A SYMPOSIUM ON RESURFACING OF CONCRETE PAVEMENTS

Arranged by the Committee on Design

WITH BITUMINOUS TYPES, by B E GRAY and GEORGE E MARTIN
WITH BRICK, by GEORGE F SCHLESINGER
WITH PORTLAND CEMENT CONCRETE, by E M FLEMING

The planning of highway improvements is done with the expectation that at some future time extensive rebuilding will become necessary In many cases the rebuilding will involve the application of a new wearing surface In fact many comparatively modern pavements have already reached this stage, and the discussions in this symposium of the various materials and methods used for this purpose are illustrated by information from existing examples

RESURFACING WITH BITUMINOUS TYPES OF SURFACES

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SYNOPSIS

This report discusses the use of both tar and asphalt for surface treatments, road mixes and plant mixes Long time service records and cost data of existing installations are presented and methods for carrying on the work and specifications for materials are recommended

There are four general methods of resurfacing concrete pavements with bituminus materials, these are, surface treatment, road mix surface, penetration macadam, and plant mixes laid hot and cold

The bituminous materials include tar and asphalt, and the recommended procedure for employing the four methods are set forth separately for the two materials because of certain differences in their utilization Surface treatments are generally employed where the main body of the concrete is still sound, but where scaling and cracking have developed to a considerable degree The road-mix, penetration macadam, and plant-mix surfaces are used where the old concrete has become broken and deformed, and where a new surface of appreciable thickness is required, both to cushion against the impact of traffic to prevent further deterioration and to take out irregularities in the old pavement

When widening is necessary in connection with the resurfacing, a cement concrete, black base, macadam or gravel foundation may be used and the resurfacing extended over it Cement concrete shoulders are also used for the widened portion with the bituminous resurfacing between them

Many states widen concrete roads with bituminous treated gravel or macadam edges, thus preparing a foundation for future resurfacing and widening.

SURFACE TREATMENTS

All bituminous surfaces having a finished depth of less than one inch will be considered as surface treatments

Concrete roads have been surface treated in all stages from new concrete which has not been opened to traffic, to that which is very badly shattered Both extreme cases may give trouble after treatment On new concrete, where excess surface mortar of poor quality occurs, it may scale off later, taking the surface treatment with it Thorough cleaning with steel brooms may remove the loose material so that the bitumen can grip the solid concrete Dilute acids have been used to scrub the concrete surface in some instances

Concrete which is badly shattered may move under the treatment and cause the disintegration of the treatment

Surface treatment of concrete dates back to 1910 Some early concrete pavements, such as Dollarway, carried a surface treatment as a part of the construction

Costs of Original Treatment Costs vary in different localities according to difference in freight rates and labor costs, and also according to the amounts of materials employed. At present prices, the range will be from 6 to 12 cents a square yard, or for an eighteen-foot pavement, about $600 to $1,200 per mile

Maintenance Retreatments will be required at intervals of from three to five years, according to traffic and climatic conditions Earlier treatments, made at shorter intervals, were frequently unnecessary and resulted in too thick a mat Proper attention to patching the old concrete before treatment, and the proper use of primer when needed, will obviate the necessity for treatment at intervals of less than three years, and then it will be needed only to replace the wear of traffic Retreatments are usually at the rate of 0 2 to 0 3 gallon per square yard, with 15 to 20 pounds of cover coat Annual costs per square yard of maintaining surface treatments over old concrete will not exceed three to five cents

Surface Treating Construction Methods Using Asphalt

Several grades of asphalt are used successfully in surface treatment work over concrete These include cutback asphalts, emulsified asphalts and hot asphalt cements For initial applications, or prime coat, cutback asphalt or emulsified asphalt is recommended, while for seal coat all three grades are used with the trend of practice being toward the hot asphalt cements

