Pavement cost comparisons

Alternate bidding may not give the best comparison between concrete and asphalt pavements

BY E. GOEB

To some specifiers and owners who want to get the best pavement buy for a highway, street or parking lot, the method for choosing between concrete and asphalt seems simple. Prepare designs that are equal; take bids; and award the contract to the lowest bidder. What could be simpler? Asphalt pavers for years have thought that to be a great idea. Having historically enjoyed a first cost advantage, they would, of course, prefer cost comparisons that don't include all of the future costs.

To take a close look at that approach, let's ask one key question. Can pavement designs for these types of pavement ever be equal when one of them—concrete—can be designed for a longer service life, is less costly to maintain, and will provide better riding quality, skid resistance and nighttime visibility during its life? The answer is no. So-called equal designs don't produce pavements of equal performance. Contracts awarded to the lowest bidder as a result of alternate bids will be based on nothing more than the lowest first cost of unequal pavements.

The status of alternate bidding

There have been numerous court decisions related to alternate bidding. One of the best known precedent-setting decisions was handed down by the Ohio State Supreme Court. Based upon an engineering analysis, the Ohio Turnpike Commission had selected concrete pavement for the construction of the turnpike. In response to a court challenge from asphalt interests seeking to force alternate bidding, the court unanimously supported the commission's right to make the pavement type decision. In fact it reminded the commission of its responsibility to do so. The opinion stated, "The commission would be remiss in its duties if it adopted a cheaper type of construction notwithstanding its judgment that a more expensive type would be worth its cost and better serve the intended purpose."

The Federal Highway Administration (FHWA), in requiring cost justifications from the state departments of transportation on federally-funded projects, currently allows alternate bidding but with one important limiting condition. The state must furnish documentation that the two pavement designs would produce equivalent performance. Since the differences in performance between asphalt and concrete are well documented, this condition is all but impossible to meet, and for all practical purposes eliminates alternate bidding.

In a 1983 letter from the office of the U.S. Department of Transportation, written in response to a Senate inquiry, the FHWA Administrator made this point. "In revising the interim guide [1972 American Association of State Transportation and Highway Officials Interim Pavement Design Guide] AASHTO did not attempt to provide equal designs between competitive products or to balance the initial costs.... The AASHTO Guide has for many years recognized that costs other than initial costs, as well as a number of other factors, should be taken into account in deciding the pavement type that will best serve under the prevailing conditions." That would seem to say "Amen" to the Ohio Supreme Court decision on that subject and put to rest the idea of coming up with equal designs for concrete and asphalt and then awarding a contract on the basis of first cost alone.

Important elements of a cost comparison

Consistent with sound engineering practice, the merits of concrete pavement will best be recognized when selection of pavement type takes long-term performance into account. The selection should be based not on initial cost only, but on a cost comparison that takes into account initial cost, anticipated service life and surface and base maintenance costs.

Initial cost—Pavement designs should be selected using the same traffic loading for each pavement type. One of the most difficult problems to overcome is the common practice of comparing the initial cost of adequate concrete designs with the initial cost of inadequate asphalt designs. The AASHTO Interim Guide (now being revised) is very helpful in providing a design for each pavement type for a specific traffic load. While the designs do not produce equal pavements, as AASHTO itself points out, they do provide a logical starting point for a cost comparison.

Service life—The design life often used with the AASHTO Interim Guide is 20 years. However, 20 years is a period for traffic analysis and isn't intended as a life for economic analysis purposes. Service life, while not always

TABLE 1. ANNUAL COST COMPARISON OF CONCRETE AND ASPHALT PAVEMENTS					
Pavement type	**Initial cost per 2-lane mile**	**Life years**	**Annual depreciation**	**Annual surface maintenance cost***	**Total annual cost per mile**
Concrete	$195,000	25	$ 7,800	$320	$ 8,120
Asphalt	$180,000	15	$12,000	$400	$12,400

* Cost is for joint maintenance for concrete pavement and crack filling for asphalt pavement. It does not include cost for rehabilitation at termination of life. Cost is based on unit cost estimates applied to Michigan DOT maintenance schedule for life cycle cost analysis.

defined in precisely the same way, is the age at which a pavement is first resurfaced or the age at which rideability standards are no longer met and corrective work is required. Many state highway departments and some municipalities have made service life studies for different pavement types. The average age of concrete pavements prior to resurfacing varies in these studies, but can be as much as 35 to 40 years. This is about 1½ to 2 times greater than the service life of asphalt pavements. When economic analyses are made, a longer analysis period better reflects the long-term benefits from superior concrete performance.

