Selecting The Pavement To Use

(Continued from Page 1.)

but will refuse to put up any longer with the nonsense and guff that is being foisted upon them by the present Oregon advocates of good roads. Other states do not enter into a good-road campaign in the haphazard manner that Oregon voters are being urged to, and it is time that Oregon voters demanded that good-road enthusiasts study the road costs obtained in other states before they try to stampede them into a hair-brain policy of voting money for good roads without adequate provision to safeguard the spending of it.

To Get Good Roads at Right Prices Competent Engineers Must Direct Road Expenditures.

No matter how much the present advocates of good roads in Oregon may want you to believe it, there is no one type of pavement that is best for all road conditions, any more than there is one type of religion that fulfills the requirements of the human mind in all its many forms and developments. That there is a place for both the leading types of pavement, we will show in this article. And yet, in every case there is one pavement that will give better service than any other under the precise combination of conditions that prevails along any particular roadway, and by best service we mean good roadway at the cheapest ultimate cost during a life for the pavement of from 15 to 30 years. The selection of the best type of pavement for each roadway is an engineering problem that requires much engineering knowledge, as well as many years of experience with hard-surface pavements of the different types, in order that the solution arrived at will show itself, under the test of time, to have been the correct solution. It is simply absurd to think that automobile road-diviners can solve such problems with any approach to happy results.

The truth is that it is first necessary to make a detailed and careful study of the sub-soil conditions and of the topography along the site selected for the roadway, and then having determined these factors to ascertain the density and character of the present travel in that section of country as well as to estimate what it will become in the near future under the stimulus of better transportaion facilities. When these factors have been determined it is an easy task for the trained road engineer to decide what types of pavement must be used upon the different sections, and to figure what one of the different types that can be used will give the lowest ultimate cost for the service provided.

The type of pavement that should be used upon a road is determined largely by the condition of the base that is to carry the pavement. Other factors that influence the selection are the density and weight of the traffic passing over the road, as well as the cost of keeping the pavement in good condition under such traffic. In this article we will discuss all these different points, but of course we can touch upon the subject of the base in only a cursory manner, for it is a matter which requires first-hand study to understand, except in a very general way, much about it.

In discussing the first-cost and the maintenance cost of the various pavement and in balancing these against one another in order to show what particular pavement should be used under a certain set of conditions, we are going to use actual costs. For, if we were to use the present prices that the different pavements are costing Oregon property-owners, there would be little use in writing this article, as in practically all instances the selection would, under such conditions, be Portland-cement concrete. For, as yet, only the prices for cement concrete have been gotten down to an approach to bedrock figures. Indeed, to tell the truth, bitulithic is doomed if its promoters try to hold its price at the present high level much longer, for it is only a matter of a few years before the voters of the different states will have become sufficiently educated in road matters to demand that all pavements compete upon strictly an engineering basis, instead of upon the present politician plane.

This Article Discusses County Highways Rather Than City Streets.

The reader must also remember that, in this article, we are discussing the paving of country highways and not that of city streets. So that the difference in cost of cleaning the several types of pavement will not enter into this discussion, nor will noisiness or appearance have the importance that they would have in determining the type of pavement that should be used were it streets and not highways that we are discussing. Moreover, it should be remembered that we are discussing the paving of the roads that are to serve the Oregon of today and not the Oregon of 50 years from now, so that while along the main trunk-roads the traffic will be dense and, owing to the auto-trucking done over them, the vehicular load will be heavy, still in no instance will the traffic be such that there will be any need for such expensive, even if efficient, road coverings, as brick, wood-block, or stone-block pavements, for the traffic must be heavy indeed to make it economically justifiable to use such costly types of pavement.

