# ENGINEERING ECONOMY AND ENERGY CONSIDERATIONS

ALTERNATIVE BIDDING FOR PAVEMENT STRUCTURES AND PAVEMENT COMPONENTS

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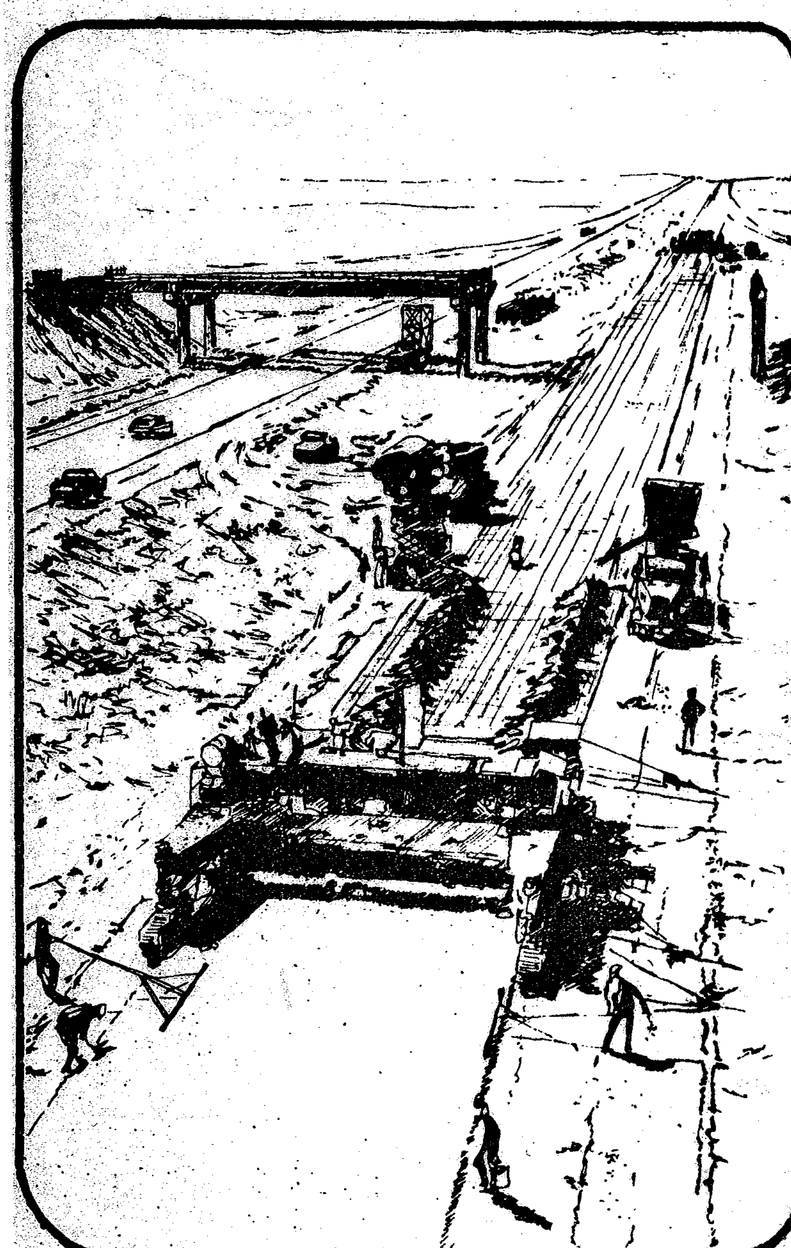

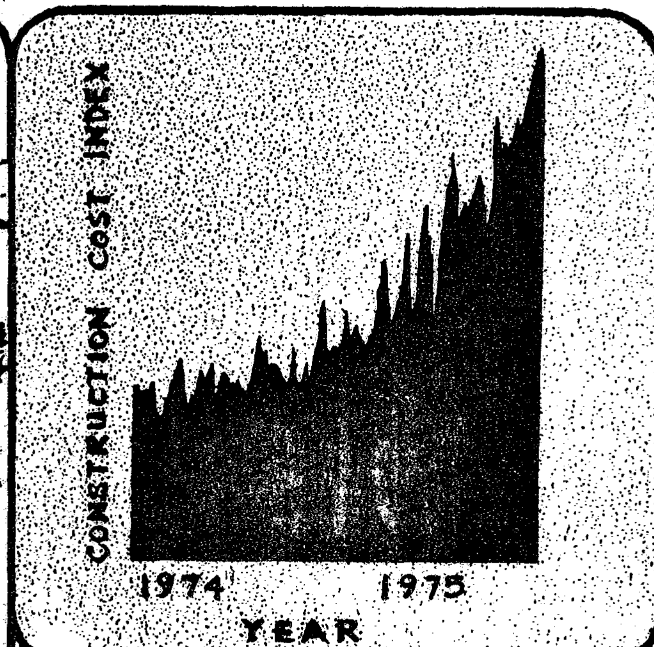


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TEXAS STATE DEPARTMENT
OF HIGHWAYS
AND PUBLIC TRANSPORTATION
AND
TEXAS TRANSPORTATION INSTITUTE
TEXAS A&M UNIVERSITY

