THE RESURFACING OF CONCRETE BASES AND PAVEMENTS WITH BRICK

By Geo F Schlesinger, *Chief Engineer and Managing Director, Natural Paving Brick Association*

SYNOPSIS

Some of the problems peculiar to resurfacing work are the method for joining on the new concrete usually required for widening, methods for correcting irregularities in the existing surface, replacement of worn out areas, and changes in grade and alignment Attention is called to the need for ascertaining whether or not the old pavement will serve adequately as a base for the new surface Owing to the combined action of weather and traffic over a period of years it has often reached a degree of stabilization that renders it more reliable than would be a new base course on a new subgrade Resurfacing old bases with brick has been more common Here an important consideration is the possibility, in the case of an old brick pavement, of using the old brick by relaying them on the side instead of on the edge

The report discusses the important question "When is it advisable to take the step of resurfacing?" It also points out that in addition to its economic justification the resurfacing of old pavements of any type has an appeal to the public, due to the continued use of the existing investment

Information regarding the resurfacing of concrete paved highways was secured from the state highway departments—and to a minor extent from county engineers—where there has been this type of improvement In an endeavor to secure data regarding brick resurfacing of streets a questionnaire was sent to 74 engineers of cities located in the brick using territory Replies were received from 30 The records and publications of the National Paving Brick Association and Proceedings of its Annual Meeting were other sources utilized

RESURFACING CONCRETE PAVEMENTS

No cases where brick had been used to resurface concrete street pavements were given in the answers received from the questionnaires sent to city engineers However, one case on record is the main street of Bettendorf, Iowa, where, in 1927, a six inch concrete pavement 50 feet in width was resurfaced with three inch brick on a cement sand bed The original concrete pavement was constructed in 1912

The resurfacing of concrete pavements with brick has had its principal application to worn concrete highways and not city streets The Illinois Division of Highways constructed over 60 miles of this type in 1931 and about an equal mileage in 1932. The experience of the Ohio Highway Department with resurfacing concrete with brick dates back to 1921 when State Route 332 in Geauga County was improved in this manner for a distance of 1.52 miles According to a recent report the

present condition is "good" The Indiana Highway Commission this year constructed its first brick-over-concrete resurfacing, the project being $3\frac{1}{4}$ miles in length on U S Route 41, south of Sullivan

General Principles

When a resurfacing project is being considered, the question always arises as to whether the old concrete slab will be satisfactory as a base for the new surface It is essential that the existing concrete be resurfaced before it has deteriorated to a point where its future adequacy as a base may be questioned This is especially true for a high type of resurfacing In considering the condition of the concrete pavement to be resurfaced most engineers consider that its past existence endows it with certain advantages as compared with a new base The combined action of traffic and weather over a period of years has tended to bring about stabilized conditions Failures due to slab weakness or subgrade conditions have usually been corrected For these reasons it is contended that there is less uncertainty regarding future eventualities than with a new base course on a new subgrade Additional curb and widening is a usual accompaniment of brick resurfacing This affords opportunity in the design for structural reinforcing of the old concrete slab if this is considered necessary There will be further reference to this in the discussion of design. Of course, the replacement with new concrete of completely disintegrated sections is a part of the reconstruction procedure

It is believed that addition to the structural strength of the old concrete is not the primary function of resurfacing In most cases structural weakness has not been the principal cause of the unsatisfactory condition of the existing slab Subgrade and concrete volume changes, frost action and the general effect of time and the elements may be mentioned as more potent factors However, the addition of $3\frac{1}{2}$ or 4 inches of brick and cushion to the thickness of the paving structure does serve to decrease the load concentration on the subgrade The principal reasons why the addition of wearing courses increases the service value of old concrete slabs are believed to be

