SAND-BITUMINOUS STABILIZATION

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SYNOPSIS

In order to obtain a low cost, year-round pavement in sparsely populated sections of Florida where existing road material was impassable sand or silty sand, the Florida State Road Department began the work of stabilizing these sandy materials with bituminous material

Stabilization of sandy soil has been accomplished by the addition of bituminous material, in proper quantity, to existing road material This is mixed uniformly in place with harrows and graders or a traveling plant mixer, and then compacted with rollers

Stability tests on the sand are made prior to addition of bituminous material, and if necessary the stability is increased by the addition of other fine aggregate, pulverized lime-stone or similar material having greater stability The bituminous material used has been cut-back asphalt and tar

The results obtained have been entirely satisfactory About 314 miles of this type of road are carrying traffic with a very low maintenance cost When the surfaces began to show signs of wear they were converted into bases by application surface treatments In some cases the surface treatments have been necessary in about two years, while other pavements have gone seven years and are still holding up The necessity for treatment depends on the type of bituminous material used and the amount of traffic

Sand-bituminous stabilization is as its name implies stabilizing sand or sandy soil with bituminous material to produce a stable pavement, base for surface treatment or subgrade It is a comparatively new type of construction and one which we feel originated and has been developed in Florida

There no doubt has been a time with all who have the responsibility for constructing roads or streets, when considerable mileage of roads had to be constructed and made serviceable for year round traffic with very limited funds This was the case of the Road Department of Florida in 1930 There existed considerable mileage of sandy grade, located many miles from other suitable road building material with practically no railroad facilities The mileage was too great to consider hauling in standard materials for other types of construction and the people were demanding some kind of pavement as the sand was impassable These conditions are the reason for the Department becoming interested in this type of pavement The necessary equipment was obtained and experimental work begun with State forces This work progressed 2 or 3 years until it had passed the experimental stage before any projects were let to contract

The sand-bituminous stabilization is accomplished by mixing the materials mechanically on the road, with harrows and graders or with a travelling plant

A few requisites for the success of this type of construction are

(1) Warm, dry construction period
(2) Light or medium traffic
(3) Sandy soil
(4) Good drainage

It may well be remembered that the sand-bituminous stabilization surface is not the ultimate solution of road surface regardless of location, available material, or volume of traffic The contention is made, however, that this type of road surface does have merit and utility in sections where the existing road material is predominately sand, where a warm and reasonably dry construction period exists, where the traffic is not above medium density, and where good drainage may be

obtained It is not recommended where the above conditions do not exist

The sand-bituminous stabilization work when used as a pavement, so far, has been a marked success in Florida and has passed the experimental stage

When this type of construction was first begun very little preliminary testing of the existing road material was done, the reason being that no one knew what tests, if any, were desirable Tests were made on the gradation of the material, more as a matter of record than anything else, for when a so-called poor gradation was found, there was very little that could be done about it without greatly increasing the cost This would defeat the purpose of a low cost pavement, so we used the material as it existed to learn what effect the poor grading would have on the service life of the pavement We did know that foreign matter was undesirable and attempts were made to remove same Also the presence of clay in appreciable quantities was undesirable as it would cause balls in the mix not coated with bitumen, therefore clay determinations were made and the detrimental content was arbitrarily set at 10 per cent

With these preliminary tests this type of pavement construction went along very satisfactorily for a year or so until finally trouble was experienced, which will be discussed later Due to this trouble is was decided that a preliminary survey of all proposed sand-bituminous stabilized projects was needed

Now when a project is proposed the first step is to have a material survey made by a competent engineer During this survey drainage should be investigated, and if the project is not drained adequately, it must be corrected for drainage before any other work is done This is essential for any type of surface, and especially so for this one Assuming drainage is satisfactory the material survey is then made by obtaining representative samples from the surface to a depth of 8 or 10 in of the existing road material These samples should be taken at intervals not exceeding 500 ft or whenever it is apparent the character of the material changes, either in quality or gradation The samples are analyzed for percentages of silica, clay, loam, silt and foreign matter Sieve analyses are made, and stability tests or bearing values are determined