Prime Coat. While concrete surfaces which are worn so that the

coarse aggregate is exposed may be treated without priming, yet the non-uniform surface condition usually found makes the priming operation a desirable step, and insures a complete bond with the seal coat The asphalt primer may be either a low viscosity cutback asphalt (as specified later), or a quick-setting emulsified asphalt The old surface should be swept clean before its application, as the object of the primer is the penetration of all the small cracks and crevices in the old surface so as to insure bond with the seal coat The rate of application is approximately 0 25 gallon per square yard and no cover coat is used. If possible to exclude traffic from the road during application, its use is desirable, otherwise, the surface should be treated one-half width at a time

Seal Coat A rapid-curing cutback asphalt, a quick-setting emulsified asphalt or a hot asphalt cement of around 250 penetration may be used

TABLE I

SPECIFICATIONS FOR ASPHALTIC MATERIALS USED IN THE SURFACE TREATMENT OF CONCRETE PAVEMENTS

	Cutback asphalt primer MC-1	Cutback asphalt seal RC-1	Emulsified asphalt	Hot asphalts
Flash, degrees F		80+		
Furol Viscosity at 77°F	40–150			
Furol Viscosity at 122°F		80–160		
Distillation, per cent by Volume			See manu-	See local
Total distillate to 374°F		5+	facturers	state
Total distillate to 437°F	10−	12+	recom-	specifi-
Total distillate to 600°F	25+	25+	menda-	cations
Total distillate to 680°F	50−	40−	tion	
Tests on Residue from Distillation				
Penetration, 77°F	70–300	60–120		
Ductility, 77°F	60+	60+		
Solubility, CS_2	99 5+	99 5+		

for the seal coat The application is usually at the rate of 0 25 to 0 35 gallon per square yard, followed by an application of crushed mineral aggregate, brooming and rolling. On rough concrete, it is desirable to drag the surface after the application of the mineral aggregate, in which case the cutback asphalt or emulsified asphalt should be used Sometimes for a very heavy treatment, 0 4 to 0.5 gallon per square yard of hot asphalt is used, covered with 40 to 50 pounds of aggregate, followed by one pass of the roller to set the bottom fragments firmly in the asphalt, and then by a combination of rolling and broom-dragging there is obtained a smooth surface.

Cover Coat Aggregate Cover coat aggregate may be crushed slag, gravel or stone and should range from $\frac{1}{4}$ to $\frac{3}{4}$ inch in size The amount of cover coat is in the proportion of ten pounds to each 0 1 gallon of asphaltic material.

Examples of Asphalt Surface Treatment

The following figures for a surface treatment project in Massachusetts (Route 2, North Adams, Williamstown) are typical of aspalt surface treatments over old concrete

Date of treatment	1929
Age of concrete	12 years
Yardage	33,200
Asphalt used	¼ gallon
Cost	093
Retreatment	none
Condition	good

Surface Treating Construction Methods Using Tar

Various grades of tar have been used successfully in this surface treatment work ranging from a cold refined tar to a hot surface treating material No definite standards have been developed, each engineer using his own method There have not been sufficient failures to prove that any of these materials or methods were wrong In general, the grades of tar used may be stated as cold refined tar, medium refined tar, and hot surface treatment tar The cold material is used for the prime coat on two-coat work and sometimes as a single surface coat

As a result of the study of existing jobs the following recommendations for the surface treatment of concrete with tar products are made

Prime Coat If the concrete is new, a prime coat which will penetrate into the concrete surface is needed If the concrete is not new but scaling and dusty, a prime coat will be needed to penetrate the dust and bind up the surface.