In this paper we will not discuss each and every pavement that has been used extensively in this or other states. Instead, we are going to select bitulithic pavement as representative of the bituminous group of pavements, which includes sheet asphalt, asphaltic concrete (Topeka mix), and bitulithic itself, and, as representative of the cement-concrete pavements, discuss ordinary cement-concrete pavement of 1:1½:3, or Wayne County, mix. We have not selected bitulithic for discussion simply in order to disparage it, but because bitulithic is slightly less expensive in first-cost of construction, does not require such painstaking care as do the others to insure good results, and is fully the equal if not the superior of the other bituminous pavements, both in length of life and in low cost of maintenance. Ordinary cement-concrete of rich mix, we have selected as representative of the concrete pavements, because it is as good as any of the concretes, as they are at present laid; for Hassam, the patented concrete pavement, although it has a greater density than ordinary cement concrete for the same richness of mix, is usually mixed in the proportion of 1:2.4, and therefore is neither denser nor stronger than concrete mixed according to Wayne County specifications, while royalty is also a matter to be reckoned with when Hassam is used. Of course, a royalty charge is GENERALLY exacted when bitulithic is used. But the validity of the bitulithic patents is very questionable, and in all probability the patents will have expired before much hard-surfacing has been done in this state. And anyway, general knowledge on road matters is spreading so rapidly that the bitulithic people will soon have to offer their pavement at bedrock prices if they are to get any paving to do. So that we feel justified in using our figures for bitulithic without adding a royalty charge to them, for we have made our estimate of the first-cost of putting down bitulithic pavement high enough so that a profit is left amply sufficient to compensate the patentees for the use of their pavement, provided that they bring their construction costs down to a bedrock figure, and, abandoning their high-priced legal and promotion departments, put bitulithic into competition with other pavements strictly upon an engineering and merit basis. Of course, in case that the owners of the bitulithic patents should be so foolish as to continue to hold their pavement at the artificial price level at which they are now trying to foist it upon taxpayers, asphaltic concrete would have to be used whenever, owing to its lower first-cost, a bituminous type of pavement showed itself the cheapest in ultimate cost of service.

Moreover, in our discussion we have assumed that if the state does take up a comprehensive program of road building, laws will be enacted limiting the tire load that can be thrown upon its roads, and that the excessive tire loads that might otherwise come upon the pavements along the main trunk roads with increasing size of truck load, such as it is sure to come as more and more use of the road system is made in freighting, will be avoided by such laws, as is the practice in European countries, and not met by thickening unduly the pavements put in along the roadway.

When the Road Base Is Poor, Cement-Concrete Pavement Should Be Used.

The all-important point in road construction is the nature of the base upon which the pavement is to be laid. A base is classed as good or bad according to the way in which it can be drained and kept in a comparatively dry condition. For we all know that dry earth, once that it has been rolled and well compacted, forms a base that is able to sustain any ordinary weight that will come on it from vehicular traffic. The first question to determine in road-building, just as in putting up a building, sifts down to ascertaining the nature of the sub-soil over which the roadway passes and the topography of the various portions that are to be paved. In general it can be said that the base is good if the sub-soil and the topography is such that it can be kept in a well-drained condition at all times of the year. On the other hand, if the base is soggy and can not be kept well drained because of the lay of the ground, the base is poor, and so the pavement itself must have an inherent resistance to deformation under load. Therefore, whenever the base of a roadway is poor, the pavement must have a concrete base if it is to give efficient service. So as concrete with a thin bituminous wearing-surface such as is used in California is the cheapest in first-cost, and also costs no more to keep in condition than would a sheet-asphalt pavement, or a bitulithic pavement with a concrete base under it, we will dismiss that phase of the problem simply by stating that when the base is poor a cement-concrete pavement six inches thick should be used.

We shall, therefore, discuss in detaily only roadways having a good earth sub-soil, or a firm macadam base along them. The problem then becomes one of what pavement to use when the traffic is heavy or dense, and what to use when the traffic is light. When the traffic is dense bitulithic pavement having a two-inch wearing-surface and a four-inch, or six-inch, crushed-rock base, and cement-concrete six inches thick with a thin bituminous wearing-surface on it come in competition with one another. When the traffic is light, bitulithic pavement with a two-inch wearing surface and a four-inch crushed-rock base comes in competition with concrete pavement four inches thick and unprotected by a wearing-surface. When the roadway has a good macadam base in place, bitulithic re-dress pavement having a wearing-surface two inches thick laid upon a crushed-rock base 1½ inches thick, put in to level up and re-crown the old macadam base, comes in competition with four-inch cement-concrete pavement.