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# ALTERNATIVE BIDDING FOR
# PAVEMENT STRUCTURES AND PAVEMENT COMPONENTS

by James L. Brown

## Introduction

The purpose of this report is to discuss ways to receive more economical bids on pavement structures and pavement materials through use of alternative bidding. Throughout this report the term "alternative" will be used to mean either an alternate or an option which the contractor is permitted. Further, an alternate will be used to indicate the case when the contractor must designate on the proposal which choice he has selected. An option will be used for the case where the contractor can make the choice at a later date during the construction process. To reiterate, an alternative can be either an alternate or an option.

In general, giving the contractor more flexibility by permitting him to use alternative methods for constructing highway components should result in lower costs. More bidders should be competing for the construction on both the contracting and the material supplying end. Additionally, the decision as to what is to be built is made at a point in time much closer to actual construction. Therefore, the contractor does not have to use as large a risk factor to cover price fluctuations. (If designers select the alternatives prior to bidding, they are further in time from actual construction and, therefore, must include these high risk factors in selecting the alternatives.)

The expected benefits cited above may be more than offset by the fact that engineering costs will be greater. The increased effort to develop the alternatives in the PS&E are direct increased engineering costs. Additionally, more paper work will be required to obtain approvals by reviewing authorities--both internally and with the Federal Highway Administration. An additional disadvantage in using alternatives in bidding for pavements follows from the fact that proper selection of the optimum or best pavement structure depends to a large degree on the experience of the engineer with the materials, traffic, construction methods, maintenance techniques, and environment of a particular locality. Most often, this experience is unquantified, so that the engineer has difficulty in documenting precisely his reasons for his decision. However, at this time, most people in the industry are satisfied with letting the engineer exercise his professional judgment. It can be anticipated, however, that if the quantified results of the engineer's considerations are made public in the form of "equivalent alternatives" on bid proposals, vociferous exceptions and objections will be raised.

In order to withstand the harassment from material suppliers, equipment manufacturers, contractors, and others that have a vested interest in a particular alternative, it is therefore recommended that the Department present a consistency in the use of alternatives that has been lacking in previous pavement type selection decisions. It is believed that when alternatives are provided, they should be arrived at by a repeatable method such as the FPS design system. State-wide standards should be used for concrete pavements. Additionally, state-wide standard specification items should be used.

## Other Specific Pavement Considerations

The recent wide fluctuations in prices (downward as well as upward) and uncertain availability of asphalts, Portland cement, aggregates, and reinforcing steel would certainly indicate there is a need to wait until the last possible minute to make the decision as to which alternative to select for pavements. Additionally, not too infrequently, a material supplier has an almost monopolistic set-up for a specific material source to supply a specific project due to the proximity of this source to the project. The need to provide alternatives in this situation is quite evident.

Even though the need to specify alternatives seems quite clear, it becomes a more difficult problem when one examines the "how-to." Three definitions are necessary to clarify this examination.

> A pavement design strategy is defined as a complete plan of initial construction of pavements plus the expected future maintenance and rehabilitation throughout some analysis period. In other words, a short-life initial construction followed by heavy rehabilitation at a later date would constitute an alternative pavement design strategy to a heavy initial construction followed by relatively minor future maintenance.
>
> An alternative initial pavement construction is defined as different initial construction which can be expected to have the same future maintenance costs. These future costs should include both the cost incurred to the Department and to the users during these maintenance operations.
>
> An alternative pavement component will be defined as a portion of the pavement structure that will perform the required functions of that component in the overall structural system.

Taking alternative bids on different design strategies is beyond the considerations intended for this paper, since contractors would have to provide for future maintenance as well as build the initial construction. (Such bidding is done occasionally in private industry and foreign countries.) It should be noted that even though alternative bids are not being considered for various pavement design strategies, the designer should still generate such alternative strategies to help him select the optimum strategy for each project.