Cold refined tar as specified later is used for the prime coat

It is applied at the rate of approximately 0 25 gallon per square yard and permitted to soak into the surface for 24 hours This work should be done when the road is warm and dry Traffic must be excluded from the treated area No cover is used when a seal or surface coat is to follow

A modification of the method is to cover the tar with sand and use this prime coat as a surface or final treatment Such a treatment should be given a maintenance seal coat of medium or hot refined tar the second year

Surface or Seal Coat The materials and methods of application are the same whether the surface coat is a seal coat over a prime coat or a single application over the concrete

Either medium refined tar or a hot surface treatment tar may be used Where the concrete is rough and a dragged surface treatment is needed to produce a smooth riding road, the medium refined tar should be used, otherwise, the hot surface treatment tar

These tars must be heated for application The proper ranges are

from 125°F to 175°F for the medium refined tar and 175°F to 225°F. for the hot surface treatment tar

The surface coat is applied at the rate of $\frac{1}{4}$ to $\frac{1}{3}$ gallon per square yard

Covering material may be slag, gravel or crushed stone and should range from $\frac{1}{2}$ to $\frac{3}{4}$ inches in size The amount needed will vary from 20 to 40 pounds per square yard

A modification of this method is to apply two coats of medium or hot refined tar of 0 25 gallon per square yard each, with 15 to 30 pounds of cover per square yard on each coat

Cover on the medium refined tar should be dragged with a sled drag and rolled in place

TABLE II

TARS FOR SURFACE TREATING CONCRETE

	Cold refined tar	Medium refined tar	Hot refined tar
Specific Gravity at 25°/25°C	1 11 to 1 18	1 14 to 1 22	1 18 to 1 24
Water, per cent by volume, not more than	2 0	1 0	0 0
Specific Viscosity, Engler			
50 cc at 40°C	8 to 13		
50 cc at 50°C		26 to 34	
Float Test at 32°C , seconds			60 to 150
Distillation, per cent by weight			
0 to 160°C , not more than	7 0	5 0	1 0
0 to 270°C , not more than	30 0	25 0	15 0
0 to 300°C , not more than	35 0	32 0	25 0
Distillation Residue			
Softening Point, °C (R & B) not more than	60 0	60 0	65 0
Total Bitumen (soluble in CS_2), per cent	89 to 98	89 to 98	80 to 95
Specific Gravity at 38°/38°C of Total Distillate to 300°C , not less than	0 96	0 98	0 98

Cover on the hot surface treatment tar should not be dragged but should be swept during the rolling to insure even and uniform distribution over the road surface

ROAD-MIX SURFACES, COARSE AGGREGATE TYPE

The use of the macadam aggregate road-mix type for resurfacing old concrete roads is of comparatively recent origin, most of such work having been accomplished during the past three or four years The ease of application, the remarkable smoothing-up qualities, coupled with low cost and durability have made it an increasingly popular method for salvaging old concrete in the same way that the type has been so satisfactory for the low-cost surfacing field in general It is useful where the old concrete is badly shattered and out of shape, and an appreciable thickness of new wearing course is required

TABLE III

TABULATION OF SURFACE TREATMENTS OF CONCRETE USING TAR

	Location				
	Bernardsville, New Jersey, N J State Hwy No 16	Washington Crossing, Mercer Co , N J	Bellwood-Dutch Gap, Va , Rt No 31	Pelhamdale Ave , Pelham Manor, N Y	Apex, N C U S Route 1
Yardage	18,000	22,000	65,000	26,000	1,700
Date	1928	1927	1930	1915	1924
Age of Concrete	6 years	10 years		New	
Prime Coat	None	None	Cold Refined Tar	None	None
Amount			¼ gal		
Cover			None		
Amount					
Seal Coat	Hot Surf Treat Tar	Hot Surf Treat Tar	Hot Appli Tar	Hot Surf Treat Tar	Hot Surf Treat Tar
Amount	½ gal	¼ gal	½ gal	½ gal	¼ gal
Cover	⅜″ chips	⅜″ chips	Trap Rock Chips	⅜″ Trap Rock	⅜″ chips
Amount	30 lbs	20 lbs	60 lbs		25 lbs
Original Cost	$0 14	$0 08	$0 08	$0 15	$0 15
Retreatments	¼ gal every 2 years	Same as above almost every year	None to date	¼ gal every 3 years	3/10 gallon Hot Tar with 25 lbs ⅜″ chip in 1930
Annual Costs	$0 06	$0 07		$0 04	$0 04

