results are noticeable in the work produced. The engineer who produces a good set of plans will inspire and maintain the confidence of all concerned, as it is only natural to expect that poorly drawn plans may result in careless execution of the work.

RECONSTRUCTING OLD ROADS TO MEET PRESENT DAY REQUIREMENTS

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The capacity of a pavement of any given width has been both theoretically and practically analyzed. Theorists have evolved formulae which give varying estimates, but are on the whole generally faulty in that they cannot take into consideration the personal equation. The writer has made many careful observations and has come to the conclusion from these observations, together with a study of the observations of others, that a one lane pavement has a practical capacity of about 450 vehicles per hour; a two lane pavement has a capacity of about 1,400 vehicles per hour; a three lane pavement has a capacity of about 2,000 vehicles per hour; and a four lane pavement a capacity of about 3,000 vehicles per hour. The figures given are exact for a two lane pavement, the actual maximum capacity in this case being in the neighborhood of 1,600 vehicles per hour. The figures given for the one lane pavement are meant to cover a single one lane pavement under average conditions of traffic going both ways, and does not represent two adjacent but separated one lane pavements. The figure given for the four lane pavement is approximate, while that given for the three lane pavement is theoretical.

There is little doubt but that ten feet is the practical width for one lane and multiples thereof for two or more. In the writer's opinion there is very little excuse for the construction of a three lane pavement, except that it be as a transitional type, so designed as to permit its completion as a four lane or its duplication as a dual three lane pavement. There has been considerable discussion in Ohio with reference to the construction of two twenties as against one forty. The capacity of two twenties would only be 80% of the capacity of one forty. There are occasions, however, where other conditions might intervene, making the two separated pavements desirable; the aesthetic, and presence of car tracks in the middle

space. If this dual type is to be at all safe, one way traffic should be enforced on each side. The species known as the three lane pavement is, in the writer's opinion, desirable only near fairly large centers of population where the daily movement of traffic is excessive in one direction at a given time.

Salvaging Old Macadam

Numerous samples exist in the east where old macadam has been salvaged through the center with lanes of concrete, brick and other types along each side. In general this type of salvage is practical, especially where the appearance of the surface of the widening is sufficiently different from the appearance of the surface of the central portion of salvaged macadam to secure the desired separation of traffic. The capacity of the over-all width is not so great as it should be if it were all of one type, due to the fact that traffic will generally keep to the right, avoiding the central portion of salvaged macadam, especially when it is not so smooth riding as the widening. In all such cases widening of this character, especially with concrete strips, should be approximately 42 inches or 10 feet on each side, if proper consideration is given to the requirements of traffic. It has been the writer's repeated observation that the 42 inch strip is sufficient in width for fast as well as slow moving vehicles to keep the right wheels centered thereon. The desirability of the width of 10 feet is, of course, self-evident.

The three lane pavement should under no circumstances be centerlined for the purpose of guiding traffic. All others should be centerlined, especially on curves both vertical and horizontal and on tangents where traffic is heavy. This centerlining, although expensive, is well paid for through decreased accidents and through decreased shoulder maintenance.

The salvage value of an existing type is in many cases of minor importance. Probable future traffic requirements should not generally be the sole guide in determining the economy of reconstruction. The use of this word "economy" is frequently misleading. It is here used in its stricter engineering sense and is meant to apply to the final cost of the reconstructed project and not to its initial cost. A road will too frequently be reconstructed at $10,000 per mile where $30,000 would be a more economical investment. This will apply especially on sections where alignment and gradient are either or both faulty. Roads constructed ten and fifteen years ago were too frequently constructed without vision, and it is a question of grave doubt whether we are even at the present day doing much better in a great many places. It is difficult to estimate the cost to the traveling public of a year's time in rounding a square turn on a road even of minor importance. It is idle here to discuss the petty reasons for our

failures to properly relocate such a turn. It is only too frequently a lack of stamina rather than a lack of engineering conception. The same applies to vertical curves of short sight distance, the crest of which is in front of Farmer Jones' barn; the same applies to abrupt grades and to numerous other conditions which tend to increase the hazard in driving. The State of Ohio is awake to right of way problems and is doing its utmost to remedy the mistakes of the past in correcting situations arising from the above where extra property is required and in securing extra parallel right of way over the more important roads where widening is soon to become a necessity, or where it is already a necessity but adequate funds have not yet been provided.

It is an economic fact that the less the investment in the existing type of pavement the less emphasis should be placed upon its salvage value under average conditions. The macadam type properly constructed frequently has a very high salvage value for fairly heavy traffic. We have salvaged a number of such types in Ohio with merely a waterbound course over the top of the old; others by feather edging to reduce the crown and placing thereon a penetration top, others by a combination of the above with concrete edgings for an over-all width of 20 feet. It will be well to remember that this concrete edging for a width of this type is not practical for any traffic unless the strip is 36 inches to 42 inches in width. It is an economic blunder to construct curbs on this type of less width.

