ENGINEERING ECONOMY AND ENERGY CONSIDERATIONS

HELPFUL HINTS IN HIGHWAY COST ESTIMATING

RESEARCH REPORT 214-8

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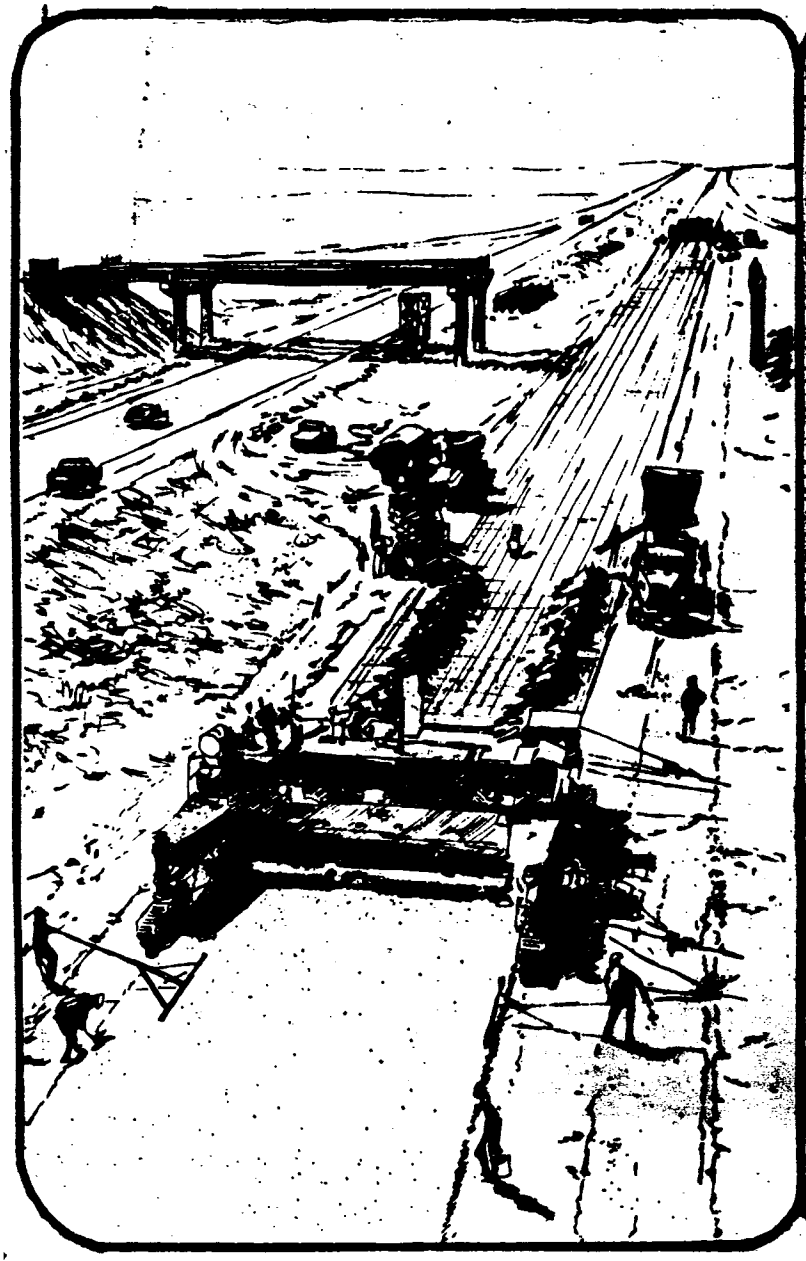