(1) Progressive breakage of the concrete is arrested
(2) Protection is given against temperature and climatic extremes The new surface and widening completely envelops and waterproofs the top and sides of the old concrete
(3) The new smooth surface decreases traffic impact and checks further vertical displacement of the sections of broken slab.
(4) The direct abrasive wear of traffic is transferred from the concrete to the wearing surface. This is of especial consequence in the case of chained wheel traffic in winter

The effectiveness of wearing courses in adding to the service life of pavements is shown by the two-course sections of the Connecticut Ave-

nue (Chevy Chase) test road of the U S Bureau of Public Roads The surface courses in this case were laid on a 6-inch 1–3–7 concrete base

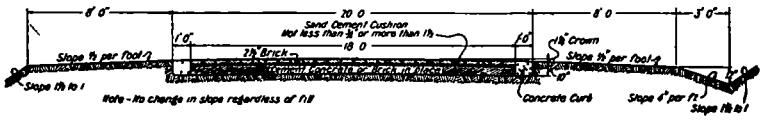

Figure 1. Indiana Highway Commission (Standard)

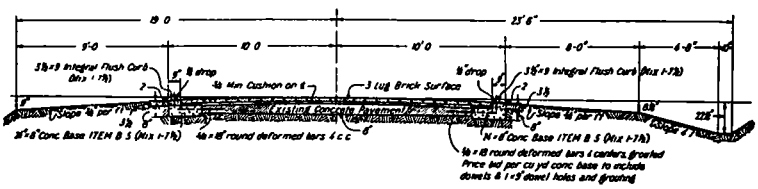

Figure 2 Ohio Highway Department (Route 73)

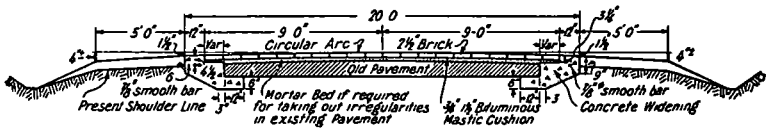

Figure 3 Illinois Division of Highways (1932 Standard)

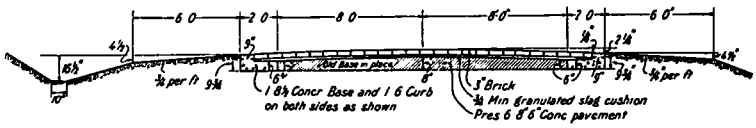

Figure 4 Ohio Highway Department (Route 3)

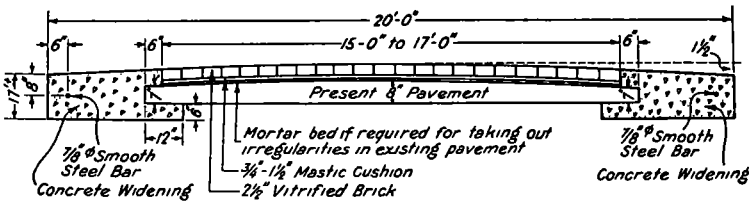

Figure 5 Illinois Division of Highways (1931 Standard)

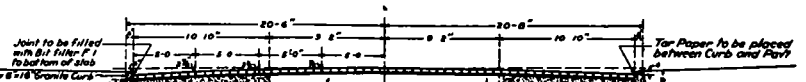

Figure 6 Ohio Highway Department (Route 8)

Design Features

Figures 1 to 6 show cross-sections for brick resurfacing over concrete pavements which are typical of the latest practice

The design of a pavement structure for the resurfacing of an existing concrete slab with brick has been productive of variations in details It is the almost universal practice to accomplish widening at the time the pavement is resurfaced If the concrete is 18 feet in width, it is customary to use a 12-inch curb raised above the existing slab, on each side, providing a header for the new brick surface and making the total new pavement width twenty feet (Figure 1) If the concrete width is less than 18 feet the practice varies The total width of twenty feet can be attained entirely in the new concrete curb (Figure 5), or the old slab can be extended with new concrete with an integral curb of standard dimensions (Figures 2–3–4–6) The latter method is in greater use and has in its favor a more pleasing appearance because of a uniform width of brick surface and concrete curb and a greater affective travelable surface, as vehicles are prone to keep off the curb

