211

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COMBATING INFLATION IN RIGID PAVEMENT CONSTRUCTION

Report by TRB Committee A2F01: Construction Practices—Rigid Pavement.

modes

1 highway transportation
4 air transportation

subject areas

11 administration
24 pavement design and performance
33 construction

INTRODUCTION

The Rigid Pavement Construction (A2F01) Committee of the Transportation Research Board at its Annual Meeting in January, 1979, formed a task force to synthesize those factors which would combat inflation in rigid pavement construction.

The scope of the task force was to minimize inflation in rigid pavement construction and identify those other elements which directly affect rigid pavement construction costs.

PURPOSE

Transportation officials, industry and legislators are deeply concerned with the inflation rate of transportation construction. The FHWA Highway Index Cost has escalated to 300% since 1970. In April, 1979, the Dodge report showed the construction costs up 12.3% during the previous 12 month period. The construction materials increase was 15.4% while labor was up 7.7%. The purpose of this synthesis is to identify specific actions which can be taken by transportation officials and the industry to minimize the cost of construction of portland cement concrete pavements, without loss of quality.

AN OVERVIEW

It is recognized that many of the major determinants in the cost inflation problem are beyond the control of transportation officials and the industry.

A substantial portion of the inflationary costs problem is directly related to Federal regulations regarding occupational safety and health, equal employment opportunity, the participation of citizens in project planning, the preservation and enhancement of the natural environment, the Davis Bacon Act and the immensity of paperwork and "red tape" created by these regulations.

CONSTRUCTION

Construction firms are especially vulnerable to the costs of inflation because a high inflation rate means more risk and higher interest rates. Moreover, when credit markets tighten, construction firms are among the first to be squeezed out. Uncontrolled inflation, the costs of inflation itself, and of the recession that inevitably follows are evident in the high failure rates that construction firms experience during such periods. Thus, construction firms have a major stake in the efforts to slow the inflation without causing a recession.

A successful effort to moderate inflation must break the upward spiral of wages and prices that has become deeply ingrained in our economy during the past decade. Restrictive monetary and fiscal policies will create an overall climate in which this process can unwind. But government must also deal with its actions that exacerbate the problem by **regulations which restrict competition and promote higher prices in the private sector.**

Federal regulations are beyond the scope of this assignment; therefore, this effort is directed to recommendations concerned with construction practices, methods, materials, specifications and design procedures for concrete pavement construction.

Figure 1 reflects the results of a contractor survey made to show the percent change in labor, materials, equipment, and overhead for pcc pavement construction using 1970 as the base year. This is compared to the FHWA Highway Index and the Consumer Price Index for the same period.

The following six general areas and topics were investigated.