Widening Concrete Pavements

Numerous blunders have been made in widening concrete pavement. If the existing pavement is 10 feet wide and in condition considered adequate for 100% salvage value, the widening if placed on one side only should be of equal width in spite of the fact that the prevailing standard might be 18' on either end of this section. There are two reasons for this. The widened portion of equal width creates a central center line, whereas if an 8-foot strip is placed alongside a 10-foot strip the heavy traffic using the former will drive dangerously close to the joint, materially increasing maintenance and decreasing the probable life of the pavement. On the other hand if it is considered economically necessary to construct nothing more than an 8-foot width in this particular instance it will be much preferable to use 4 feet on each side of the existing 10 feet rather than to use 8 feet on one side.

The writer has one four-mile section in mind widened in this way from 10 to 18 feet, using a 4-inch strip on each side. This work was completed three years ago. Previous to its completion numerous failures had been occurring in the old 10-foot section and it was presenting a serious traffic hazard.

The widening contract included a reasonable amount of replacement in the existing 10-foot section and the result has been that in three years not one yard of concrete has been replaced in this section in spite of the continually increasing traffic, a concrete pavement to be widened from 16 feet, or thereabout, to 20 feet should, if at all possible, be widened on one side only, not from the standpoint of first cost but in order to keep traffic away from the edge of the old 16-foot pavement as much as possible. The same would in general apply to a brick pavement.

Widening Brick Pavement

It is unquestionably of considerable merit to contemplate the widening of a brick pavement with brick. This would be especially true if the character of the design would agree with that of the existing pavement. It is a psychological fact that traffic desires uniformity in superficial appearance if traffic is to be distributed over the entire driving surface. A 16-foot brick pavement widened to 20 feet with two 2-foot concrete curbs is still a 16-foot section. This is not a mental attitude of the writer but is the result of careful observation of a number of miles of this type of pavement existing in Ohio. Ninety per cent or better of the traveling public is never on this 2-foot curb. The only vehicle which uses it in any large way is the four-wheel truck. Trucks with trailers weave a great deal and very little advantage is secured in this instance. Automobiles never use it. It would have been a far better investment to have placed a 42-inch curb on either side rather than 24-inch, and in my judgment infinitely better still to have placed a 10-foot pavement on one side.

Concrete replacement curbs along old brick pavements should be either 8 inches or 42 inches. The widening of this type to an additional 10 feet would undoubtedly serve traffic better if this were of brick rather than concrete. In case only a small percentage of the brick or concrete pavement is salvagable and it is found necessary to virtually discard the same, we in Ohio have frequently found it advantageous, economically, to resurface one with the other. This, of course, would not apply if the concrete or brick were in very bad condition in so far as their resurfacing with brick were concerned. We have found that on resurfacing these types with concrete, where the new width is greater than the old, proper reinforcing over the edge of the old pavement, in some cases after three or four years' service, has prevented the formation of cracks over the old pavement edge.

There are a number of other factors that should be considered. The prime desideratum of modern traffic is a smooth riding surface. Surfaces presenting depressions greater than ½ inch are objectionable to fast moving traffic. An abrupt

depression of ½ inch creates a heavy impact where heavy traffic is involved. It is hardly necessary to dwell at length upon this item. It is only necessary to compare construction of 1927 with that of 1920. In Ohio we have done considerable seeding of banks to protect against wash. This is illustrated in Figs. 1 and 2. We are frequently prone to con-

Fig. 1. Dressing Bank for Seeding.

Fig. 2. Slope Seeded.

struct drainage structures of insufficient width. It is financially excusable to permit a narrow structure to remain where the structure is in good condition and the cost excessive. It is, however, bad practice to reconstruct the average small drainage structure on a two-lane pavement without allowing

at least 3 feet on each side in addition to the width of the pavement. It is a common experience that the motorist requires approximately this extra clearance in order not to move toward the center of the pavement as he is passing a drainage structure. In my opinion the structure must be rather expensive indeed not to warrant at least 20 feet for a two-lane pavement.

Future Traffic Developments

The development of buses in the next twenty years will prove amazing. It is my opinion that 20 years hence, 90% of all travel under a 100-mile radius will be by bus. Waiting stations, parking places and rest rooms must be provided at convenient and desirable intervals. Major highways must be lighted to permit the larger usage of the highway. Freight development will undoubtedly follow passenger, although perhaps in not so large a way. If we are to improve the highway properly and are to encourage this line of development, it should be encouraged by the night usage of a lighted highway.