In some cases a mechanical connection has been provided between the old slab and the new concrete widening with the object of preventing possible vertical displacement at the junction line In one method the new concrete has been extended under the old slab a depth of 6 inches and a width of from 6 to 12 inches, with reinforcing (Figure 6) or plain (Figures 3–5) The Illinois section of 1931 (Figure 5) also provided for a projection over the old slab, but this was changed in 1932 when the uniform 12 inch curb was adopted (Figure 3) The 1932 design also economizes in concrete by using a beveled or sloping curb bottom In the Illinois designs a continuous $\frac{7}{8}$ inch round lubricated edge bar is placed in the new concrete curb In one design used in Ohio $\frac{5}{8}$ x 18 inch round deformed anchor bars were inserted and grouted in the old slab (Figure 2) This practice was later discontinued because of doubtful value and difficulty in construction There is a difference of opinion as to whether a mechanical connection is worth the additional cost Arguments against this practice are that the old compacted subgrade is disturbed and proper construction is difficult Test cores taken in the Illinois work showed in general that the concrete was being forced under the slab satisfactorily although it was necessary to permit a slump of 4 to 6 inches

In the Indiana standard section (Figure 1) and in a majority of the projects constructed in Ohio (Figure 4) no attempt has been made to join the new base or curb with the old slab Ohio, which formerly made the curb 12 inches wide, has now adopted a 9 inch width as standard (Figure 4) For reasons already given this increases the surface that will normally be used by traffic

Construction Methods and Specifications

The proper construction of the brick course itself presents no problems that are peculiar to resurfacing In line with general practice lugless wire-cut brick (vertical fiber) of $2\frac{1}{2}$ inch depth have been used

west of Ohio and 3 inch lug brick in Ohio The type of lug brick, introduced about two years ago, that is meeting with almost universal favor is the vertical fiber lug This differs from the old wire-cut lug brick in having the wire cut instead of the die side in the pavement surface Difficulties in manufacturing this type of brick have been overcome and with proper workmanship in the application of the asphalt filler, the wire-cut surface provides a non-skid feature The recently developed "surface removal" method of filler application insures a clean brick surface immediately after completion

There is a divergence of practice in the method of correcting irregularities in the old slab and in the type of bed or cushion course The method used in the former is to some extent dependent upon the type of material in the cushion A plain sand cushion should not vary in the thickness and the base should be brought to a true cross section For granulated slag—which has cementing properties—, sand cement and bituminous mastic bed, a variation of $\frac{3}{4}$ to $1\frac{1}{2}$ inch is the usual tolerance permitted For correcting large irregularities, a cement sand mortar—1 3 proportions—is the material commonly specified Bituminous concrete has also been used The Illinois requirement is

"The mortar bed shall be used only when necessary to correct large irregularities in the surface of existing pavement Other irregularities shall be taken out by means of the bituminous mastic cushion, but the thickness of the same shall not be less than $\frac{3}{4}$ inch nor more than $1\frac{1}{2}$ inch As soon as the mortar bed has been placed as provided herein, it shall be protected against rapid drying by curing with burlap "

Following is a description of patching and correcting depressions on several Ohio projects (1).