It is preferable to have a well graded coarse sand, however, if this does not exist, it is not advisable to haul in material to correct the grading, unless it can be obtained locally at a very small cost During our work with this type of construction many different gradations of sand have been encountered and used Some of the sands from a grading standpoint, when studied from a theoretical point of view and compared with ideal gradation for fine aggregate for bituminous mixtures, seemed absolutely unfit for use Some of the sands have contained very little 10 or 80 mesh material, being all one size with percentages at times between 80 and 90 of 40 mesh material We have never made an effort, for reasons of economy, to correct gradations and so far we have, surprisingly, had no ill effects It appears from observations to date that a so called poorly graded sand, if made up of angular particles, will afford sufficient stability, while those with round particles may give trouble

After the tests are completed a study of the results should be made to determine the suitability of the material As a rule loam and silt do not affect the quality of the material, in fact, they aid stability by acting as filler and their presence is advantageous Foreign matter if excessive should be removed A small percentage of clay is not detrimental, although percentages greater than about 10 prevent uniformity of mix by balling Any material containing more than this amount of clay should be

considered unfit for use, unless the clay is of such character that it will disintegrate during mixing and not create balls

The test which has proven most beneficial has been the stability or bearing value test which was improvised by the writer to eliminate an unstable condition experienced with some materials The mixture would not set up and harden in a reasonable length of time and also would not carry traffic, especially slow moving traffic or stationary loads It appeared that the mix was too soft to hold up any stationary load and just a few minutes' parking would result in the vehicle sinking into the mix to where it would have to be pulled out During the investigation of the trouble it was thought that the character, shape and gradation of the aggregate in the existing road material was probably the cause Microscopic examination of the material disclosed this fact and it was found necessary that some kind of stability test should be made on this material and the results compared to stability tests made on other materials from projects which had proven satisfactory To make these tests we used, with slight modifications, a machine which had been developed by the U S Bureau of Public Roads, for obtaining bearing values of sub-soils Our machine is similar to the one described in *"Public Roads,"* Vol 6, No 2, April 1925, p 38, except that the lever arm system was changed to a single straight line lever It consists of a four-legged stand on which is mounted a lever arm and a soil bearing cup Shot is run from the funnel mounted on the left of the stand into a bucket suspended by a spring balance, on the end of the lever arm The soil cup rests on a plate which screws into the stand and the cup is 3 in in diameter and 3 in deep The bearing plug is circular and has an area of 1 sq in on the bearing face A small ball bearing is welded to the underside of the lever arm and fits in a socket in the top of the bearing plug When starting the test the whole system is leveled up by screw adjustment under the soil cup and the lever arm is balanced by a counterweight on the right of the lever arm

The procedure is to oven dry the sample to constant weight Take 600 g of the oven dried material, break up all lumps, add 10 5 cc of water and mix uniformly The cup is filled with the material and a bearing plate covering the entire surface is placed in the cup and an initial pressure, by hand, is applied to the material The bearing plate cover is then removed and additional material is added and piled conically above the cup and the plate cover is again placed on the material and hand pressure applied The excess above the cup is then removed and a total pressure of 1200 lb is applied The large bearing plate is then removed and the small bearing plate of 1 sq in area is placed in the center of the cup resting lightly on the surface of the material The lever arm of the machine is then balanced and the constantly increasing load applied by allowing the shot to run from the funnel into the bucket until the pressure on the bearing plate is great enough to upset the stability of the material The load is recorded at failure The load or the stability is in pounds and is calculated by multiplying the scale reading by 4, which is the lever arm ratio of the machine