Maintenance costs—For concrete pavements, future maintenance is confined to little more than joint sealing and joint repair within a service life of 35 years. Within that time, asphalt pavement maintenance can be expected to include two resurfacings in addition to programmed surface maintenance such as crack filling. Maintenance costs will be higher for asphalt than for concrete pavements.

Annual cost—a comparison of actual construction and maintenance costs based on a pavement life

One way to use service life data is to combine it with data on local maintenance costs to find an annual cost for a mile of pavement. If local data aren't available, FHWA data may be used as a basis for comparison. According to the latest report on the FHWA long-time study on the lives of highway surfaces, published in 1971, the life of concrete is 25 years and the life of asphalt is 15 years. In Table 1 annual depreciation is calculated based upon a 25- and 15-year life for concrete and asphalt respectively. Annual depreciation and annual surface maintenance cost are then added to obtain the total annual cost per mile of pavement.

If both of the pavements were to be resurfaced at the end of their service life, a salvage value equal to the cost of a base for asphalt surfacing could be assigned to each pavement. This would reduce the depreciation and the annual cost of each type of pavement. The amount of the reduction would be dependent on the condition of the pavement to be resurfaced.

Initial costs shown in Table 1 are representative of FHWA published averages and are for pavements only. If concrete curb and gutter is a part of the construction, initial cost for both pavements will be higher. But concrete gains considerably in the first cost comparison when an integrally constructed curb is a part of the concrete design. The additional cost of integral curb with concrete pavement is much less than the cost of separate curb and gutter with asphalt pavement. That could change the difference in initial cost between concrete and asphalt by $20,000 or more per mile.

Total cost analysis

Another way of making a long-term comparison is to select the same analysis period for both pavement types, and simply add together all of the expenditures that will be made during that period. The analysis period should match or exceed the service life of the longer lasting pavement. For concrete pavement a life of 35 years can be justified, and that becomes the analysis period. A typical total cost analysis is shown in Table 2. The mainte-

TABLE 2. TOTAL COST COMPARISON OF CONCRETE AND ASPHALT PAVEMENTS	**Concrete**	**Asphalt**
Initial cost	$195,000	$180,000
Joint repair-resealing and replacement	21,500	—
Grinding at 25 years	29,000	—
1st Resurfacing at 15 years (mill and recycle 4 inches)	—	96,000
2nd Resurfacing at 25 years (mill and recycle 6 inches)	—	143,000
Crack sealing (4 times)	—	12,000
Total Cost—35 years	**$245,000**	**$431,000**

nance costs are computed from unit costs for similar work in Michigan, based on a schedule of anticipated maintenance requirements. As in the annual cost comparison, when the total costs of the pavement are compared for the same service life, any first cost advantage for asphalt disappears.

Life cycle cost analysis and present worth

A life cycle cost analysis is now being used by many state DOT's, although with numerous variations. It starts with a total cost analysis for each pavement type, taking into account initial cost, future maintenance and rehabilitation costs. The same analysis period is used for each pavement, up to 35 years in many states. Most states use initial cost estimates for pavement designs based upon the AASHTO Interim Guide (not to be misinterpreted as equal designs). The future maintenance costs reflect the policies and experience of the state making the cost comparison, supplemented by other states' experiences.

Life cycle costing is a considerable improvement over alternate bidding and is a sound approach to making cost comparisons as long as actual costs are used in the analysis. But in about half of the states using this approach, life cycle costing has been expanded to include the economic analysis of present worth. Present worth, as applied to pavement construction, is described as a means of expressing all costs incurred during the service life of a pavement in equivalent dollars. Costs of new construction are not adjusted. Projected maintenance costs are discounted by the estimated real interest rate (market interest rate minus the inflation rate) that an investment made at the time of construction has the potential to earn until spent on maintenance.