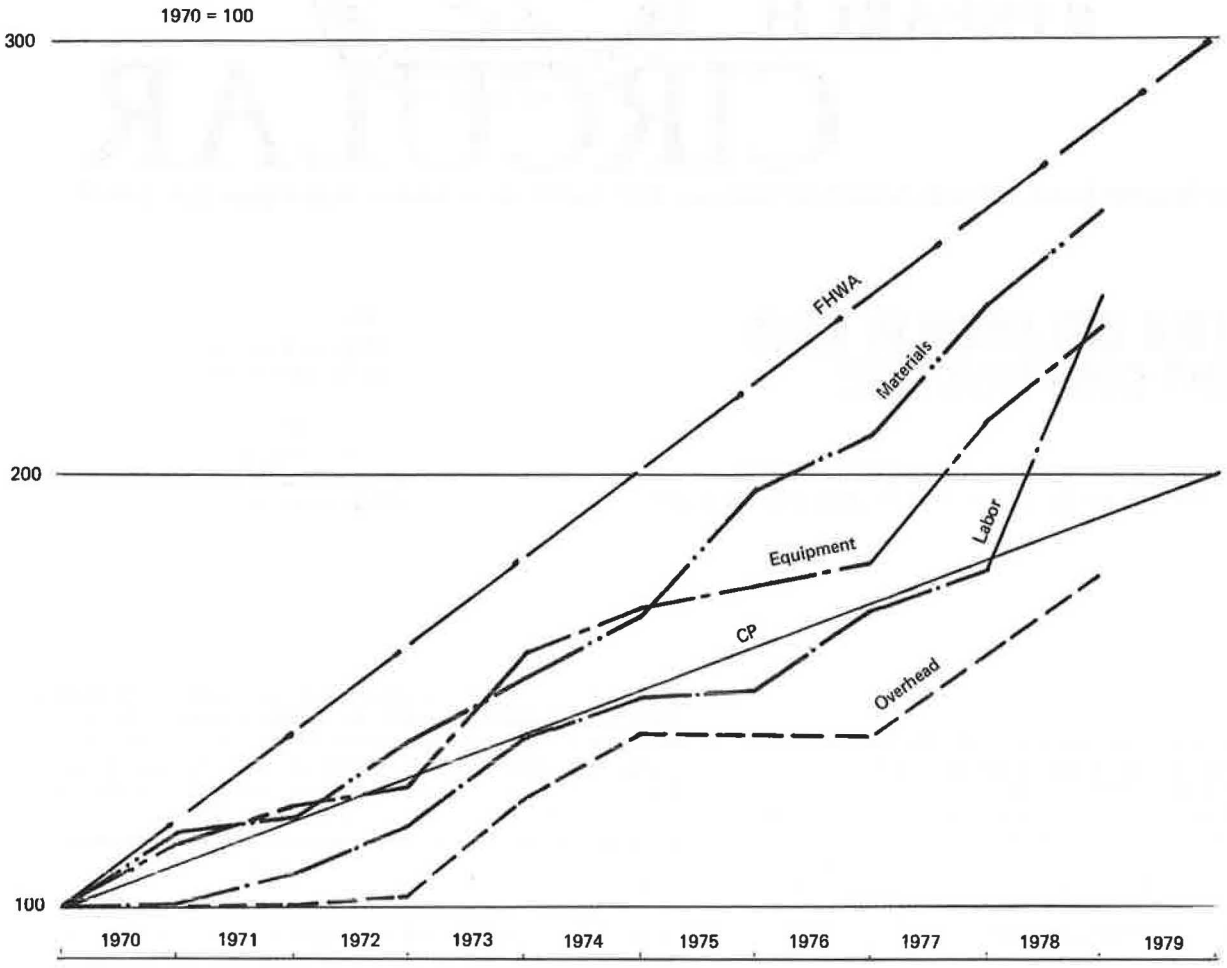
Administration

- Program
- Contract Size
- Lead Time
- PreBid Conference
- Stage Construction
- Agency Industry Communications
- Retainage

Standardization

- Specifications

Figure 1. Concrete pavement construction cost.



Cement Factor
1-P Cements & Fly Ash
Water Reducers
Subbases
Stockpiling Materials

Standards
Ramps
Curb and Barrier Sections
Pavement Width & Shoulders

Tolerances
Surface Tolerances
Texturing Tolerances
Thickness Tolerances
Steel Tolerances
Temperature Tolerances

Design

Jointed Pavement
Continuously Reinforced Concrete Pavement
Composite Pavements
Recycled Concrete
Culverts - Bridges

Production

Minimize Interruptions

Value Engineering

Utopia

ADMINISTRATION

All of the items identified in this publication require administrative decisions. Some of these could be implemented by administrative directive, which would have an immediate benefit in fighting inflation.

Program:

The Agencies should plan far enough ahead so they can announce a firm construction program to the industry at least one year in advance. While many programs are announced, the actual projects included on lettings are dramatically different. It is sometimes necessary to order special equipment tailored to a project. The design of the project, including such details as the type of material used in the shoulders, the type of reinforcement required or even the number of lanes which can be paved in a single pass, can be very important to the contractor. Agencies should be aware that the single act of allowing a longer lead time can cause significant savings in money to a project.

Contract Size:

The size of a concrete paving project is directly related to the bid price. There are certain con-

tractors' fixed costs which must be prorated over any project. Mobilization and plant setup are good examples. Both contractor and agency engineering costs are higher on smaller projects. Economy of scale can be an important factor in many phases of construction.

Lead Time:

Agencies should allow one month lead time between advertising and the letting. Because of the changing nature of the program, the urban type projects are becoming very complicated. Paving is no longer the only major consideration on a paving job. It is complicated by utility relocations and electrical and sewer modifications. A contractor cannot consider only his work in preparing his bid but is now responsible for coordinating all of these other items which have major effects on his costs. The agencies must realize that specialized types of electrical and utility materials are not available on short notice. If the economies which are available through concrete paving are lost through complications of special items, the results will be an overall increase in project costs.