This method of test has been used about four years and has proved very successful and valuable in determining satisfactory material It is rather difficult to determine the exact stability that will or will not prove satisfactory However, from what work we have done we do know that the stability of the material from the project which gave trouble when tested had a value of 6 lb per sq in , while material from other completed projects upon which the mix was entirely satisfactory had values of 25 lb per sq in or more, therefore, until further re-

search can be made, we have arbitrarily established 25 lb per sq in as a minimum stability At the present time we are conducting stability tests on materials from all proposed sand-bituminous stabilization projects and where stability values are found less than 25 lb per sq in we are recommending the addition, in the proper proportion, of a suitable aggregate available to the project, which has a stability value sufficiently high that when blended and uniformly mixed with the existing road material it will produce a material with a stability of 25 lb per sq in or more When it is found necessary to stabilize, samples of all available materials are submitted to the laboratory, stability values are determined, the proper materials selected from these test results and the correct blend is calculated and checked for stability If suitable local materials cannot be found, then it is necessary to ship in suitable material Pulverized limestone has been found very satisfactory

If it is known that this type of pavement is proposed for a particular project before the road is graded the material survey should be made in advance, and suitable material selected so that during the grading operations the project can be made suitable for this type of construction

The Florida Highway Department has used and experimented with several bituminous materials, those most commonly used being cut-back asphalt, refined coal tar and petroleum tar However, we have one project constructed with Pine Tar Pine Tar is still in the experimental stage and is not included, at this date (1937) in the Department's specifications The tar materials seem to make satisfactory bases when surface treated soon after being constructed

SPECIFICATIONS

Following are the specifications for the bituminous materials

Cut-back Asphalt Shall be a pure liquid bitumen, free from water and other decomposition products, cut-back with naphtha It shall meet the following requirements for physical and chemical properties

	Min	Max
1 Viscosity, Furol at 122° F	70	140
2 Distillation A A S H O—T-52 with the following exceptions Samples distilled shall be 200 cc, the weight of this volume to be calculated from specific gravity at 60° F		
Bulb of thermometer shall be immersed to a point ¼" above the bottom of the flask		
Condenser shall be water cooled		
Distillate shall be collected in graduated glass cylinders		
Distillation shall be stopped at 680° F, and the entire residue shall be immediately poured into standard penetration containers and allowed to cool for further tests		
(a) Distillate (percent by volume) to 302° F	0	5
(b) Distillate (percent by volume) to 437° F	20	30
(c) Distillate (percent by volume) to 600° F	26	38
(d) Distillate (percent by volume) to 680° F		38
3 Tests on residue from above distillation		
(a) Penetration at 77° F	85	100
(b) Solubility in CS_2 (percent)	99.50	100

The penetration of the base asphalt, before cutting back with naphtha, shall be between 85 and 100

The Department reserves the right to change the above should conditions warrant Same would consist in a change of asphaltic content and percent of naphtha, also consistence of the base asphalt

The Department has found this cut-back asphalt to be more satisfactory in most cases than any of the other cut-back asphalts experimented with, although on one project, where the existing

road material contained a high percentage of silt, loam and some clay, mixing was affected by a tendency of the material to ball with the oil To eliminate this, or to obtain better results, it was found necessary to alter the specifications by requiring the penetration of the base asphalt to be 100 to 120 This gave a little softer grade of material and one which mixed more readily On the other hand, on some projects where the material was weak in inherent stability a 45-60 base penetration asphalt has been used For the majority of materials, however, it is recommended that a base asphalt of 85 to 100 penetration be used

In this specification you will notice a distillation requirement (percent by volume) to 302° F of 0 to a maximum of 5 In our early work we did not have this requirement and found in extremely hot weather that the mix was not homogeneous but contained numerous balls of fat material, some pure asphalt Upon investigation it was found that the percentage of distillate at 302° F was high, around 17 This meant that the naphtha used in manufacturing the cut-back was so highly volatile at the lower temperature that in hot weather, after the cut-back had been distributed into the existing road material, these light ends of the naphtha were evaporating too rapidly before mixing could be accomplished and causing this balling condition, therefore the distillation requirement at 302° F was added and the maximum limit set at 5 percent This has assisted in eliminating the unsatisfactory condition