"All weak and broken places in the old pavement were cut out and replaced with concrete base at the time that the curbs were being built On three of the jobs asphalt binder was used to level up all depressions where the cushion would be more than $1\frac{1}{2}$ inch deep If the depressions were shallow $\frac{1}{2}$-inch stone with about 6 per cent bitumen was used A templet riding on the curbs was used to locate where binder was necessary and to strike it off before rolling The amount of material necessary is rather difficult to estimate on account of the variation in different old pavements and in the way the curbs are built, one job required 330 tons per mile, another 210 tons "

The function of mortar or bituminous materials used in correcting irregularities in the old slab is as a filler for shaping up and not to add structural strength Being confined under the brick course and cushion proper and between the curbs there is little opportunity for displacement even if cracking occurs

According to tests and studies of the U S Bureau of Public Roads, a bedding course of plain sand is to be preferred to one of cement sand (2) This would indicate that a flexible type of cushion such as bituminous

mastic is desirable The development and extensive use of the bituminous mastic cushion has been coincident with the brick resurfacing program in Illinois In sections of the country where granulated blast furnace slag is not economically available mastic cushion is recommended for all brick paving construction It is stable but resilient, will not sift down into small cracks, has water proofing qualities and would seem to be especially applicable to brick resurfacing construction

In the resurfacing constructed in Illinois in 1931 expansion joints, extending the full depth of the pavement, were placed They were four inches in width at about 1,000 foot intervals and filled with asphalt It was also the practice to locate them at points where blow-ups had occurred in the old slab In the projects constructed in 1932 this feature of design has been eliminated This conforms to general practice for brick surface construction as transverse expansion joints have not been found necessary with a bituminous filler

The following, taken from the 1932 Specifications of the Illinois Division of Highways is descriptive of the required "Order of Work "

"The construction of the concrete widening shall be done on both sides simultaneously The removal and replacement of defective and broken pavement shall be done before or simultaneously with the concrete widening There shall be no hauling over the old concrete pavement until the new concrete in replacement and widening shall reach a beam strength of 650 pounds per square inch The hauling of all brick and other materials, except for the mortar bed, the mastic and the sanding, shall be done before the mortar bed is placed The mortar bed may be placed where directed by the Engineer as soon as the strength of the new concrete reaches 650 pounds, and no traffic will be permitted over the mortar bed for a period of 18 hours or until directed by the Engineer The placing of the mastic cushion and laying of the brick may proceed on the next morning following the placing of the mortar bed As soon as the brick surface is thoroughly sanded and rolled, the pavement may, by direction of the Engineer, be opened to traffic "

It is the general practice to require that all cracks in the concrete in place be thoroughly cleaned and filled with bituminous material The excavation for the widening curb would appear to present difficulties especially for the beveled section used in Illinois (Figure 3) The specifications require that "all loose earth shall be removed and any excavation outside the dimensions shown on the detailed cross-section shall be filled with concrete at the Contractor's expense " However, contractors have been very ingenious in devising equipment to cut the section without hand labor It is accomplished by several trips of a tractor drawn excavator which has changeable cutting blades

The basis of payment varied somewhat but that used by Illinois is recommended It is commented upon as follows by Mr C M Hathaway, Engineer of Construction, Illinois Division of Highways (3)

"The typical bidding sheet called for the following quantities a unit price per cubic yard on portland cement concrete in curb widening, which included excavation beyond the edge of the old pavement and underneath it. Some discussion arose as to the method of measurement of concrete and it was finally decided to measure and count batches rather than to attempt actual measured dimensions This was easily done due to the fact that all materials were proportioned by weight The unit price for concrete widening also applied to concrete used in patching There was a unit price per square yard for removal of old pavement and a unit price for mixing and placing the mortar bed, and this latter was figured on the basis of the number of batches used Brick resurfacing was paid for on the square yard basis, including the one inch mastic cushion, the placing of brick, filling joints and sanding the surface"

Costs

It has been practically impossible to secure cost data of brick resurfacing over concrete as such At the time these projects were constructed opportunity was taken to revise alinement and grade These changes of course required entirely new concrete bases Curve superelevation, gutters and widening of drainage structures have been included in many of the contracts The cost quantities can not be segregated so as to exclude expensive items the necessity for which was not created primarily by the resurfacing operation This should be kept in mind when considering average cost per mile figures