Construction Operations

Mineral Aggregates The mineral aggregate may be crushed stone, crushed gravel or crushed slag of the standard quality required for bituminous construction Crushed gravel should have not less than 60 per cent of all particles showing a fractured face. While various depths of road-mix surfaces have been placed, experience has demonstrated that a compacted thickness of two inches is the most desirable. For this depth the grading of the aggregate should range from $\frac{3}{4}$ inch to $1\frac{1}{2}$ inches

Bitumen Both tar and asphaltic materials have been used extensively for this type of resurfacing

Asphaltic Materials Either rapid-curing cutback asphalts or slow-setting emulsified asphalts may be used as the bituminous binder in the road-mix surface For a compacted depth of two inches, the amount

TABLE IV

ASPHALTIC MATERIALS FOR MACADAM AGGREGATE ROAD-MIX SURFACES

Specification item	Cutback asphalt for spring and fall R^C-2	Cutback asphalt for summer R^C-3	Emulsified asphalt
Flash Point (Open Tag)	80°F +	80°F +	
Furol Viscosity at 122°F	200 to 400		
Furol Viscosity at 140°F		275 to 400	
Distillation, per cent by Volume			See manu-
Total Distillate to 437°F	10+	3+	facturers
Total Distillate to 600°F	20+	14+	specifica-
Total Distillate to 680°F	35−	30−	tions
Tests on Residue from Distillation			
Penetration, 77°F	60 to 120	60 to 120	
Ductility, 77°F	60+	60+	
Per cent Soluble in CS_2	99 5+	99 5+	

required will be approximately 1 2 gallon per square yard, applied in three applications of 0 5–0 4–0 3 gal , respectively With cutback asphalts the first two applications are followed by mixing operations, and the third application is a seal coat With emulsified asphalts the first application is followed by mixing, the second application is a penetration one and the third application is a seal coat

The tar should be heated to a temperature of 120° to 175°F for application.

Construction Operations. 1. Spread mineral aggregate ($\frac{3}{4}$ by $1\frac{1}{2}$ inch size) to a loose depth of $2\frac{1}{2}$ inches

2 Apply first mixing application of bitumen by pressure distributor at the rate of 0 5 gallon per square yard

3 Mix, using blade graders or other appropriate equipment

4. Apply second application of bitumen at the rate of 0 4 gallon per square yard

5 Mix until uniform and spread evenly over road surface

6 Roll

7 Fill voids in surface with aggregate ranging in size from $\frac{1}{8}$ inch to $\frac{1}{2}$ inch

8 Broom and roll until smooth and even

9 Apply seal coat of 0 3 gallon bitumen per square yard

10 Cover with aggregate ($\frac{1}{8}$ by $\frac{1}{2}$ inch size), drag and roll

Costs Costs of surfacing vary according to local conditions, some work having been recently accomplished under favorable conditions as low as $0 30 per square yard In general, however, the range in price will vary from 40 to 60 cents per square yard, depending upon the length of the job and accessibility of materials

TABLE V

TAR FOR MIXED-IN-PLACE SURFACE

	Spring and fall	Summer
Specific Gravity at 25°/25°C	1 14 to 1 22	1 14 to 1 22
Water, per cent by volume not more than	1 0	1 0
Specific Viscosity, Engler, 50 cc at 50°C	16 to 22	26 to 36
Distillation, per cent by weight		
0–170°C	5 0	5 0
0–270°C	25 0	25 0
0–300°C	32 0	32 0
Distillation Residue		
Softening Point, °C (R & B) not more than	60	60
Total Bitumen (Soluble in CS_2), per cent	89 to 98	89 to 98
Specific Gravity at 38°/38°C of Total Distillate to 300°C , not less than	0 98	0 98