In regard to this treatment of the paving problem, the cement men will complain because we recommend the protection of the surface of the concrete with a bituminous wearing-surface when the traffic is heavy. Many of them will contend that it is more economical to let the concrete surface wear and then apply another coat of rich concrete whenever the abrasion becomes considerable. But the highway engineers of California, New York state and Maryland have all found it, in the long run, cheaper and better practice to protect the concrete with a thin bituminous covering instead of letting the concrete itself take the wear and tear of traffic. So we have followed their practice as we believe that it is best.

On the other hand, the bituminous paving companies will object to our putting four-inch concrete pavements into competition with bituminous pavements when the traffic is light. They will urge that practically all the concrete pavements in the United States that are not protected with bituminous wearing-surface are six inches thick. Still the experience of California on its highways has shown that, when the base is good and well rolled before the pavement is laid, four-inch concrete is amply strong enough to carry the traffic even when travel over the roadway is fairly heavy. So as the bituminous wearing-coat used in California is put on largely for esthetic reasons we feel justified in recommending the use of four-inch cement-concrete pavement of rich mix without any protecting bituminous coat when the traffic over the roadway is light.

The Life of Hard-Surface Pavements.

In calculating Table I we have taken the first-costs developed earlier in this series. For instance, we have placed the first-cost of two-inch bitulithic wearing-surface at 43 cents per square yard because we have shown that it can easily be put down that cheaply. To this first-cost of 43 cents for the wearing-surface we must add 18 cents for the cost of the rock in the four-inch base, and nine cents for the placing of this base in the roadway, in order to get the first-cost of standard bitulithic pavement in place upon the roadway. This makes our cost for standard bitulithic having a four-inch crushed-rock base, 70 cents per square yard. Similarly we make the first-cost of bitulithic re-dress pavement 60 cents per square yard, for, to the 43 cents that the wearing-surface costs, must be added nine cents for the materials in the 1½-inch crushed-rock base, and eight cents for putting the base in place on the old macadam, making the total first-cost of the pavement 60 cents, as we have said. In the case of the cement-concrete pavements we have also assumed bedrock prices, especially on the Portland cement used. So we have estimated the first-cost of six-inch cement-concrete pavement to be 95 cents per square yard in place upon the county highways, in accordance with the cost we showed in our last article, while we have estimated the cost of four-inch cement-concrete pavement to be not more than 65 cents per square yard. As the state of California has laid four-inch concrete for an average cost of 59 cents per square yard over 211 miles of roadway, we feel that 65 cents is a figure that can easily be attained in Oregon.

Before the final, or ultimate, cost of a pavement can be calculated it is necessary to take into consideration the life of the pavement. Now the truth of the matter is that all the standard types of pavement will last much longer than 15 years—the usual length of life of road bonds at the present time. Moreover, if the pavement is properly laid and properly cared for as to its wearing-surface, as well as being repaired as soon as it chances, for one reason or another, to give away, as all pavements will in time, most of the pavements now in use in Oregon will last twice that long. So that it is difficult to fix the life of a pavement. Of course our readers who have followed the present good-road boosters of this state will think that there is only one pavement that will last any length of time. But that is not true. The real doubt in regard to the life of hard-surface pavements is concerning the length of time that bituminous pavements will stand up under heavy traffic, for it is only bituminous pavements that deteriorate under the elements.