The Department should take alternative bids on initial pavement construction or alternative pavement components when (1) it can generate equivalent alternatives, and (2) when the engineering costs to generate such alternatives are substantially less than the expected benefits in taking bids on them. The remainder of this paper will be an attempt to draw boundaries around what the author feels are logical places where equivalent alternative initial pavement construction can be located or alternative equivalent pavement components may be found. Some discussion of the expected engineering costs is also presented.

## Alternative Initial Construction of Pavement Structures

Pavement structures can be grouped into three general categories. Within each category it appears feasible to generate alternative initial construction that can be expected to have similar future maintenance requirements. Conversely, it is doubtful that alternatives across these three general categories can be generated that will have similar future maintenance requirements.

Category A will be called slabs with controlled crackling. Jointed and reinforced Portland cement concrete pavements constitute the bulk of this category of pavement. Composite jointed pavements and some jointed bituminous pavements have also been built in the past. Such pavements spread the effect of wheel loads to the earth foundation by having relatively high stiffness compared to the foundation. Because they have this high stiffness or high modulus of elasticity, they are affected by thermal change (and usually drying-shrinkage) to the point that cracking occurs. If this cracking is controlled by means of intentionally placed joints, both longitudinal and transverse, or by the inclusion of reinforcing steel to control the width of the crack, we have controlled cracking.

Provided the structural design has been adequate, anticipated maintenance consists primarily of preventive maintenance at the joints. The objective of such maintenance is to keep out incompressibles and water. Hence, periodic cleaning and sealing of both transverse and longitudinal joints is required. Two kinds of distress requiring repair maintenance are occasionally encountered: surface spalling resulting from inadequate durability in the concrete and subsurface failure, usually preceded by pumping.

Category B pavements will be termed slabs with random cracking. Bituminous concrete and cement-treated bases constitute the bulk of this category of pavement. At one time, unjointed non-reinforced Portland cement concrete pavements were also constructed. Again, such pavements use their high stiffness to reduce the effects of wheel load stresses on underlying layers. When asphaltic concrete or black base is used to make the slab, this stiffness is greatly reduced during hot weather. Such lowered stiffness requires a thicker slab or an underlying layer of material to support the asphaltic layers. When cement stabilization is used, the effects of thermal and drying shrinkage usually cause so many cracks as to reduce the effective stiffness of the slab. Again, greater thickness is required.

While long term experience with asphaltic slabs is somewhat lacking, it is expected that the ultimate wear-out for both the black base and cement stabilized pavements will be caused by combinations of environmental (water, cold, sunlight) factors acting with the wheel loads. It is not believed possible to design such pavements with as much environmental resistance using present specifications as the Portland cement concrete slabs described above. Further, the lack of control exercised at the joint will probably cause the underlying foundations to lose strength faster. (This statement assumes that the required preventive maintenance is performed on the controlled cracked slab.)

The third general category of pavements, Category C, will be termed thin-surfaced flexible pavements. The thin-surfaced qualification on a flexible pavement structure is necessary to prevent it from acting like the slabs described in the second pavement category. Flexible pavement is used to mean those with untreated base materials which transmit load through aggregate interlock rather than slab stiffness. Generally, such pavements reduce the stresses on the underlying foundation by virtue of their thickness rather than their increased stiffness. The total thickness required to reduce these stresses and the internal shear strength within the layers of the flexible pavement are the primary design considerations.

Flexible pavements usually require surface maintenance (seal coats) to keep water from entering the base material and level-ups to restore a distorted surface. While repeated sealing and leveling may either succeed or fail in maintaining the integrity of the base, the pavement eventually fails in fatigue, even when the sealing is successful. If the sealing is unsuccessful, the flexible base will usually fail by shear distortion. In any case, ultimate wear-out of this type of pavement requires either reworking as a new flexible pavement or a major rehabilitative effort (thick overlay) to transform it into an adequate slab-type pavement.

