ASPHALT EMULSION STABILIZATION ON CAPE COD

By A. V. Bratt

Testing Engineer, Massachusetts Department of Public Works

The geological formation of Massachusetts is such that for most of the state soils stabilization is not vitally essential. Crushed stone and gravel are generally plentiful and as a result the practice has developed of replacing all undesirable material rather than improvement by means of stabilization. This practice has been found financially sound and the economic advantage of stabilized bases as experienced by other sections of the country has been materially reduced.

Cape Cod, however, is one section of Massachusetts that does not follow the general rule. Here we find a peninsula jutting out some 75 miles from the mainland in the form of a hook. Provincetown, the first landing place of the Pilgrims is at its tip and across Massachusetts Bay and sheltered by its presence is located Plymouth with its wealth of historical background. Unlike the rest of Massachusetts, however, whose geology is greatly influenced by glacial deposits, Cape Cod has been formed by the motion of a sea. Based upon the same principle involved in the construction of hydraulic fill earth dams, Cape Cod probably has its core of silt and plastic materials as evidenced by the few outcroppings of clay deposits. These are far below the surface, however, and from a practical standpoint it is an area of fine sand, poorly graded, with no deposits of stone and gravel and negligible deposits of soil binder. There is a slight deposit of top soil which might be classed as a very sandy loam but this material has a plasticity index of 0.

It has been the practice in the Cape Cod section to construct pavements consisting of plant mixed bituminous concrete known in Massachusetts specifications as Type A. It consists of a mixture of local sand, ($5\frac{1}{2}$—8 per cent) asphalt with a small addition of stone screenings. This material was not always highly stable but with a low cost of production, it was possible to use a $5\frac{1}{2}$-in. thickness and obtain satisfactory stability.

With the introduction of higher grade bituminous concrete composed of mixtures of well graded crushed stone, sand, filler and asphalt classified by the Bureau of Public Roads as Type I, this cost was materially increased. The use of $5\frac{1}{2}$-in. of Type I bituminous concrete was not economically possible in the secondary road system of this section and it became necessary to design a base sufficiently stable that a $1\frac{1}{2}$ to 2-in. layer of Type I would be adequately supported to give satisfactory stability under heavy summer traffic. Sand bound and penetrated crushed stone bases were both found satisfactory for primary roads, but, the cost of importing the stone unbalanced the construction cost on secondary roads. The next consideration was stabilized bases and although the best type of stabilization has not been decided upon, there is little doubt that stabilized bases will play an important role in construction methods on the Cape Cod secondary road system.

The first experimental project consisted of a short section of new construction in a cut off running from the easterly end of the Bourne bridge across the Cape Cod Canal to a location known as Trading Post Corner. The base material while it contained a higher percentage of material passing a No. 200 sieve than is usually the case with Cape sands, was typical in its behavior of base material throughout the Cape. The only available binder was top soil which had a zero

plasticity index. Because of the lack of natural binder, it was decided to combine these materials to give a high percentage of material passing a No. 200 sieve. It was also considered advisable to use a binder which would tend to lessen the permeability of the mixture which because of its high silt content was moderately permeable and subject to loss of stability due to absorption of moisture. After some experimental work with several binders, asphalt emulsion was decided upon for this particular project but with the plan in mind to carry on further investigational work with other binders on future projects of this nature. The grading of the base material,

TABLE 1

Sieve	Sand Used in Bourne Base	Top Soil at Bourne	50-50 Mixture at Bourne	Typical Cape Sand Grading
Retained on No. 10	3.0	0.0	1.2	21.0
Pass. No. 10 Ret. No. 60	53.0	39.5	46.3	72.0
Pass. No. 60 Ret. No. 200	24.2	26.0	25.1	6.4
Passing No. 200	20.2	34.5	27.4	0.6
Plasticity Index	0	0	0	0

top soil binder and the resultant mixture of equal parts of these materials is given in Table 1. We are also including the grading of a sand more typical of material generally occurring throughout the Cape.

Laboratory stability tests were made with the Hubbard-Field Asphalt Stability Machine. Briquettes moulded at room temperature but otherwise in the method recommended for this apparatus gave results as follows:

	Lb. Stability
2½% Asphalt Emulsion	2930
3% Asphalt Emulsion	3350
3½% Asphalt Emulsion	3950
4% Asphalt Emulsion	4025

Absorption tests made on the samples showed that with this silty mix, it was not feasible to reduce absorption as low as would be possible with better graded aggregate and greater percentages of bitumen. It was found, however, that this absorption did not seriously affect the stability of the mix. Briquettes made up without the asphalt emulsion binder absorbed water rapidly and lost stability in a very few minutes. The results of absorption tests on the above series of briquettes are as follows:

Asphalt Emulsion Used in Moulding Briquettes	Absorption after 24 Hours Average of 3 Samples
2½%	9.6%
3 %	9.5%
3½%	8.9%
4 %	8.3%

For economic reasons 3½ per cent to 4 per cent asphalt emulsion was decided upon as it gave satisfactory stability even when wet. The absorption of this mix was somewhat high but as this section of the state is not subject to severe frost action and as good drainage is to be expected with a sand base, this condition was not considered serious.

TABLE 2

Prime with 1545 gallons water

Bitumen Application	Emulsion, gal.	Water, gal.
1	700	845
2	500	1045
3	400	1145
4	400	1145
5	400	1145
Total	2400	6870

Applied to approximately 1400 sq. yds.
Equivalent to 1.7 gallons of emulsion per sq. yd.
Equivalent to 4.9 gallons of water per sq. yd.

The construction methods consisted in first spreading about 2½-in. loose depth of top soil over the existing base material. This was then mixed to a depth of about 5 in. with the existing base sand by means of tooth harrows. An application of about 1.1 gal. of water was then made and harrowed into the soil mixture. Stabilization emulsion was then applied according to the schedule in Table 2.

In each case the emulsion was diluted with water at an approximate ratio of 2 or 3 to 1.

Based upon a compacted weight of 400 lb. per sq. yd. 4-in. thick, the total application figures:

	Per cent
Emulsion	3.7
Bitumen	2.2
Water	10.2

Harrowing and blading were performed after each application resulting in a mixture with the consistency of stiff mud. This mixture was allowed to set over night, bladed to shape and initial compaction obtained by means of a sheepsfoot roller. Due to poor drying weather and other conditions peculiar to the project, final compaction was not complete until after about 10 days. This was obtained by means of an eight ton three wheel roller. The result is a base of 4 in. compacted depth. This has been surfaced with 1½-in. Type I bituminous concrete and although the pavement has been in service only about five months, it appears to be giving as satisfactory service as adjacent pavement laid over a sand bound crushed stone base installed for the purpose of comparison and costing about twice as much as the asphalt emulsion stabilized base.

The approximate costs of 4-in. stabilized depth on this project were as follows:

	Cents per sq. yd.
Asphalt Emulsion	19.5
Applying Water	1.3
Labor and Equipment	9.2
Total Cost	30.0

Some problems encountered on this project are as follows:

1. In cohesionless materials of which Cape sand is typical, it seems essential to establish a base upon which to start compaction. This fact was emphasized by the action of the sheepsfoot roller which picked up the sand subgrade and caused weak spots in the stablized mix.

2. While thorough mixing resulted from the use of a wet mix, the slow drying time is a serious drawback. It would be of interest to know how dry a mix of this type can be successfully made in order to shorten this drying time.

3. It has been found in the use of road mix emulsions with run of the bank gravel, that there are wide differences in the behaviors of emulsions meeting the same specifications. It would be of interest to know if there is any specification which would guarantee consistent behavior of emulsions.