Pre-Bid Conference:

Past experience proves that pre-bid conferences between agency and industry on all major projects can result in more intelligent bidding, more realistic prices and very often, substantial savings. Major airport projects are excellent examples of the value of pre-bid conferences.

Stage Construction:

Stage construction should be reexamined by agencies to provide the first year for grading and drainage and the following year for paving and finishing work. It is even more important in the new urban type projects to permit flexibility in the handling of the stage construction work. It is realized that many projects have to be built under traffic and the safe handling of the traffic is of utmost importance. While the designer should develop the plan to handle traffic during the construction stages, flexibility should be provided in the contract to permit the contractor to negotiate changes if he has a better way to handle the traffic and complete the project.

Agency/Industry Communications:

Establish a regularly scheduled format for discussion between the Concrete Paving Industry and Agency Construction, Design and Materials Engineers. Those departments having such a format attest to its effectiveness in simplifying problems, reducing costs, and obtaining better overall understanding and cooperation.

Retainage:

Reduce the amount of retainage to improve the contractor's cash flow. Consideration should be given to accepting securities placed in escrow as an alternate. This would permit the contractor to collect interest on the securities and improve his cash flow situation.

STANDARDIZATION

Standardization of design, specifications, and construction procedures can have a major influence on reducing costs. A discussion of standardization necessarily overlaps subjects addressed under other headings in this report. It is emphasized here that improved standardization should be considered along with reevaluation of all phases of design and construction, including especially the following:

Specifications:

Details of concrete pavement elements should be standardized on a national or regional basis to the maximum extent practicable. It is unlikely that a single standard or specification can be developed for each element. However, the number of different standards or specifications can be minimized.

Cement Factor:

Unrealistically high cement factors are being used in many areas. There are situations where adjacent projects crossing state lines have utilized the same traffic but have had cement factors varying by as much as 100 pounds (45.5 kilograms). A specification based on strength with a realistic minimum and necessary measures to insure durability will reduce concrete pavement costs. Some designers are basically conservative and wishing to protect against all problems, will increase the desired strength requirements far beyond the amount actually needed to comply with design criteria. Establishing concrete strengths higher than actually needed wastes portland cement and increases costs. It is often possible, particularly in pavement construction, to use less cement than we have been accustomed to using by designing for lower strengths. Concrete paving mixes for roads should use 28 day strengths instead of 14 day, and for airfield pavements, we could use 90 day strengths instead of 28 day strengths. strengths.

1-P Cements & Fly Ash:

The use of Type 1-P cement should be accepted by all agencies. In this case, the cement supplier is responsible for the quality control of the high grade fly ash used to manufacture 1-P cement. The contractor will find better placement and consolidation characteristics while using 1-P cement or fly ash as an admixture in his concrete. It should also be noted that it may require more air entraining agent to produce the required amount of air voids in a mix containing fly ash. Specifying agencies should permit more than one brand of cement to be held in storage on a project. The specifier can help the industry conserve cement and reduce costs by having specifications which will permit the use of proven admixtures. Many state highway departments, county and city agencies and the Corps of Engineers have used fly ash as a replacement for up to 20% of the cement with good results. Fly ash will result in lower initial strengths, but will gain normal expected strength at about 28 days, and will probably exceed normal strengths at 90 days. Contractors and suppliers must obtain high quality, uniformly controlled fly ash which meets specification requirements (a maximum of 5% for sulfur trioxide and loss on ignition is recommended).

Water Reducers:

Water reducers should be utilized in paving mixes whenever possible. The resultant mix should reflect an adjusted cement factor to account for the reduced water required while still maintaining the same water/cement ratio.

Subbases:

The design, durability, surface tolerance and width of subbases, all affect the overall cost of concrete pavement construction. The contractor needs a subbase, at least 3 feet (.91 m) wider than the pavement so that the slipform tracks have adequate support and track line. The subbase should be durable to withstand construction traffic without distress. Inadequate subbases which will not tolerate construction traffic increase hauling and production costs. The subbase surface tolerance should be within 1/4 inch (.6 cm) and the specification tolerance must be enforced to reduce yield loss. A subbase design which permits the concrete paving contractor to properly utilize his concrete mixing plant, hauling and slipform paving equipment ultimately reduces the overall project costs.