TABLE 1

	Coal tar in base		Pitch oil in base		Flux		Mixture	
	Min	Max	Min	Max	Min	Max	Min	Max
Water, percent by volume		2		2		2		1
Float at 89 6°F in sec	150	210						
Specific Viscosity, Engler, 50 cc at 212°F			7 5	11 5				
Specific Viscosity, Engler, 50 cc at 104°F					1 1	3 6		
Specific Viscosity, Engler, 50 cc at 140°F							12	32
Distillation, 1st drop			455°F					
Percent by weight								
To 338°F		1			0	7		2
To 455°F		10						12
To 518°F		15						18
To 572°F		30			25	87		30
To 752°F				20				
Residue at 572°F	70						70	
Total bitumen, percent by weight, soluble in CS_2	78		95				88	
Specific gravity at 60°F /60°F			1 20	1 27				

Coal Tar The coal tar shall be composed of a heavy coal tar base containing pitch oil and fluxed with water gas tar or distillates thereof, or light coal tar distillates

The coal tar base shall be composed of 85 to 97 percent by volume of refined coal tar and 15 to 3 percent pitch oil as directed The ratio of pitch oil to tar shall be as directed by the Engineer, which may vary according to the type of soil, acid soils generally taking a higher percentage of pitch oil The mixture shall be composed of 80 to 93 percent base and 20 to 7 percent flux

The refined coal tar and pitch oil in the base, the flux and final coal tar mixture shall meet the requirements in Table 1

The specific viscosity shall be within 3 points, plus or minus, of the specific viscosity designated by the Engineer between the above limits

Petroleum Tar The Petroleum Tar shall consist of not less than 60 percent of refined petroleum tar base, fluxed to the specified viscosity with a tar material (liquid at 60° F) The material shall have the characteristics of tar and when combined in proper proportion with the road material from the proposed sand bituminous road mix project, and air cured, the mixture shall show a tendency to set within 6 hours, have a firm set in 4 days and hard set in 7 days It shall meet the following requirements for physical and chemical properties

	Min	Max
Eng Spec Vis at 158° F	22	32
Percent Water		1
Total Distillate, by wt		
To 338° F	0	5
To 572° F	15	40
Bitumen, percent sol in CS_2	88	
Specific Gravity at 77° F /77° F	110	

The specific viscosity shall be within 3 points, plus or minus, of the viscosity designated by the Engineer between the above limits

On construction in which coal tar is used, after final rolling and checking of the surface for irregularities, and about one month from the time mixing operations are completed, the finished surface shall be treated with 0 20 gal per sq yd of coal tar of the same quality as used in the mix, and covered lightly with sand to prevent picking up by traffic

On construction in which petroleum tar is used, 0 25 to 0 35 gal per sq yd shall be applied as above described except that the material shall be liquid cut-back asphalt as hereinbefore specified This seal treatment using liquid cut-back asphalt may be applied on construction consisting of asphalt if deemed necessary by the Engineer

QUANTITY OF BITUMINOUS MATERIAL

The amount of bituminous material needed to make a satisfactory job varies with the nature and grading of the material to be mixed with the bituminous material and the kind of bituminous material to be used In this respect, this type of mix follows the theory of all bituminous mixtures, in which the quantity of bituminous material shall be sufficient to coat entirely each individual particle of the mineral aggregate with a slight excess to partially fill voids and secure durability Finer graded material contains more individual particles per unit volume, therefore, there is more surface area to be coated and more bituminous material is required

The surface character of the material also influences the amount of bituminous material necessary, as a rough, rugged surface will require more than a smooth one In view of this fact and also the great changes in gradation of the road materials in different locations, and even on the same project, it has been impossible thus far to create a cut and dried table of quantities necessary for this type of construction

