalt is considerably below the amount necessary to prevent raveling under traffic. For this reason it is necessary in all cases, to cover the stabilized layer with an adequate surface course so that raveling is prevented.

Surface courses of well-bound and thoroughly stable nature, 1 in. or $1\frac{1}{2}$ in. thick, have been found adequate under most conditions, although in some cases 2 and 3-in. surfaces have been used. In all cases, however, the type of surface should be one which protects the pavement from surface leakage. Emulsified asphalt stabilized foundations are usually designed for resistance to capillary water, and not to surface water. They can be designed for submersion, if necessary, but a more carefully controlled mixture is necessarily used to control more closely the amount and size of voids. This is always done when the stabilized material will be subjected to submersion, as in reservoirs or in roads which are subjected to periodic flooding. These conditions require the use of considerably higher fines contents than normally used in pavement design, resulting in the necessity for more emulsified asphalt for complete stabilization. It is always preferable and more economical, therefore, to design pavements to resist capillary water and to seal the surface against leakage.

One very satisfactory method used extensively of late, has been the application of a penetrating prime coat to the surface of the stabilized base as soon as it has become thoroughly dry and hard. This treatment forms an enriched layer on the surface of the stabilized material which provides protection against water infiltration. This penetration application can then be covered with light dense wearing surfaces, with the assurance that leakage will give no difficulty. Where the dense graded asphaltic mixtures are used as a surface course, the prime coat is sometimes dispensed with, but in most cases it is recommended, if only to tie down any dust on the surface of the base which might not allow a satisfactory bond between the foundation course and wearing surface.

A very economical thin surface treatment for light traffic roads can be constructed by the use of a high viscosity quick-breaking emulsion which, when covered with stone chips, forms a resistant and non-skid wearing course. Many jobs have been recently constructed with this type of wearing surface and have proven quite satisfactory. Such a treatment is always placed over a penetrating seal coat such as previously described.

A very satisfactory and economical asphaltic concrete wearing surface for heavy traffic duty can be constructed by mixing enough well graded aggregate with emulsified asphalt in place, to result in a wearing surface 1½ in. to 2 in. in thickness. The great capacity of the traveling plants makes it possible to obtain this high type of wearing surface at very low cost.