In Illinois the average cost per mile for 36 40 miles of brick resurfacing of concrete and widening to 20 feet, in the June 8, 1932 letting was $26,755 00 There were 14 distinct projects, in widely separated locations, varying from 0 94 to 8 24 miles in length On these projects the unit bid price for the brick pavement (including mastic cushion) varied from $1 40 to $1 72 per square yard, the average being about $1 50 per square yard

On three projects, totaling 11 46 miles, for which bids were received by the Indiana Highway Commission on May 19, 1932, the low bids averaged about $21,000 00 per mile There was a considerable quantity of new base construction included in these projects It will be noted that the Indiana standard cross-section for brick resurfacing of concrete is economical in regard to the curb and widening detail (Figure 1)

RESURFACING OF CONCRETE BASES

In the form that this type of reconstruction usually takes it is really a replacement operation That is, the condition of the original surfacing material having become unsatisfactory, it has been removed and replaced with a new surface course after the old concrete base has been properly rehabilitated In the case of brick pavements, in some

instances, the *old brick* (or a portion of them), after removal, have been relaid on the existing concrete base There are also projects where a new brick top course has been laid on an old two-course concrete base pavement without removal of the original surface This may be considered as resurfacing a concrete base although there is an old intervening course

Base Preparation

The question of the adequacy of the old base in place arises as in the case of resurfacing concrete pavements It can likewise be advanced that, similar to an old pavement, an old base has inherent attributes in its favor City streets differ from highways in that, because of underground drainage systems the subgrade conditions are usually more favorable, also established curb grades in most cases limit or preclude raising the elevation of the new surface

In 1931 the surfaces on two old asphalt block streets in Newburgh, N Y , were renewed with vitrified brick, involving 38,800 square yards The old pavement was almost 20 years old and the base course was five inch concrete of unknown proportions According to the city engineer, "for the most part the old foundation was found to be in good condition, though not quite as uniform as to surface as present day practice would call for" (4)

In Albany, Georgia, where, in 1931, brick were relaid on two streets, the six inch concrete base 26 years old required practically no repairs (5)

Concerning the preparation of an old concrete base for a new brick surface in Bloomington, Illinois, the city engineer reports (6)

"The asphalt top and binder were removed with teams and plows, then cut into smaller pieces for handling After the removal of the wearing surface and binder the old base was thoroughly brushed with steel brooms and cleaned of all loose materials All depressions one inch or greater below the general contour of the concrete base were removed and new concrete put in All concrete extending above the contour of the old base was also removed We had estimated 150 square yards of new base for these patches, where we thought the old base would be bad but we only used 50 square yards of new base Wherever the old base appeared bad it was entirely removed and new base built All new base was 1–3–5 mix and conformed to the grade of the old base Estimating how much of the old base would have to be removed was more or less of a guess since it was covered with the asphalt top when we made our estimate The smaller depressions which were one inch or less were simply filled in with sand when the cushion was applied but as these were not deep nor wide we thought it was not worth while to remove them The old base was in very good condition considering that it had been built for twenty-eight years and we permitted the contractor to haul bricks in over it "

Concerning the concrete bases in Lima, Ohio, on which large areas of brick pavements have been salvaged and relaid there is the following comment (7)

"If the base is bad in places we replace and properly re-enforce it, so there will be no danger of settlement We do not feel especially concerned about the quality of the base That base has been there for twenty-five or thirty years and we feel that its weakness, if any, has been revealed long since The ground beneath it is established and hard-packed, and we do not feel there is any chance for the base to settle any more except in case of service cuts"

Costs of Brick Replacement

The cost per square yard on the projects reported on varied from $1 63 to $3 16

In the Newburgh, N Y, work completed in 1931, and previously mentioned, the cost per square yard was $2 05 Vertical fiber lug brick, 2½ inch depth, were used and the freight rate on the brick was considerably higher than the average.