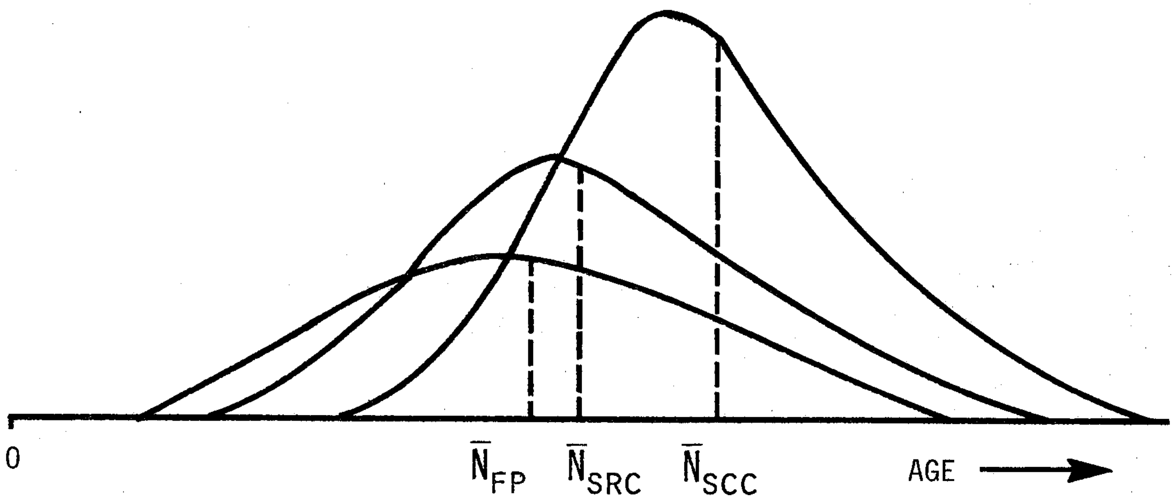
It is hoped that the foregoing discussion has established that fundamental behavioral differences can be expected of the three basic pavement categories. Figure 1 and Table 1 summarize these differences. The following discussion covers problems anticipated in permitting alternative bidding on each basic category.

Category A - Slabs with Controlled Cracking

The Highway Design Division has been developing new Standard Design Detail Drawings for continuously reinforced, CRCP; skewed transverse joints,

FIGURE 1

Expected Life Distributions for Adequately Designed, Constructed, and Maintained Pavements in the Three Categories




$\overline{N}_{FP}$ = Average Life of Flexible Pavements

$\overline{N}_{SRC}$ = Average Life of Slabs with Random Cracks

$\overline{N}_{SCC}$ = Average Life of Slabs with Controlled Cracks

TABLE 1

RELATIVE PROPERTIES OF THE THREE CATEGORIES OF PAVEMENTS

| | Flexible Pavements | Slabs With Random Cracking | Slabs With Controlled Cracking |
|---|---|---|---|
| Initial Construction Costs | | | |
| for low traffic roads | Low | High | High |
| for medium traffic | Low | Moderate | High |
| for high traffic | Moderate | Moderate | High |
| Cost of preventative maintenance | Moderate | Moderate | Moderate |
| Cost of repair maintenance | High | Moderate | Low |
| Cost to reconstruct or rebuild | Low | Moderate | High |
| Relative probability of early failure | High | Moderate | Low |
| Relative probability of very long life | Low | Moderate | High |

CPSJ; jointed reinforced, CPJR; and contraction design, CPCD; (all concrete pavements). Equivalent thicknesses for various conditions are being established. At this time, no consideration is being given to jointed or reinforced asphaltic, sulphur-asphalt, or low modulus concrete pavements. Composite pavements with controlled cracking are also being ignored for the present.

It is felt that satisfactory specifications presently exist for specifying the primary component, the concrete slab, of a total pavement of this category.

Category B - Slabs with Random Cracking

The FPS design system can be utilized to generate alternative pavement structures in this category. However, considerable effort needs to be expended to develop an in-place specification for the asphaltic, cement-treated, or concrete slab materials to be used as the primary component in this category of structure. Such a specification must, for all practicable purposes, indicate the minimum amount of stabilizer that is going to be required. For asphaltic materials, this can be difficult because there is also a maximum asphalt content. Our practice of specifying a rather wide range of asphalt content and then selecting the optimum during construction can no longer be employed because asphalt cannot be a separate pay item. (The most difficult part of this problem may be one of obtaining a consensus within the Department as to what is a satisfactory asphaltic or cement-treated or Portland cement concrete material to use in a randomly cracked slab!)

Category C - Flexible Pavements

The FPS design system can be utilized to generate alternative pavement structures in this category. Specification Item 249 provides for in-place payment for the flexible base materials provided careful utilization of the Class, Grade, and Compaction Method is done so as to accommodate varying unit weights of materials.

## Alternative Pavement Components

On some occasions, it may be desirable to specify alternatives for a particular pavement component, but not for the overall structure. In order to do this, the designer must (1) identify the specific function(s) the component performs, (2) find alternatives that will perform the same function(s), and (3) check the compatibility of the alternatives with the remainder of the pavement system. Three such components will be discussed briefly because there appears the need to consider them at this time.