The method used at the present time to determine the amount of bituminous material necessary to produce a satisfactory mixture is a combination laboratory investigation and trial mix in the field Samples of the material are analyzed for quality and gradation in the laboratory and small batches made up From the results of this study the field engineer is furnished with an approximate quantity of bituminous material necessary for good results He is then to use his own judgment after trying a section using the predetermined quantity and from visual inspection of the actual road mix should vary the quantity of bituminous material, if necessary, to accomplish satisfactory results The final mixture, after the last application of bituminous material has been added and the mixture thoroughly mixed, should have a black glossy appearance Any mix having a brownish color is too lean and should be reworked by adding more bituminous material and the mixing continued until the black appearance is produced

On the work completed in this State the bituminous material has averaged from a minimum of 3 5 gal to a maximum of 7 gal per sq yd of 6-in compacted pavement

Table 2 shows some of the typical sand gradings used on active projects and the quantity of cut-back asphalt necessary to produce satisfactory results

Please note as the material changes from coarse to fine the quantity of oil must be increased, which is in line with the theory of finer graded aggregates having more surface area However, sometimes this theory is upset as the quality and shape of the individual particle of the material plays an important part as is illustrated by sample 7 This is a slightly coarser material in that it contains more 10 and less 40 than sample 4, 5 and 6 with the 80 and 200 mesh material being about the same, yet number 7 requires a little more oil

It might be well to caution against the use of too much bituminous material The tendency is to use too much as it makes mixing conditions easier, but failures can be caused just as easily by using too much as too little The character of the failures will of course be different but will be just as difficult and costly to correct Failures from a dry mix or a mix with an insufficient amount of bituminous material will be in the nature of dusting and ravelling away of the surface until holes occur Failures from a fat mix or a mix with an excessive amount of bituminous material will be in the nature of shoving into an irregular riding surface or an unstable condition resulting in rutting by traffic

TABLE 2

Sample No	Project No	Station No	Mechanical analysis of sand				Gal of oil per sq yd mix approx 6 in thick
			Pass 10 Ret 40	Pass 40 Ret 80	Pass 80 Ret 200	Pass 200	
1	802-C	491	55	41 0	3 6	0 5	3 20
2	857	15	38 0	54 6	4 2	3 2	3 85
3	857	295	29 2	65 4	3 4	2 0	4 00
4	857	300	28 6	66 4	2 8	2 2	4 00
5	857	450	28 6	68 2	1 4	1 8	4 20
6	857	470	20 8	74 6	2 4	2 2	4 70
7	857	895	33 0	60 8	3 8	2 4	5 00
8	857	885	25 0	70 2	3 0	2 0	5 50

STABILIZING OPERATIONS

In preparing the existing road material prior to application of bitumen, the grade is plowed to a depth of 2 in below the proposed depth of the pavement and one-half foot from each proposed edge All roots and foreign matter are removed as far as practicable The removal of roots on some projects has been a problem, and as no satisfactory equipment is available for this work, garden rakes, spring tooth harrows and hand picking have proven the most effective methods The grade is then dressed to line and grade as shown on the plans

Two types of distributors can be used, namely, the regular pressure distributor and the distributor-trailer tank-unit type The latter has been developed for this type of construction and is preferable When this distributor is used, the tanks are constructed with flues for heating The trailer distributor is attached behind the tank truck, and each tank load is distributed direct without transfer of loads as is necessary when the pressure distributor is used

In beginning, the most suitable end of the project is selected as a starting point so that the material will not be hauled over the finished pavement

All automotive equipment is preferably equipped with balloon type tires of capacity for transporting the loads through sandy material