Cities, not included in the replies, in which concrete bases have been resurfaced with brick are Pensacola, Fla, Newnan, Ga, New Orleans, La, Flint, Mich, Hattiesburg and Jackson, Miss, Newburgh, N Y, Akron, Lima, Springfield, Toledo, Ohio, Checotah, Okla, Pittston, Pa

Brick Resurfacing over Two-Course Pavements

Examples of this type of brick resurfacing where the original base was concrete are not numerous In Summit County, Ohio, in 1928 and 1929, a total of 11 1 miles of four inch grout filled brick on a four inch concrete base with two inch sand cushion, 14 feet wide, was resurfaced with brick and widened to 20 feet using a 12 inch concrete curb 15 inches in depth On the first project completed the bricks were 2½ inch plain wire cut and on the later construction 3 inch wire-cut lug Asphalt filler, granulated slag cushion not to exceed 1½ inches, and asphaltic binder to "level up" were used According to Mr H G Sours, County Engineer, "while extensive patching had been done the general condition, as far as the surface was concerned, was fair and as a foundation the old road was considered to be very good," (8). The cost of these projects, including repairing and shaping the old pavement, widening to 20 feet, renewing driveway pipe, grading and widing shoulders, and erecting guard rail was from $29,500 00 to $32,500 00 per mile for 3 inch brick and $27,000.00 per mile for 2½ inch brick A recent inspection showed their present condition as "excellent."

In Springfield, Illinois, several old streets originally constructed of brick on a concrete base have been improved by the addition of a brick surface course In 1932, Capitol Avenue, 1120 square yards, was resurfaced with 2½ inch brick at a contract price of $2 02 per square

yard, North Grand Avenue, 5,000 square yards, with 2½ inch brick at a contract price of $2 10 per square yard The 35 year old pavements were brought to a true cross section with cement mortar, and a bituminous mastic cushion and asphalt filler was used

The sheet asphalt pavement on a four inch concrete base on State Street, in Sycamore, Illinois, constructed in 1904, was resurfaced with a brick wearing course in 1927 The old asphalt was removed only where necessary in order to conform with the new cross-section Holes in the old pavement and an old street car track area were filled with water bound macadam, compacted with a ten ton roller A one inch limestone screening bedding course with 2½ inch asphalt filled brick surface completed the pavement The cost complete, including the new macadam for the car track area, was $2 00 per square yard

Gutter Construction

On concrete base resurfacing projects, it is frequently impossible or undesirable from the standpoint of economy to raise the old curbs to provide sufficient gutter In some cases the original curb height was ample to allow for additional surface depth When this is not the case and the new surfacing is brick, the difference to be taken care of can be eliminated or minimized by the use of a tapered or wedge shaped brick at the gutter line Such a brick for example would taper from 3 inches at one end to 2½ or 2 inches at the other Several courses of thinner brick are then laid at the curb to give the required gutter section If necessary, the depth of cushion course can also be decreased—one-half inch being quite feasible especially with bituminous mastic

Relaying Brick on Concrete Bases

There is no difference between this type of resurfacing and that which has been referred to previously as replacement except that instead of new material for the new surface course the old brick are re-used in whole or in part Brick is unique in this respect among manufactured paving materials Of course, new filler and usually new bed material are required

As the removing and cleaning of the old brick before relaying is entirely a labor item, the cost will vary with the wages paid The cost of cleaning is also dependent upon the type of filler used in the original construction The extreme conditions would be represented by sand filler and a rich cement grout filler Because of the factors mentioned the cost among different projects has varied from $1 00 to $12 00 per thousand of brick

In most of the old brick pavements the bricks were laid on edge When relaid they are usually laid flat-wise, according to present day practice, and there is a gain in surface area This fact affects the percentage of salvage measured by the area covered by the relaid brick

In some cases this has actually resulted in a salvage greater than 100 per cent and a surplus of brick which were used for additional paving The general average is 75 to 80 per cent Due to the increase in manufacturing costs since the brick pavements were originally constructed 20 to 30 years ago, the relay value of the brick is in many cases materially greater than the original cost