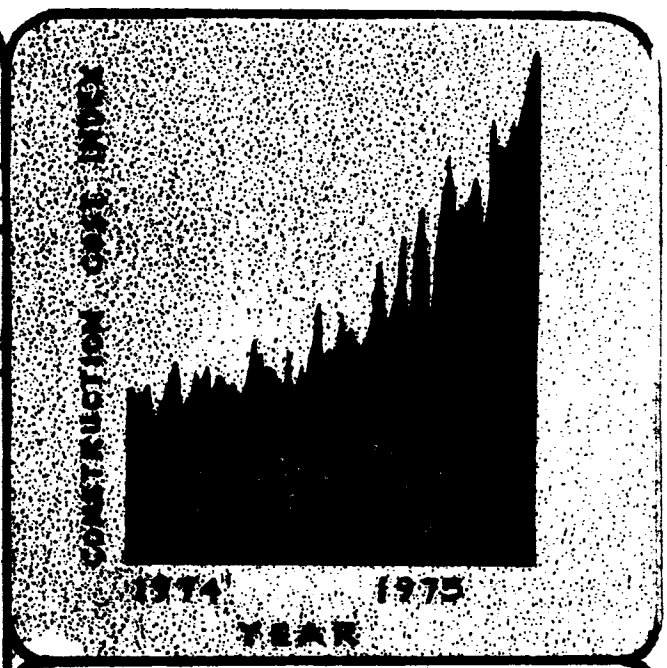

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"ENGINEERING, ECONOMY AND ENERGY CONSIDERATIONS IN DESIGN, CONSTRUCTION AND MATERIALS"

TEXAS STATE DEPARTMENT
OF HIGHWAYS
AND PUBLIC TRANSPORTATION

AND

TEXAS TRANSPORTATION INSTITUTE
TEXAS A&M UNIVERSITY

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HELPFUL HINTS IN HIGHWAY COST ESTIMATING

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Introduction

Procedures for estimating project costs within the Department are sophisticated, detailed, and very thorough. From the residency office, through the District office, and finally to the appropriate Division office, each estimate is carefully analyzed and updated. Bid quantities are estimated for each job and used together with unit bid costs to estimate project costs. Tools of value to the engineer include the 12-month moving average for each bid item, which is calculated each month by district and statewide, the statewide 3-month moving average of each bid item, and the Whitley-Siddons bid tabulations for each project.

To uncover what improvements, if any, could be made in current cost estimating procedures, representatives from four Districts and two Divisions met with researchers at the Texas Transportation Institute to discuss cost estimation. From this discussion some "helpful hints" that may be of use in cost estimating were discussed and are summarized briefly. These are "hints" only and are not intended to be considered as concrete guidelines for cost estimation.

Uses of Cost Estimates

Engineer's estimates of construction costs are used in several ways by the Department. Estimates are used for planning and programming future highway expenditures, needs, and lettings.

When cost estimates are used for monthly lettings, it is desirable that the total low bid cost for all projects let in each month be approximately equal to the amount of funds budgeted to handle the letting. Current methods of estimating project costs have served this purpose very well, and monthly letting estimates generally have been within five percent of the actual low bid totals. There was some difficulty in making monthly estimates in 1973 and early 1974 because of rapid increases in inflation. This can be adjusted for by using an index to adjust each project in the letting or by adjusting the total letting.

When the low bid for a particular project exceeds the estimated cost by an exorbitant amount, it may be desirable to not let the project, especially if there is a lack of competition. However, if the only problem may be an inaccurate cost estimate, reletting such contracts at a later date may result in a higher rather than a lower cost.

Another phase of cost estimating, sometimes overlooked, in which accuracy is necessary is the preparation of cost estimates in the early stages of project proposals and development. Accurate early estimates are fundamental in the decision making process as the first cost estimates often determine whether or not a project is viable.

Underestimating a project can result in future difficulties if later cost estimates exceed funds available at the time the project approaches a letting date. Overestimating a project at an early date could, of course, result in denial of a project that otherwise would be built.

In comparing alternate projects for cost effectiveness and in comparing competing projects located in different areas by using a benefit/cost approach as a guideline for project selection, accurate cost estimates are absolutely necessary if benefit/cost guidelines are to have any meaning.

By definition, preliminary project costs cannot be as accurate as cost estimates prepared after detailed construction plans are available. Predicted future costs are influenced by possible escalations and deescalations in costs of right of way and construction. Preliminary project costs should be updated periodically to show the cost in today's dollars. Updating costs can be accomplished by applying a price index to the overall project costs or by simply re-estimating the project by applying the most recent contractor's bid prices in a given area. In making early estimates it would be desirable to have available items of gross work such as cost per lane mile, drainage costs per station, interchange costs, lumped miscellaneous costs, etc. Preliminary engineering costs are also necessary in arriving at the total cost, of a given project.