A section approximately 3000 ft in length is selected for each mixing and finishing operation The bituminous material is applied in successive applications of approximately 0 35 gal per sq yd until the amount required to finish the mix is approximately 0 5 gal , then the applications are reduced as low as 0 15 or 0 20 to avoid flooding the mix The first operation consists of applying bituminous material at the rate of 0 35 gal per sq yd until approximately 1½ gal have been applied and this is mixed with disc harrows to a depth of 3 or 4 in This depth should be about half of the total thickness required This 3 or 4 in of material is next pushed with a blade into windrows clear of the 20-ft width which the pavement is to occupy Bituminous material is then applied to the base or lower half of the existing road material in the quantity of 0 35 gallon, with mixing operations going on continuously until a brown lean mix is obtained, lean base and richer top The material is then shaped with the blade and the windrowed material pulled back in three operations, each one receiving an application of approximately 0 35 gal per sq yd and mixed to guard against any sand streaks between the base and top After all of the material from the windrows is in place the edges and quarters are plowed to the full depth of the required pavement thickness After plowing, the material is pulled from ½ ft outside the specified width to the center with a 12-ft blade, cutting to within ½ in of the specified depth of the finished pavement at the edge After this operation the final applications of bituminous material are made with 0 15 to 0 2 gal per sq yd , and at the same time mixing operations are carried on with harrows and 12-ft blade When using tar the 12-ft blade is used to obtain a uniform mix and the harrows are used only to cut in each application In this connection the 12-ft blade has proven the most useful equipment for mixing and is used extensively on all mixing operations regardless of which bituminous material is used

The material is rolled back to the edges This insures proper depth and uniform mix at this point During the final mixing a retread mixer and blades are used to insure a uniform, homogeneous mix

The final finish of the surface is obtained with long wheel base graders having 12-ft blades, of light construction with a maximum weight preferably of 8000 lb The wheels should be equipped with steel tires 12 to 14 in in width to eliminate sinking into the mix The wheels should also be equipped with scrapers, and heavy door mats or burlap saturated in a 50-50 mixture of kerosene and old cylinder oil or some other suitable material to prevent the mix adhering to the wheels While the mix is new and soft it is shaped to crown and grade For the final finish the blade is turned to its maximum angle with the edges of the pavement The top of the mold board is leaned forward so that the blade is at its maximum skinning or scraping position The loose material is skinned down to a solid firm mix This is essential, otherwise scabs will result on the pavement surface

After the finishing operation, the pavement is rolled with a 5-ton tandem roller The rolling operations should be carried on early each morning before the pavement becomes warm, or on cloudy days It is continued until a smooth surface is obtained free from all roller marks

The surface is then checked with a template and straight edge for crown and smoothness All irregularities greater than ½ in in 10-ft are corrected by shaving off the high places with a sharp blade

The edges of the pavement are cut with axes and shovels to true line The waste mix from cutting edges is salvaged and stock piled for future use in constructing turnouts, parking places, etc All dry, hard material is buried in the shoulder On this type of pavement when the bituminous material used is of such character that the mix becomes hard and brittle at the surface and will not resist wear without excessive dusting, it is necessary after the finish is obtained to apply a 0 2 to 0 3 gal per sq yd seal coat of the same bituminous material as used in the mix When petroleum tar is used it is necessary to make this seal application of cutback asphalt with a 50-60 penetration base asphalt

Sometime during the final finishing and rolling operations, the project engineer should take sufficient measurements of the pavement to check the thickness These can be made at holes or trenches dug into the pavement at various intervals, or a coring tool can be made out of a 1½ in or 2 in piece of steel tubing with a handle and plunger similar to an automobile pump A tool of this kind is used by the Division of Tests of the State Road Department after the pavement is completed to obtain final measurements of the pavement thickness

A traveling plant is sometimes also used for mixing which eliminates a great deal of the mixing procedure and expedites the work

I should like to mention something new that has recently been invented to facilitate mixing when the blade and harrow method is used The success of this type of pavement depends largely on the mix being homogeneous It requires considerable mixing with numerous types of mixing equipment to obtain this condition Under ideal weather conditions it is not so difficult, but when the weather is cool or cold it is very difficult and if the material is too wet, work is suspended until the mix dries Also during the winter months it is generally late in the morning before the mix is warm enough to accomplish very much