Bitulithic pavements have been laid in this city during the last 12 years under varying conditions of traffic so that it is possible from a study of Portland streets to get a fairly accurate idea of what the life of these pavements will prove to be. Probably Fifth Street from Jefferson to Burnside Street traversing the heart of the business district has withstood heavier traffic than any other bitulithic street in this city. It has been in use 12 years and is still in good condition. Yamhill is another street in the business section that has been down for 12 years, and it also is still in good condition. Judging from these streets it is not unreasonable to accept the claims of the patentees of this pavement that it will last 15 years under heavy traffic without requiring re-surfacing or an undue amount of repair.

The best example that we have in Portland of bitulithic pavement under light traffic is that of Madison street west of Vista avenue which has now been in for 12 years. The most easterly block of this improvement was laid by the Warren Company while the westerly portion extending to the limits of Washington Park was laid by the Barber Asphalt Pacing Company. After the Barbers became involved in litigation with the Warren Company, the part that was laid by the Barber people was neglected as the laying of it was considered an infringement of the Warren patents. So it offers a splendid example of a bitulithic pavement under light traffic left to care for itself in a struggle with the rains and frosts of Oregon. This pavement is full of cracks throughout its entire length, and in as much as there has been practically no traffic over this portion of the street it is certain that these cracks and the distintegration that has taken place over the whole surface of the pavement are due to the elements, which slowly but surely affect the binding qualities of the asphaltic cement. The crushed-rock body of the pavement is, of course, still absolutely intact. So a thorough re-dressing of the top of this pavement would render it fit for another 12-year battle with the rains and frosts of Portland.

Experience with cement-concrete pavements has absolutely demonstrated that concrete pavement even of a very rich mix suffers to a noticeable degree from abrasion after only a few years, when subjected to the wear and tear of heavy traffic. There is no use for the cement people to try to deny this, as California, New York and Maryland, the three states that have laid the most cement-concrete pavement in this country up to date, have all found it advisable to protect their cement-concrete pavements with a bituminous wearing-surface when they must be subjected to dense traffic. On the other hand, experience with cement-concrete pavement under light traffic has proved that it shows practically no sign of wear and tear after 20 years of use. For instance, the alleys that were paved 23 years ago in Bellefontaine, Ohio, are today in almost as good condition as when they were laid, showing that, when the abrasive action upon the pavement is small, concrete forms an ideal pavement so far as durability goes.

So far as the bituminous re-dress pavement is concerned experience has shown that the bituminous wearing-surface will stand up under heavy traffic just as well as if it had been laid upon a concrete base. So that the life of bituminous re-dress pavements can be taken to be the same as for bitulithic pavements under heavy traffic, assuming, of course, that the macadam base has been in place for several years, and so has become thoroughly compacted.

Cost of Keeping Different Pavements in Condition.

After the life of the pavement the next factor to be considered is the cost of keeping the pavement in good condition under different kinds of traffic. As it has been stated above, concrete pavements, when subjected to heavy traffic, show signs of abrasion after only a short time. So engineers have found it practicable and necessary to place a bituminous surfacing upon concrete roadways when subjected to much abrasion. In the case of California, the State Highway Commission has found that a bituminous surfacing from three-eighths to one-half inch thick can be laid on the concrete at an initial cost of nine cents per square yard. This surfacing requires renewal and mending at the end of three or four years at a cost of 5 cents per square yard, so that, assuming a life of 15 years for the pavement, as we will do for all the pavements, as that is generally the life of the road bonds, and also because it is impossible to determine the actual life of the different pavements, the annual cost of keeping up the wearing-surface on concrete pavement is two cents per square yard for heavy traffic.

In the case of bitulithic pavement under heavy traffic a study of the safeguards taken in Portland by the patentors of bitulithic to give their pavement the longest life possible, is worthy of attention. Every Spring and Fall when construction work is light Warren repair crews flush-coat the streets that show signs of wear and tear, and also patch the surface wherever it has worn badly. In as much as the flush-coat that the Warrens use is practically the same treatment in the end that the California engineers give their concrete pavement, in that its purpose is to build up a thin, sandy, bituminous coat about three-eighths of an inch thick to take the wear and tear of traffic, the cost of maintaining this wearing-surface must be practically the same for both types of pavement under the same atmospheric conditions and the same densities of traffic. So that it can be assumed that it will also cost two cents per square yard annually to keep bitulithic pavements in good condition over a period of 15 years.