The tar should be heated to a temperature of from 100 to 175°F for application

Maintenance Maintenance will include a light seal coat at intervals of from three to six years, and occasional small patches as the old concrete pavement may continue to settle The annual maintenance cost will vary from three to five cents per square yard

Examples of Asphalt Road-Mix Surfaces

One of the advantages of road-mix surfaces is the adaptability of the type to widening operations A typical example of this kind is as follows

Date of resurfacing	1932
Age of concrete	14
Yardage	10,000
Depth of surface	1–1½ inch
Cost per square yard	$0 20
Annual maintenance	—
Traffic	1000

The old concrete, 14 feet wide, was widened with stone and gravel shoulders to 20 feet, and the road-mix top was then placed over the whole width Thorough dragging and rolling made a smooth riding surface

TABLE VI

TABULATION OF MIXED-IN-PLACE CONCRETE RESURFACING

(Tar)

Location	Pleasant Valley Rd Cuyahoga County, Ohio	Montezuma, N Y N Y State No 5610	Holcomb, N Y N Y State No 5635
Yardage	10,000	40,000	900
Date	1931	1930	1932
Age of Concrete	8 years	9 years	11 years
Prime Coat	Medium Tar	None	None
Amount	$\frac{2}{10}$ gal		
Top Depth	2½″ loose	2½″ loose	2½″ loose
Cost per yard	$0 58	$0 43	$0 46
Maintenance	None	None	None

PENETRATION MACADAM

Penetration macadam has been successfully employed as a resurfacing material over old concrete, notably in New York and New England It has been particularly of value where the old road surface was broken and disintegrated, and definite structural strength was required in the resurfacing course An interesting example of such use is on the main route between Portsmouth and Portland, Maine, while another is located in New York State on the main route to Montreal north of Schroon Lake The latter concrete was resurfaced in 1916, with a three inch penetration macadam course at a cost of 65 cents per square yard and has given satisfactory service ever since

The introduction of mechanical manipulation of coarse aggregate and broom dragging of keystone and chips has made possible increased smoothness and uniformity of riding surface in penetration macadam. It thus compares favorably with other types of mechanically finished work One example of this type of work is the emulsified asphalt penetration section on the Maryland Experimental Road near Glenburnie

Another may be found in Trumbull County, Ohio and is typical of such work, except that the construction cost is somewhat lower than average

Date of surfacing	1926
Age of concrete	13 years
Yardage	27,000
Depth of surface	3 inches
Cost per square yard	$0 50
Annual maintenance	$0 025
Condition	Good

A considerable part of annual cost is in the replacement of failed areas of the base, and too much emphasis cannot be placed on the need for careful conditioning of the old surface prior to placing a new wearing course

Because of the ease and rapidity of constructing either road-mix or plant-mix surfaces, however, resurfacing work is being accomplished largely in this way today, and accordingly only a brief comment is thus made on the use of penetration macadam for this purpose

PLANT-MIXES FOR RESURFACING OLD CONCRETE PAVEMENTS

The resurfacing of concrete pavements with plant-mixed bituminous types, laid either hot or cold, is of long standing, and a great many examples from all over the country may be cited as successful instances of this method of salvage As a matter of fact, the resurfacing of old concrete pavements is no different in principle from the standard construction of bituminous surfaces on concrete bases, except that the old concrete often makes a better foundation than the present-day design of concrete bases There are two reasons for this fact In the first place, there has been a trend in recent years to design concrete bases with rich mixtures, such as 1 1½ 3 and 1 2 4 Wider cracking is certain to result with such mixtures, and unless properly controlled will be reflected soon afterward through to the bituminous pavement above Some old concrete pavements were laid with mixtures of 1 2½ 5, 1 3 6, and even leaner, so that there is little likelihood of further cracking after the bituminous surface has been placed Secondly, the old concrete pavement in cracking and breaking has become adjusted to the subgrade, which also has settled to a condition of more or less permanent stability, and, consequently, when the bituminous surface is placed and finished smooth, there is every reason for this smoothness to be retained, provided proper construction details have been attended to