Stockpiling Materials:

Award construction contracts so that processing and stockpiling of aggregates can be done in the off season. Materials delivered to the project, although not installed, should be paid for on submission of appropriate invoice. Eliminate restrictive stockpiling specifications.

Standards:

Ramps:

Standardize all ramp widths to utilize normal 24 foot (7.3 m) mainline paving equipment. Deliniation can be economically achieved by corregations in the shoulder portions as required or by means of paint stripes. The American Concrete Pavement Association has two excellent references on this subject, "Simplified Ramp Designs Pay Off" Technical Bulletin No. 9, 1971, and "Comparative Costs for Concrete Ramp Pavement Designs."

Curb and Barrier Sections:

The standardization of curb and barrier sections would reduce the cost of these items. There is no need for the great number of sections when a few would achieve the same end result. The number of different sections required throughout the nation is staggering. For example, one manufacturer alone has 300 different barrier templates. There are only three basic crosssections and FHWA approves only two of these. The American Concrete Pavement Association is currently in the process of publishing a manual in an attempt to standardize these items.

Pavement Width & Shoulders:

The location of longitudinal construction joints should be at the contractor's option. This should include the option of constructing either one or both shoulders with the mainline pavement. This flexibility will not only reduce costs but also construction time.

Tolerances:

Surface Tolerances:

Surface tolerances should be the same nationwide. It follows that the method of measuring an acceptance should necessarily be standardized. Contractors could bid more intelligently and overall rideability could be improved. Tolerances should be reasonable and in keeping with the use of the pavement, it would appear that more emphasis should be put on a rideability requirement than on a surface tolerance requirement. The rideability requirement could be tailored to the intended use of the pavement. When a rideability requirement is used, the specifications should include incentive as well as a penalty clause.

Texturing Tolerances:

Texturing requirements should be standardized within the limits allowable due to variations in local aggregates.

Thickness Tolerances:

There should be greater latitude in thickness requirements and these tolerances should be standardized from state to state. Some engineers believe that the pricing for concrete could be substantially reduced if the thickness requirement was based on yield such as for asphaltic concrete surfacing rather than on the current coring process as a means of determining penalty for reduced pavement thickness.

Steel Tolerances:

Steel tolerances among the states vary from very strict to loose. NCHRP Synthesis 16 on CRCP states "The longitudinal steel should be located vertically such that there will be at least 2 1/2 inch (64 mm) of cover, and the resulting placement should not be more than 1 inch (25 mm) below middepth of the pavement. A variation of $\pm$ 1 inch (25 mm) in vertical and horizontal location does not appear to adversely affect pavement performance: therefore, steel placement tolerances should not be set so tight as to add to costs without significantly improving performance."

Temperature Tolerances:

Maximum concrete temperatures permissable in the various specifications vary from 80°F to 95°F (27°C to 35°C) at the time of placement of the concrete. With special precautions in the design of concrete mixtures and placement procedures, pavement concrete can be placed at temperatures up to 95°F (35°C). It should be noted that higher temperatures may result in higher water demands, higher rate of slump loss, and loss of air.

DESIGN

Although the committee scope is restricted to rigid pavement construction, it recognizes that there are certain elements of pavement design which overlap into construction and directly affect the overall pavement costs. These elements are discussed so that they can be brought to the attention of the design engineer.

Jointed Pavement:

An optimum joint spacing of mesh dowel design relative to costs should be adopted based on a cost analysis and local practice. A study made by Halm, "An Analysis of Factors Influencing Concrete Pavement Cost," HRB, January 1962, shows the most economical mesh dowel design at 43 ft. (13 m) joint spacing. The analysis for joint spacing should include a cost comparison with a plain pavement design. The designer should select the maximum joint spacing (based on local aggregates and experience) which will control transverse cracking. It would appear appropriate that further attention should be given to jointing and the type of joints that would lend themselves to production slipform paving, rather than letting a joint design dictate a

higher cost method of production, i.e. longitudinal joints with heavy dowel bar requirements for airports. A plain pavement with doweled joints at approximately 15 ft. (4.5 m) spacing will generally cost about the same as the most economical mesh dowel design. Dowel implanters may provide additional cost savings and should be permitted in lieu of dowel basket assemblies.