In the case of light traffic, the abrasion of the concrete under traffic is practically nothing, and the effect of the elements is nil. So, under these conditions, the cost of maintenance for concrete pavement also becomes practically nothing. But this is not true of bituminous pavements under light traffic. For, at the end of ten and very possibly of even seven years, the disintegrating effect of the elements upon the asphaltic cement in the pavement causes the surface to give away rapidly under the traffic as by then the cement has lost its binding power, and re-dressing of the surface must be resorted to in order to mend the cracks and bind the rock aggregate together. The cost of this re-dressing, judging from the thickness of samples of bitulithic wearing-surface cut from light-traffic streets in Portland, should be about nine cents per square yard, for the wearing-coat is about three-eighths of an inch thick, the same as in California, and so should cost approximately the same to form. Therefore, as an application of this re-surfacing coat is necessary at least every ten years, bitulithic pavement, even under light traffic, costs approximately a cent per year per square yard of wearing-surface to keep it in condition.

The Real Cost of Pavement Service.

Having determined what it costs to lay different types of pavement, and having arrived at an approximation to the cost of maintaining them in good condition, we are ready, assuming a life of say 15 years for all the pavements, to proceed to a study of what is the real cost of the service given by the various hard-surface pavements under different traffic conditions.

In case that the roads are constructed under a bond issue, the rate of interest that must be paid for the use of the money will be about five per cent. The annual interest charge upon the first-cost of a standard bitulithic pavement having a two-inch wearing-surface and a four-inch crushed-rock base laid at a total cost of 70 cents per square yard will, therefore, be 3.5 cents. If the life of the bonds is 15 years, the portion of the principal, or first-cost of the pavement, that must be raised each year so as to retire the bond issue in 15 years, will be 4.7 cents. Adding to these charges the cost of maintenance under heavy traffic, which, as shown above, is two cents per square yard, we have final total cost, per year per square yard, of 10.2 cents for standard bitulithic pavement. Similarly in the case of a concrete pavement six inches thick under heavy traffic we find that the interest charge upon a first-cost of 95 cents is 4.8 cents, the charge to return principal of bonds in 15 years 6.3 cents, and the maintenance charge two cents, making the total annual cost for six-inch cement-concrete pavement, 13.1 cents per square yard of pavement. In the case of light traffic we find the cost of a four-inch concrete to be interest at five per cent upon 65 cents, the first-cost per square yard of the pavement, 3.3 cents, the annual sum necessary to repay first-cost in 15 years, 4.3 cents, and the maintenance cost, nil, or a total cost of 7.6 cents per year per square yard of four-inch concrete pavement. In the case of bitulithic pavement under light traffic the cost would be for interest upon a first-cost of 70 cents, 3.5 cents, retirement instalment, 4.7, and maintenance, 1 cent, making the total annual cost, 9.2 cents per square yard of bitulithic pavement.

Now let us see what this study of the service cost of the various pavements really shows. Table I shows that, in order to compete at all with concrete pavement, bituminous pavements must be obtained at approximately their actual cost of construction plus a very reasonable profit. Otherwise Oregon will become as partial to concrete pavements as California, Maryland and New York state have shown themselves to be. On the other hand, if bituminous pavements are laid at figures approaching their actual cost of construction. Table I shows that, under heavy traffic, on main main highways where an old macadam roabed is already in place bitulithic is preferable to concrete. Also, when the base or foundation is good, bitulithic can compete under heavy traffic conditions with concrete. However, in the case of lateral highways upon which the traffic is light, the table shows that, in spite of the fact that it favors bitulithic because of the comparatively short life assumed for all the pavements, economically a four-inch cement-concrete pavement is the best to use.