There are two varieties of plant-mix bituminous surfaces, one which is mixed in a nearby plant, transported and placed while still hot, and the other where the bituminous mixture is made in a plant, but so prepared that it can be transported for any distance and laid cold, even after the elapse of several weeks, because of the delayed setting of the bituminous material employed These will be discussed separately under these two headings There are also several varieties of cold plant mixes using emulsified tar or asphalt where the mixture is placed and finished on the road surface immediately after mixing

Plant-Mixes Using Asphalt Laid Hot

Hot-Mix Types The several standard types of hot-mix asphalt surfaces are applicable to the resurfacing of old concrete, and include sheet asphalt, fine and coarse graded asphaltic concrete and hot-mix asphalt macadam. For certain city streets or in locations where coarse

aggregate is not easily obtainable and sand is abundant, the sheet asphalt surface is recommended, but for all other locations asphaltic concrete is particularly suitable and should be employed

Coarse Graded Asphaltic Concrete There are two varieties of asphaltic concrete, one using coarse graded aggregate where the percentage of particles larger than one-quarter inch diameter is greater than for any other constituent of the mix, and the other using fine graded aggregate where the percentage of particles passing a ten mesh sieve is the largest single constituent For resurfacing of rural highways, the coarse graded aggregate concrete is to be preferred in the majority of locations The grading of such a mixture will fall in the following range·

Passing 1½ inch screen retained on ¾ inch screen	15 to 45%	55 to 65%
Passing ¾ inch screen retained on ¼ inch screen	15 to 45%	
Passing ¼ inch screen retained on 200 mesh sieve		25 to 35%
Passing 200 mesh sieve		4 to 6%
Asphalt cement		5 to 8%

There has been a trend in recent years to holding the asphalt cement content down to around six per cent, as with the growth of traffic and oil drippings this amount is sufficient to give a thoroughly bonded wearing course without excess

Construction Methods As a result of long experience, it has been determined that the minimum depth of resurfacing should be not less than 1 5 inch, and where the old concrete is very badly broken this should be increased to as much as three inches maximum Usually the depth will be about two inches

A common error in construction procedure in past years was the attempt to accomplish the resurfacing in a single operation, regardless of how uneven the old road surface might be This was particularly bad practice where the old concrete was badly broken, or where a high crown had been used While for a few weeks the surface remained smooth, it was only a question of time before the thicker areas were further compressed under traffic, and the new surface took the same contour as the old rough surface This difficulty will be entirely overcome by placing an "evener" course, to take out all depressions and excess crown, and of a minimum thickness as will accomplish such purpose The wearing course proper is then placed at uniform depth, compressed and finished to a true cross section, and will retain its smoothness practically unchanged The use of mechanical finishing equipment, similar to that used for portland cement concrete, has become widespread, and should be standard practice everywhere The steps are as follows.

1 Condition the old concrete surface by replacement of all broken areas Cut off flush to the pavement any old expansion joints or surplus bituminous crack filler Give a light paint coat of cutback asphalt or emusified asphalt

TABLE VII

TABULATION OF HOT-MIX RESURFACING OVER OLD CONCRETE

(Plant-mix with Asphalt)