Records show that a considerably larger proportion of old brick pavements have been relaid on reconstructed bases of the flexible type and on new concrete bases than on old reconstructed concrete bases This is because most of the older brick pavements were laid on stone, gravel or sand bases, which in many cases were simply a thin bedding course over the earth subgrade Excellent results can be secured in relaid brick pavements if care and skill are used in their construction Many of these projects have the appearance of new brick pavements

Costs

In Lima, Ohio, in the last eight years, 72,000 square yards of brick pavement have been taken up and relaid on old concrete bases, at an average cost of $0 97 per square yard The old brick had been in service from 22 to 33 years and the salvage averaged about 80 per cent These relaid pavements have required practically no maintenance to date

In Albany, Georgia, in 1931, the brick on Washington Street, 56 feet wide, were taken up and relaid on a section 1,800 feet in length The original pavement was laid in 1905 and the construction was four inch repressed brick top, tar filler, on two inch sand cushion with six inch concrete base. Following is a detailed statement of the cost

Labor	
Taking up and cleaning brick	$0 1525
Hauling sand and pulling sand cushion	0 0312
Relaying brick surface	0 1563
Heating and pulling asphalt	0 0050
Cost per square yard	$0 3450
Material and Equipment	
Asphalt	0 1070
Incidentals, tools and depreciation of machinery	0 0430
Insurance—Liability and compensation	0 0130
Cost per square yard	$0 1630
Total cost per square yard	$0 5080

"These prices paid for supervision and labor were as follows Four foremen were used, two at $40, one at $30 and one at $20 per week The brick dropper was given $5, the sand cushion man $4 and all others $1 25 per day The brick cleaners were paid $2 50 per thousand Asphalt cost $21 30 per ton delivered As the sand came from city-

owned property no charge was made except for the hauling, which averaged only a mile The cost per square yard does not give any credit to the job for 17,000 bricks that were left over, nor to the bats that we have run through a crusher and utilized as aggregate for concrete work of various nature" (9)

On another street relaid the same year the salvage was about 80 per cent and the bricks were more difficult to clean as the original filler was cement grout The cost of this project was $0 76 per square yard

CONCLUSION

In considering the reconditioning of an existing pavement there is the broad question as to *when* it is advisable to take the step Without considering the widening feature, it has been said that a pavement should be reconstructed when it is at the end of what has been termed "its economic life" Dean T R Agg, well-known highway economic authority, has said that, "At the end of its economic life, the roadway surface has deteriorated to its salvage value" (10) He adds that, "It is conceivable that by careful maintenance a roadway surface might be continued in service after it had attained its economic life but the cost of maintenance would be such that it would prove economical to replace the roadway surface instead of endeavoring to prolong its life" Whenever the cost of service from an existing surface is greater than from a new surface the economic life of the old surface has been exceeded The theoretical economics of the problem of resurfacing only, are complicated by the desirability or necessity for widening which may be the major reason for the improvement Also for economic reasons it may be advisable to resurface at the same time instead of postponing this operation for several years The need for widening is of course determined by the volume and character of traffic

From the cost figures given in this report it can be seen that in some cases the cost of resurfacing and widening concrete pavements with brick has approached the cost of replacing the old pavement with a widened pavement of the same type The justification for such a procedure must rest upon the grounds that greater service can be secured from the new two-course pavement structure with a brick surface It should be more economical on the basis of annual cost, considering maintenance, depreciation and life expectancy It is not appropriate to discuss this phase of the subject in this report but the author is firmly of the belief that this is the case.