Now it is needless to say that the prices of the different pavements used in calculating this table cannot be obtained unless stiff competition is brought about between the two types of pavement. This, as we have shown so many times in this series of articles, can only be accomplished by adopting the California method of having the state furnish the contractors with the paving materials that are used in mixing the different pavements. Then all can compete, whether big or small, on an equal basis.

That the California method is a good business proposition is shown by the fact that it has been approved by the company that is about to make Portland cement at Oswego, which company through its manager recently offered to give substantial reductions in the price of Portland cement to the state and the counties if they would adopt such a scheme in building their hard-surface roadways. That it is good business is also shown by the following extract taken from a pamphlet upon Municipal Paving Plants issued by the Warren Brothers Company itself: "In addition to saving the city many square yards of repairs which are made necessary by neglect to make repairs when the defects first appear, the municipal asphalt plant saves the city in the actual cost of making such repairs, and this has been the experience of every city which has installed a first-class asphalt plant. It is not difficult to see why this should be so, when we know that cities can buy the necessary materials as cheaply as can the contractors, and the cost of the materials is about 65 per cent of the whole cost of the work."

Surely it is about time that the people of Oregon awakened to the way that they should proceed in order to get the good roads that they need so badly, put in at right prices.

Note. Save this article to compare it with others in this series. If you are a taxpayer you will want them all next November.

TABLE I. ANNUAL SERVICE COST PER SQUARE YARD OF DIFFERENT PAVEMENTS.

	Annual Charge to Pay First Cost of Pavement in 15 Years.	Annual Interest Charge at 5%.	Annual Maintenance and Repair Charge.	Total Annual Cost.
Heavy Traffic—Earth Subsoil.				
Bitulithic — 2-inch wearing surface on 4-inch crushed rock base, costing 0.70 per sq. yard	0.047	0.035	0.020	0.102
Concrete—6 inches thick, 1:1½:3 mix with ¾-inch bituminous wearing surface, costing 0.95 per sq. yard	0.063	0.048	0.020	0.131
Heavy Traffic—Old Macadam Foundation.				
Bitulithic—2-inch wearing surface on 1½-inch crushed rock cushion on old macadam, costing 0.60 per sq. yard	0.040	0.030	0.020	0.090
Concrete—6 inches thick, 1:1½:2 mix with ¾-inch bituminous wearing surface, costing 0.95 per sq. yard	0.063	0.048	0.020	0.131
Light Traffic—Earth Subsoil.				
Bitulithic — 2-inch wearing surface on 4-inch crushed rock base, costing 0.70 per sq. yard.	0.047	0.035	0.010	0.092
Concrete—4 inches thick, 1:2:4 mix, costing 0.65 per sq. yard	0.043	0.033	0.00	0.076
Light Traffic—Old Macadam Foundation.				
Bitulithic — 2-inch wearing surface on 1½-inch crushed rock cushion on old macadam, costing 0.60 per sq. yard	0.040	0.030	0.010	0.080
Concrete—4 inches thick, 1:2:4 mix, costing 0.65 per sq. yard	0.043	0.033	0.00	0.076

In Table I these results, as well as those worked out for roadways having a macadam base, are tabulated, it being assumed that the concrete as well as the re-dress pavement will be laid upon the old macadam surface with only a slight scarification and cleansing. Of course this table applies only to an assumption of 15 years as the life of the pavements. To be accurate, the actual life of each pavement should be determined, and the retirement of the first-cost of the pavement spread over that period. But, as we have said, such approximations of the life of the different pavement are, at present, little more than guesses as the data has not yet been obtained that enables them to be made with any approach to accuracy; hard-surface pavements are entirely too modern a development for the necessary data to be at hand. Experience has already shown that practically all the pavements will last much nearer 30 years than 15 years if they are properly laid in the first place and then properly cared for, even if the traffic be heavy. Whatever advantage there is in regard to length of life is entirely with cement-concrete pavements as they do not deteriorate under the elements. Hence the above cost data are, if anything, more favorable to bitulithic than to concrete; at least so far as the total costs are concerned.