	Location						
	California	Connecticut	Massachusetts	Michigan	New York	New York	Ohio
Date of Resurfacing	1927	1922	1931	1931	1925	1926–27	1931
Age of Concrete	13 years	5 years	15 years	9 years	5 years	12 years	13 years
Yardage	68,300	206	42,114	5,111	50,000	46,000	150,000
Depth							
Bottom course	*2¾″ av	1½″ binder	2″	None	1½″ binder	1½″ binder	1½″
Top course	2″	1½″ sheet	2″	1½″ sheet	1½″ mod top	1½″ Topeka	1″
Total	4¾″ av	3″	4″	*1½″	3″	3″	2½″
Cost per square yard	$1 38	$1 43	*$2 64	$0 60	$1 35	$1 28	$0 70
Annual Maintenance	0 006	Nominal	None	None	0 0088	0 01	
Traffic Density							
As constructed	3800	3000			*7000	4000	Heavy
1932	4900	8000	5000	1100	4000	4400	
Remarks	* Widening usually done at same time as resurfacing Asphaltic concrete Road X–Ceres N	An experimental section on main highway between New Haven and Hartford U S Route No 5	* Includes all items of grading-widened base, shoulders, etc Route 12, Wilbraham	* Will be reported later as to behavior of thin surfacing Manton, Wexford Co	* Traffic decline due to parallel road built later		Old Concrete widened with concrete shoulders and 20′ to 30′ asphalt center Route 422

2 If old surface is uneven or with high crown, place "evener" course just sufficient to take out such depressions and surplus crown
3 Roll
4 Place wearing course, usually 2½ inches loose, preferably with mechanical finisher
5 Roll
6 Apply asphalt coated chips (¼ × ⅜ inch size), at a rate of about ten pounds per square yard, broom evenly over the surface
7 Roll to smooth finished surface

Costs Construction costs vary throughout the country, according to local conditions, and also with varying degrees of old concrete condition Frequently much patching is required and often the old pavement is widened at the same time as it is resurfaced, using the coarse graded asphaltic concrete for both operations It is therefore usually advisable to call for bids at so much a ton complete in place Present day prices range from $4 00 to $7 00 a ton complete in place, including patching, widening and wearing course work For two-inch depth, this is at the rate of 40 to 70 cents per square yard Prices ten years ago ranged from $1 00 to $1 50 per square yard for three-inch depth

Maintenance Such surfaces require little or no maintenance for many years, except for occasional patching where further settlement of the old concrete may occur Over a period of ten years, the annual cost per square yard should not exceed one cent per year or $100 a mile for an eighteen-foot width pavement

Plant-Mixes Using Asphalt Laid Cold

Such plant-mixes include the Amiesite type, Colprovia, Macasphalt, Koldlaid and several other proprietary varieties, all of which may be manufactured under careful plant control in the correct proportions for maximum stability and then, by reason of delayed setting, may be shipped, handled and laid cold on the road surface where they reach their final consistency under the finishing operations

Thickness and Grading While these materials have been laid as thin as one-half inch in depth, experience has shown that two inches is about the minimum depth for long wear and low maintenance, and that unless the old concrete is in very bad condition no additional value is obtained with a compacted thickness of over three inches

Two different gradings are usually employed, the coarser size for the bottom course, and a somewhat finer size for the top The bottom course should be preferably a little thicker than the top

Construction Methods As with plant-mixes laid hot, a common fault in the past has been the placement of the wearing course in a single operation without regard to the condition of the old concrete The placing of the "evener" course in the minimum depth required to

produce a uniform cross section before placing the wearing course is much to be desired A method employed during the past two years to insure smoothness, particularly with the Amiesite types, has been the spreading with a blade grader in thin layers until a smooth "evener" course has been obtained, followed by the top or wearing course, also spread with a blade grader The mechanical finisher can be used very satisfactorily for the laid cold mixes just as for the laid hot mixes The construction steps are as follows

1 Condition old concrete by replacing all broken areas with the asphalt mix and thoroughly tamp in place Remove all surplus expansion joint filler and crack filler. Apply light paint coat over entire surface using either emulsified asphalt or cutback asphalt
2 Place "evener" course just sufficient to take out excess crown (if necessary) and fill all depressions.
3 Roll.
4. Place wearing course either in one or two layers according to type of mix employed.
5 Roll thoroughly until smooth and even

Costs Costs under present conditions will vary from $5 to $12 a ton, depending upon size of the job, length of haul, and other local conditions. For two-inch compacted depth, this will be at the rate of $0 50 to $1 25 per square yard Ten years ago costs were from $1 00 to $1 50 per square yard

Maintenance Plant-mix (laid cold) surfaces have the same general characteristics as plant-mix (laid hot) maintenance Annual maintenance costs for the first ten years (aside from foundation repairs) will not exceed one and one-half cents per square yard, or for a road eighteen feet wide, $100 to $150 per year.