Perhaps the largest development of highways within the next ten years will be that of the secondary and feeder lines. This is essential to reduce the steadily increasing costs of agriculture and either to offset the general drift toward the city or to facilitate the transportation of agricultural products to the centers of population. In the carrying out of this idea it must be borne in mind that in building roads of this character, whether they be secondary roads on the state system or other light traffic roads, the mistake should not be made of creating a type in excess of the requirements of traffic for perhaps ten years to come. We in Ohio have made some mitsakes in the development of this type of road in that we have not gone carefully enough in some instances into the construction of a satisfactory grade. Any road that might be expected to carry as much as 200 vehicles per day by 1930 should have a grade so constructed that it will permit of a more durable type of pavement to replace the temporary improvement where needed. Roads that will not carry more than 200 vehicles by 1935 should fall within the class which needs no particular attention to the subgrade or to certain other features of gradient and alignment. It is true that there will be exceptional cases where excessive costs might be incurred at special points. These locations might temporarily be passed up and the situation taken care of by adequate marking to control the flow of traffic.

At the end of 1927 the State of Ohio had on its secondary system of roads approximately 4,000 miles of this type of surface constructed of traffic bound gravel, limestone and slag. It is quite evident that we failed to start soon enough

on this line of development. We have been amazed in a great many instances at the increase in traffic over routes thus improved, where formerly there had been a discontinuous improvement, causing traffic to detour during bad weather. Under average financial conditions any state will find it difficult to come up with traffic development by constructing $30,000 per mile improvements at the start. At the same time an excessive development of the cheaper type where higher maintenance costs are bound to follow might lead to financial disaster from the standpoint of upkeep. We should endeavor at all times to keep in mind the probable future traffic of any given road and place improvements of this character accordingly. On all gaps in roads that will unquestionably be of major importance in the near future, the mistake should not be committed of developing an inferior gradient and alignment.

Surface Treatments

We have found that about ¼ inch of material for 100 vehicles daily is worn out annually on the traffic bound type of pavement. Apparently the surface treatment of this type is an economic necessity after traffic has reached 600 or 700 vehicles per day. If we take into consideration the added convenience to traffic on this type we can readily see that it might be extremely desirable to surface treat such types perhaps regardless of the volume of traffic.

We have well constructed traffic bound roads that have been surface treated and are now carrying 2,000 vehicles a day as an average for the year at not much greater cost than some of our other pavement types. It is not unusual to find sections of this type with traffic as high as 1,000 vehicles per day being maintained at an annual cost of $500 per mile. Many miles of the traffic bound type could be constructed by counties and townships annually on their feeder roads with narraw roadbeds and narrow surfaces capable of carrying as much as 200 vehicles per day and with a maintenance cost running perhaps as low as $200 to $300 per mile annually.

It would be difficult for me to adequately impress upon you the extreme necessity of conservation of material and adequate blade maintenance of this type of secondary roads. Easy riding surfaces are just as essential on this type of inferior road as on any primary road. The most glaring defect of maintenance as ordinarily practiced on secondary roads is the rough surface. The most common mistake made in the past has been in allotting funds for materials to be placed on the road and neglecting to provide for consistent and adequate maintenance.

Highway Finance

Financial conditions are so varied in the different states that it would be difficult indeed to give a rule that would apply generally. It is becoming more apparent that in the future taxes for whatever purpose will generally be decreased rather than increased. It is to be regretted that it is becoming increasingly difficult to provide additional funds to take care of increasing traffic requirements. The limit which property should pay as a direct tax for highway improvement has been reached or exceeded in a great many communities. The general cry has been to let traffic pay its own way. It is too big a problem to be analyzed here.

One basic principle that might be stated is, that from all funds appropriated for highway work an adequate sum should be set aside for the maintenance of existing highways. Another is that construction should follow the requirements of traffic. Each state should have as an economical minimum for highway work a sum capitalized at standard interest rates and based upon its total number of motor vehicles at an average estimated value of perhaps $500 each. A sum less than this is not adequate for normal development and maintenance, to say nothing of bridge replacements, grade crossing separations (both rail and highway), widening and reconstructing, and other specific betterments.

The big problem of the next 10 years will be that of adequately awakening the public to the fact that funds for highway work are far in arrears of the requirements of traffic.

RESURFACING OLD ROADS

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Preliminary to my paper proper on "Resurfacing Old Roads", I should like to comment on a few things which are appropriate subjects for discussion at the Road School and perhaps our best opportunity to discuss them with the county highway superintendents.

Because of the nature of the work of the state highway commission and the county highway superintendents, it is necessary that there be cooperation between these organizations in order to properly and most economically handle their problems.

We expect our local maintenance superintendents to cooperate in every way consistent with the county men and we will appreciate immensely their cooperation in return.