Continuously Reinforced Concrete Pavement (CRCP):

Specifying agencies have achieved economies by allowing, as an alternate, the placing of reinforcing bars by mechanical means, i.e. fed through tubes attached to the paver. Further economy may be achieved by permitting the use of #6 bars to achieve the same percentage of steel using fewer bars and requiring less labor.

Composite Pavements:

Hauling costs are often several times greater than the cost of the materials themselves. The designer should consider the use of local marginal materials which are less expensive but do not meet premium quality standards. These materials may be placed in the lower portion of the pavement and covered immediately in a monolithic operation with several inches of quality concrete meeting all the necessary specifications.

Recycled Concrete:

Specifiers should permit the use of recycled concrete in their overall designs. This recycled material can be used as aggregate for normal concrete. It should be noted that natural sand must generally be added to produce a good workable concrete mix. Depending on local aggregate availability and hauling costs, recycled concrete can be very cost effective for many job items.

Culverts - Bridges:

Designer should make the optimum use of culverts in lieu of bridges so that placement of bases and pavements will be uninterrupted. Such designs will reduce initial costs, maintenance costs, and provide for better riding qualities. This practice is used far more extensively in European countries than in the United States. Structures should be wide enough to accommodate full width paving equipment.

PRODUCTION

Minimize Interruptions:

Any interruption of mainline paving operations reduces productivity and increases costs. Offsets and dogears for tieing in adjacent ramp paving or intersections should be eliminated. Gaps or leave out sections should be kept to an absolute minimum. To achieve a minimum of interruptions, it is necessary to have as uniform compaction of subgrade, uniformly good condition of haul roads, uniform aggregate, uniform cement--preferably all from a single source, and uniform consistant inspection of the work. Surprises do not promote economy. Uninterrupted operations produce the highest quality pavement as well as the best riding pavements.

VALUE ENGINEERING

The Society of American Value Engineers defines value engineering as "the systematic application of recognized techniques which identify the function of a product or service, establishes a value for that function, and provides the necessary function, reliably, at the lowest overall cost."

Value engineering is **an effective tool in the** fight against inflation. Through the identification of function, cost, and worth, it is possible to isolate high cost/poor value areas, eliminate unnecessary or redundant functions, and through the development of alternative and innovative concepts, materials and procedures, simplify design, improve specifications, and enhance competition. Above all, by gaining an increased sensitivity to the cost consequences of engineering and administrative decisions, it will be possible to establish initially more realistic and cost-effective program and project criteria. The value engineering approach should be so constituted as to take advantage of both agency and industry ingenuity where appropriate.

It can be useful in determining the contract size or applicability of stage construction through consideration of influencing factors such as equipment availability, opportunities to eliminate borrow or waste, topography, and length of construction season.

It can be useful in determining when to waive old standards (influenced by variations in climate and terrain throughout the country) or when to adopt new ones.

It can help eliminate nuisance specifications, reduce tolerances where necessary, ensure optimum use of cement, reinforcing, mixing time, etc.

It can be used to discover how, when, and where recycled materials can best be used.

It can be used to determine where locally or readily available materials may be used; for example, see section on Design-Composite Pavements.

It also supports and justifies the use of contractor incentive clauses. For instance, the application of these concepts to the early completion of the Edens Expressway **in Chicago developed an incentive of $56,000 per day, which is equal to the liquidated damage charge per day for overruns in time.**

It is invaluable in arriving at the most cost-effective means of sequencing construction activities and maintaining traffic safety through construction zones. The use of pre-bid and post-bid conferences between the agency and the industry is essential to the development of the safest, most economical and best program to accomplish this.

UTOPIA

Although it might not be possible in the foreseeable future, the "turn key" concept bringing together the owners, consultant and contractor in a joint venture would result in the lowest overall cost. Design and construction could be done by separate organizations. The key is to have a large amount of work requiring essentially the same construction procedures, hence equipment, and done within a reasonable geographic area. This concept works in the building industry and therefore should be given consideration in the highway industry.

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