The present worth theory affects the estimates of project costs this way. When a dollar is to be spent on new construction the cost to the DOT in the estimate is a dollar. When a dollar is projected to be spent on sealcoating, crack filling, joint sealing or resurfacing it will still cost the DOT a dollar at the time it is spent, but it will appear in the estimate at a discounted value. How much it is discounted depends upon the age of the pavement at the time the maintenance occurs. The difference between the actual dollars to be spent by the DOT and the cost that is used in the estimate is the amount of interest that an investment is assumed to earn between the original construction date and the time of the expenditure.

It is at this point that present worth becomes controversial as it is applied to highway paving. Unlike businesses or individuals, DOT's don't have alternate investment opportunities on which to earn interest. Their expenditures are from annual budgets and current funds. For example, the maintenance programmed for asphalt in the Total Analysis, Table 2, would cost a DOT budget $251,000 over 35 years. At a 4.5 percent real interest rate, present worth would reduce the asphalt maintenance to a theoretical $103,000. That means that the cost estimate for that project, if paved with asphalt, understates the dollars that will be required from state highway funds for the project by $148,000. That $148,000 represents the theorized value of money. It does not, however, alleviate the problem of the DOT budget which will have to provide the full $251,000.

Gasoline taxes are established at a fixed rate, usually remaining unchanged for many years. The DOT purchasing power is eroded directly in proportion to inflation. While it is true that future inflated costs for maintenance will be paid with inflated dollars, to a DOT funded by a fixed tax rate—it only means fewer dollars left for new construction after maintenance demands are met. The present worth approach could compound that problem. If selection of pavement type is based on discounted maintenance costs, a DOT may find itself justifying a larger share of high maintenance cost pavements by economic theory. Every choice made on that basis would incur a future obligation for maintenance costs that will be paid by the DOT in full and in actual dollars of the time, not the discounted estimate of 10, 20 or 30 years before. Regardless of the merit of the theory of present worth in other applications, it should be recognized as a theory that helps to justify high maintenance cost pavements over better performing pavements that do not require extensive maintenance.

Concrete's competitive position

A system for comparing the cost of concrete with asphalt that includes all costs in the life of a pavement has always been a goal of those interested in advancing the construction of concrete pavement. Life cycle cost is that kind of system. Even with the advantage of discounting of maintenance through use of present worth, asphalt's high maintenance costs are great enough for concrete to be selected. With that as a start we still have to be sure that the conditions for a cost comparison are sound. These conditions include:

Pavement designs of the same load carrying capacity

Selection of pavement type on an evaluation of quality performance, not only on first cost

An analysis life that is long enough to demonstrate the advantages of concrete, both in life and maintenance

Present worth or any system of assessing or discount-

TABLE 3. COMPARISON OF ACTUAL AND DISCOUNTED MAINTENANCE COSTS

Age of pavement	Actual DOT maintenance expenditure	Present worth discounted value for project estimate (4½% real int.)
10 years	$100,000	$64,000
20 years	100,000	41,000
30 years	100,000	27,000

ALTERNATE BIDDING AND COMPETITIVE BIDDING

Often the terms alternate bidding and competitive bidding are used as if they had the same meaning. That twist in terminology, sometimes used with the purpose of justifying alternate bidding, incorrectly implies that bids must be taken on both asphalt and concrete to be competitive. If the agency advertising for pavement bids has determined that concrete will better serve the intended purpose, competitive bids will be received for a concrete pavement. The same would be true for asphalt if that were the preference. For alternate bidding, the agency could order plans and specifications prepared for both pavement types, increasing the engineering costs, and receive competitive bids on both. The low bids on each type would then be compared. In either case, with or without alternate bidding, there is competitive bidding. With alternate bidding, however, the opportunity to select pavement type based on overall quality of the pavement's service is sacrificed.

ing interest is helpful to asphalt. Present worth need not be questioned as an economic principle, but should be questioned as it may be applied to highway construction. If it is used, the first thing to check is the interest rate. The higher the real interest estimate, the greater will be the penalty to concrete. A common range seems to be about 4 to 5 percent, although some economists consider that to be at least double the real interest that historical records justify.

The threat to concrete of a misapplication of the present worth analysis in discounting pavement maintenance expenditures is the same as the threat to DOT budgets. It could be used to reverse the goal of many highway engineers—to build quality pavements so that dollars spent on maintenance can be freed to become new construction dollars for the continual upgrading of our highway system.

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