Plant-Mixes Using Tar Laid Cold

In this type of surface the aggregate and tar are mixed in a central mixing plant, shipped to the job and applied cold to the concrete surface. Close control of the quality and grading of the aggregate, proportions, temperatures, and time of mixing insure a uniform and proper mixture

It has been well established that the minimum depth should be two inches after consolidation

Two grades of material are used, one for the bottom or evening course and a smaller size for the surface

The tar-coated aggregate may be spread by hand from dumping boards or mechanically through box spreaders.

Preliminary Preparation All broken areas in the old concrete which would furnish inadequate support should be removed and replaced. All surplus expansion joint filler and crack filler should be removed. All unfilled cracks should be filled with tar crack filler.

TABLE VIII

TABULATION OF COLD-MIX RESURFACING OVER OLD CONCRETE

(Plant-Mix with Asphalt) (Date December, 1932)

	Location					
	U S Route No 5 between New Haven and Hartford, Conn		U S Route No 6 Hartford-Providence, Rd	Mass	New York State	Maryland
Date of Resurfacing	1922	1922	1924	1932	1929	1926
Age of Concrete	5 years	5 years	10 years	10 years	8 years	12 years
Yardage	*Experimental sections			62,590	140,810	38,800
Depth					Type MM-4	
Bottom course	1½″ Amiesite	None			1½″	1½″
Top course	1″ Amiesite	2″ Amiesite	½″ Amiesite	2″	½″	½″
Total	2½″	2″	½″		2″	2″
Cost per Square Yard	$1 43	$1 43	$0 38	*$1 35	$1 01	$1 30
Annual Maintenance Cost per Square Yard	Nominal	Nominal		None	$0 001	Small
Daily Traffic Density						
At time of surfacing	3000	3000	2500		5500	
1932	8000	8000	7000	4200	4500	3500
Remarks	*These experimental sections were approximately 225 square yards each, and placed on heaviest traffic roads to determine relative wear			* Includes all work, widening, grading, widening 18′ concrete to 30′ and resurfacing		Marlboro Pike

Prime Coat A prime coat is not necessary with this type of construction

Construction Methods The construction steps are

1 Spread tar coated aggregate averaging $\frac{3}{4}$ inch in size to a loose depth of two inches
2 Roll
3 Spread tar coated chips to a loose depth of $\frac{3}{4}$ inch This coat may be shaped with a drag or a finishing machine
4 Roll to the finished surface

Costs A surface of this sort under present conditions will cost from $1 00 to $1 25 per square yard

TABLE IX

TABULATION OF COLD MIX RESURFACING OVER CONCRETE

(Tar)

Location	Military Road Niagara Co, N Y	Spencerport, N Y N Y Hwy 5529	Selkirk, N Y N Y Hwy 0508	Albany, Co N Y Hwy 5036	Suffield, Ct Connecticut State Hwy
Date	1930	1928	1927–1928	1929	1928
Age of Concrete	11 years		14 years	8 years	
Yardage	14,000	6,100	18,000	11,000	3,000
Depth					
Bottom course		2½" loose			
Top course		1" loose			
Total	2"	2½" compacted	2½"	2½"	2½"
Cost	$1 09		$1 40	$1 46	$1 20
Maintenance	None	None except for service cuts	To bring sunken sections up to grade $1800 to date	None	None

Maintenance The surface should not require a surface treatment for at least five years and probably will not need it for a longer period Maintenance costs for a ten year period should not exceed 15 cents per square yard If the old concrete settles and additional material is needed to fill up the low spots, these costs will be increased by the cost of the extra evening material

ACKNOWLEDGMENT

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