This new tool known as a "Hot Blade" was invented by Mr Frank Bullard of Tampa, Florida, and is claimed to be very effective in producing a homogeneous mix in a much shorter length of time It has not yet been tried very much by the State Road Department but has been used quite extensively on work in Hillsboro County, Florida

It consists of a metal oven bolted to the rear of the grader blade, in which are three oil burners spaced one near each end and one in the center of the oven Inside the oven are perforated baffles to diffuse and direct the heat to the rear of the mold board On the rear of the grader is mounted a 42 gal fuel tank which carries 30 gal of kerosene under air pressure of 75 lb The air tank and air compressor are also mounted on the rear of the grader and the air tank carries 100 lb of air It requires about 35 to 40 gal of kerosene per 10 hours to heat the blade The working temperature of the blade is said to be 350° F The mold board is extended 10 in vertically to prevent the mix from coming over the board into the burners It is claimed that with this hot blade the mixing time and cost is materially reduced Also it seems to dry out the material after rain and prevents long delays and enables earlier mixing in the mornings in winter weather It enables heavier bodied bituminous materials to be used which increases the stability of the mix

The personnel required to construct this type of pavement should consist of the following: One competent engineer and one superintendent familiar and experienced with this type of construction About 30 men including mechanics, tractor and grader operators, roller man and unskilled laborers This organization, of course, is dependent on the size of the

unit and the volume of work desired to be accomplished

The State Road Department of Florida has built 314 miles of this type pavement, some of which is 7 years old Approximately 255 miles have been constructed by State forces at an average cost of approximately $0 41 per square yard This cost is for actual construction of the pavement including all materials, equipment and labor It does not include any cost of grading

Several counties and some municipalities have constructed considerable quantities of this type pavement and several of the southern and eastern States have inquired about it and are beginning to use it in their road systems

There has been very little maintenance as yet on this type of pavement constructed by the State Road Department The average maintenance cost has been about $180 00 per mile per year, which has been mostly for shoulder maintenance

This pavement deteriorates on the surface slightly with age The bituminous material appears to lose its life and when this condition begins the pavement is given a surface treatment Some projests require surface treating sooner than others, due mainly to the type of bituminous material used in the mix We have some projects that required treatment within two years after construction, while others were treated at five or six years and some few are now seven years old and treatment has not been necessary This type of pavement makes an excellent base for surface treatment and after such treatment the maintenance cost should not be any more than for other types of surface treated bases

Sand-bituminous stabilization has recently been used on weak, sandy subgrades to stabilize them so that they could be compacted by rolling and would support wheel loads The procedure is the same as hereinbefore stated except that a smaller quantity for bituminous material is used It was found that these low stability sand subgrades, although of Group A-3 material, were causing excessive cracking and warping of the concrete pavements laid on them The stability test indicated a stability of 15 lb per sq in , and the addition of bituminous material, equivalent to 1½ gal per sq yd 9 in loose, uniformly mixed, increased the stability to 40 lb per sq in and produced a sub-grade that could be compacted by rolling and one that would support ordinary wheel loads without appreciable rutting

This type of road has been a life saver in that section of Florida which, generally, borders the Gulf of Mexico and traverses a very sparsely populated country, however, it is a link in one of the main routes from Tampa, around the Gulf Coast to Pensacola The people of this section needed a road of some kind very badly as the deep sand was practically impassable On account of lack of railroad facilities and satisfactory material in this section, other than sand, a higher type of pavement was practically prohibitive Necessity, being the mother of invention, started the investigation and experiment with "Sand-Bituminous Stabilization," which has now passed its experimental stage Now 314 miles of this type pavement have been constructed and many more miles of similar construction are anticipated for the future