### Subbases under Concrete Pavement

Historically, various materials have been used as subbases under concrete pavement. The primary function of all these materials is to improve the foundation for the pavement such that the foundation can withstand the effect of the large amounts of water that infiltrate through the concrete pavements. Secondary functions include providing a working table for construction traffic and strengthening the foundation so that a lesser slab is required. Subbases achieve their primary function by either being erosion resistant or by being a drainage layer in an overall drainage system that carries the infiltrating water away rapidly so that high pore pressures do not develop.

In recent years, nearly all subbases in Texas have been intended to be of the non-erosive rather than the drainage type. It appears to the author that three types of material can be successfully used in this manner--durable concrete, erosion-resistant soil cement, and moisture resistant (non-stripping) bituminous mixtures. To achieve the desired qualities it appears that the concrete can have a relatively low cement factor if a good entrained air system can be created. For the soil cement, the Portland Cement Association increases cement content to create erosion resistance (for use as riprap on dams). This same approach is needed for subbases. To provide erosion resistance in bituminous mixtures, relatively high asphalt contents (low air voids) and either non-stripping aggregates or anti-stripping agents are required. Having provided alternatives that will satisfy the primary function, the designer must be satisfied that each of these materials will provide an adequate working table and sufficient foundation improvement.

Readers may recognize that <u>if subbases are to be erosion resistant</u>, quality shortcuts are not recommended. Further, the cost of such recommended materials is so close, there may be a distinct savings to the State if alternative bidding is permitted. In summary, three alternative materials are available for non-erosive subbases under concrete pavement. In-place specifications are <u>not</u> available for any of the materials.

## Shoulders for Concrete Pavements

Shoulders for concrete pavement have become an increasingly costly item. As designers have upgraded subbases, they have tended to upgrade the material being used in the shoulders. Improved performance of shoulders relative to required maintenance has certainly been needed. As upgrading of the shoulder material has progressed, with attendant cost increases, alternative materials may have become cost effective.

The primary function of a shoulder is to provide an all-weather platform for an occasional heavy load. Fatigue is seldom a consideration but saturation from infiltrating water and other environmentally-caused distresses are very important considerations.

It is believed that for high type facilities where bituminous pavement shoulders adjacent to concrete pavement are being considered, some thought should be given to specifying an alternative concrete shoulder. Jointing and reinforcing of such a material should be compatible--though not necessarily identical--with the main lane pavement.

Surface Treatments and Seal Coats

In Texas, material suppliers have long argued that we use only certain sizes of the aggregate production. There may exist a potential savings if we permit the contractor the alternative of two or even three Grades of Seal Coats and Surface Treatments. Such bidding would require the development of specifications that would use payment by the square yard and have a defensible method for selection of aggregate and asphalt rates. Similar arguments could be used for different Types of asphaltic concrete.

## Conclusions and Recommendations

The Department should consider taking alternative bids on some projects. The Districts should consider the potential pay-off, risks, and added costs discussed herein before selecting projects to contain alternative bids.

It appears highly desirable that some state-wide consistency and application of alternative bidding be utilized. For this purpose, it is recommended that the standard drawings be used for concrete pavements. Standard specifications should be used for materials. Such specifications should be generally applicable throughout the State. As noted elsewhere, some specifications do not now exist for this purpose.

Alternative bids for initial total pavement structures should be limited to one of the three basic pavement categories on a particular project. That is, all the alternatives should be only slabs with controlled cracking or only slabs with random cracking or only thin-surfaced flexible pavements.

The Highway Design Division is generating alternative design standards for slabs with controlled cracking (concrete pavements). Current material specifications appear adequate for specifying alternative pavement types of this category.

Usage of the flexible pavement design system, FPS, can be made to generate alternative thickness designs for slabs with random cracking. Current material specifications are <u>not</u> adequate for alternative stabilized layers, the major component in pavements in this category.

Alternative thin-surfaced flexible pavement structures can be generated utilizing the FPS system. Currently available material specifications for flexible bases and subbases appear to be adequate for this category.

The Department should consider some alternative choices on some pavement components, primarily shoulders and subbases for concrete pavement. Additionally, some pay-off might occur with a double-grade option for seal coats or surface treatments and a multiple-type option for asphaltic concrete. In all these cases such options could generally be permissive, that is, permitting what is normally felt to be a higher or more expensive type to be used. Revisions to the specifications to measure and pay for in-place products are required to do this.