In addition to its economic justification the resurfacing of old pavements of any type has an appeal to the public that highway administrators would do well to recognize Powerful opposition to highway transportation and the maintenance of the highway program has been manifest recently A criticism frequently heard is that the public has been deceived regarding the life of highways—that they are wearing

out before they have been fully paid for. However, when an old pavement is resurfaced it logically can be maintained that it is not being thrown into the discard The original investment is being preserved and the old pavement will continue to serve for many years as a necessary part of a new paving structure of a higher type

SUMMARY

1. Resurfacing of concrete pavements has, to date, had its principal application to concrete highways not streets. Illinois has resurfaced about 120 miles in the last two years

2 Old concrete slabs should be adequate structurally or properly strengthened before resurfacing.

3 The stability developed in the old pavement structure through the years of its existence with proper maintenance is an important advantage

4. Reasons why resurfacing increases service value are not primarily structural

5 Design details vary principally because of the method of accomplishing widening and the desirability of connecting the curb and widening with the existing slab

6 Materials used to correct irregularities in the old slab act as filler.

7 Bituminous mastic bed is especially applicable

8 Expansion joints in brick pavement with bituminous filler are not considered necessary

9 Excavation for widening curb can be performed with power drawn equipment

10 Cost data of brick resurfacing over concrete, as such, can not be segregated from items not primarily inherent to the resurfacing operation

11 Concrete bases have been resurfaced with brick by replacing old surfaces, by relaying the old brick, or with a new brick surface over an old two-course pavement

12 Adequacy of the old base must be considered

13. Examples of brick resurfacing over two-course pavements not numerous

14 Tapered brick and thinner cushion can be used at gutters

15. Cost of removing, cleaning and relaying brick varies with labor wages and type of filler

16 Salvage averages 75–80 per cent with 100 per cent in some cases due to gain in area

17 Costs for relaying have been as low as $0.50 per square yard.

18. Existing pavement should be resurfaced when it has attained its economic life

19 Brick resurfacing must justify itself on economic grounds

REFERENCES

(1) "Resurfacing and Widening Highways with Vitrified Brick," by H G Sours, 1930 Proceedings, National Paving Brick Association

(2) "Thin Brick Pavements Studied," by L W Teller and J T. Pauls, Public Roads, September 1926

(3) "Paving Brick for Resurfacing," by C. M Hathaway, 1932 Proceedings, National Paving Brick Association.

(4) "Replacement with Paving Brick in Newburgh, N. Y ," by Wm J Blake, City Engineer, 1932 Proceedings, National Paving Brick Association

(5) "Relaying and Salvaging Paving Brick in Albany, Ga ," by C Q Wright, City Manager, same citation.

(6) "Resurfacing Old Pavements with Vitrified Brick," by Scott E McCullough, City Engineer, Bloomington, Ill , 1930 Annual Proceedings of the National Paving Brick Association.

(7) "New Pavements from Old," by Herman Geiser, Supt. of Streets, Lima, Ohio, same citation

(8) "Resurfacing and Widening Highways with Vitrified Brick," by H G. Sours, 1930 Proceedings, National Paving Brick Association

(9) "Relaying and Salvaging Paving Brick in Albany, Ga ," by C Q Wright, 1932 Proceedings, National Paving Brick Association

(10) "Theory and Calculation of Highway Transportation Cost," by T R Agg, Engineering News-Record, January 10, 1924

RESURFACING WITH PORTLAND CEMENT CONCRETE

By E M Fleming, *Manager, Highways and Municipal Bureau Portland Cement Association*

SYNOPSIS

Concrete is being widely used for resurfacing pavements which have proved inadequate for modern traffic, especially where additional width and greater strength are required The report summarizes the results of surveys of concrete resurfacing in various parts of the country, describing the effect of different types of joints, different thicknesses of resurfacing and of widening, cushion courses between new and old slab, base condition and aggregate size and reinforcement, on the service rendered by the pavement Designs for resurfacing are suggested and a discussion of cost as compared with removal and replacement is included "

No careful record has been kept of pavements resurfaced with concrete. The oldest recorded concrete resurfacing was a 10-foot strip in the center of Union Street at Schenectady, New York, built in 1909