The other major use of cost estimates is for comparing costs of alternative job sizes, designs, and materials. In this use, it is essential that costs be estimated accurately enough to identify the most cost-effective alternative. With the spiraling increases in the costs of labor, equipment, and materials, with the uncertainties of weather, and with the elements of unknowns in any construction job, achieving the cost accuracy needed for comparing alternatives becomes very difficult. It is this use of cost estimates--for comparing the cost of alternatives--that is the primary purpose of this report.

Role of Cost Estimates in Reducing Highway Costs

In designing a project to meet stipulated motorists' needs, there often are alternative ways of meeting those needs. To determine the least costly alternative, it is necessary to have procedures that lead to a consideration of alternatives and accurate methods of projecting what those alternatives will cost. To do this, it is necessary to have sufficient engineering time

allocated to each project to compare the cost of alternatives in initial design and later phases.

However, even if alternatives are considered in the initial design phases, it still may be difficult to insure that the design finally used will be the most cost-effective design. This problem is compounded by: (1) the increasing lengths of time between initial designs and project lettings, (2) changes in rates of inflation, including changes in relative prices of different materials, equipment, and fuels and changes in those prices relative to the price of labor. There are at least three ways to correct for these situations: (1) increasing the frequency of updating and recomparing alternatives, (2) reducing the time between design (comparison of alternatives) and the date of letting, and (3) making increased use of options and alternates. Thus, it is important to always remember that cost estimating is an integral part, but only a part, of the total procedure for getting the best highway per dollar of cost.

Cost estimating as used in comparing alternatives, considering the size of the contract, traffic, sequence of work, and length of construction and working times, should be viewed as part of the overall procedure for developing contracts.

Helpful Hints

1. Unit price bids reflect not only the cost of the unit but also the need for the contractor to improve his cash flow position, to recover his undistributed costs (overhead, contingencies, etc.), and to recover his mobilization costs early. Hence, the history of unit price bid values (12-month moving average) may be misleading. When analyzing these past bid prices they can be examined against the spread of bid prices on a

similar project recently bid. This spread may indicate the degree to which the unit bid was influenced by factors other than direct cost. For example, if the most recent 12-month moving average for asphalt under Item 340 is $50.03 per ton, and if on a recent bid from a similar type project the spread of bids on this item ranges from $1.00 to $110.00 per ton, then the 12-month moving average may not be a good indicator of the cost of this item. In order to arrive at a more accurate estimate, the engineer might look at the total costs of both of the pay quantities in Item 340 (i.e., aggregate in addition to asphalt). Continuing with this example, assume that the 12-month moving average cost of the aggregate under Item 340 is $15.30 per ton and that the spread of costs on this similar type project ranges from $12.00 to $22.00 per ton. Combining these two costs and assuming a 5 percent asphalt design yields a 12-month moving average cost of the mixture to be $17.03 per ton, while the spread of the cost of the mixture (from this specific project) would be from $16.90 to $20.95 per ton. The average price of the mixture (from the spread) is $18.93, which could then be used as the engineer's revised estimate, and the unit price estimate could then be arbitrarily assigned to make the total mixture costs equal to $18.93. In order to make this type of analysis, the bid summary format -- now tabulated in Austin and transmitted in two copies to each district involved -- could be changed to a format similar to that used by Whitley & Siddons in their tabulations. Since Whitley-Siddons is a rearranged bid tabulation, the Automation Division could provide this format if the Districts want it. Another alternative is for Districts to use Whitley-Siddons tabulations in addition to their other information, as indeed many already do.

The Construction Division has maintained a cost index, with a 1962-64 base, on selected items for several years. This system also produces

tabulations of the index for individual items. The Bridge Division maintains a file of cost of bridge items by bridge and contract. In general, there is considerable information available in the Department to produce weighted averages and statistical information concerning various types of construction.

2. Several governmental agencies and private groups prepare economic trends to aid in economic forecasting. One such trend is the Engineering News-Record (ENR) Cost Index (Figure 1). This index can be used when the only historical bid price available for an item of work is several years old. For example, if a January, 1972 bid price for 10 inch concrete pavement (Item 360) was $\$10.52/yd^2$, then using the ENR Index for common labor plus materials the July, 1975 price might be:

$$\$10.52 \times \frac{2150}{1700} \text{ (extrapolation)} = \$13.30/yd^2$$

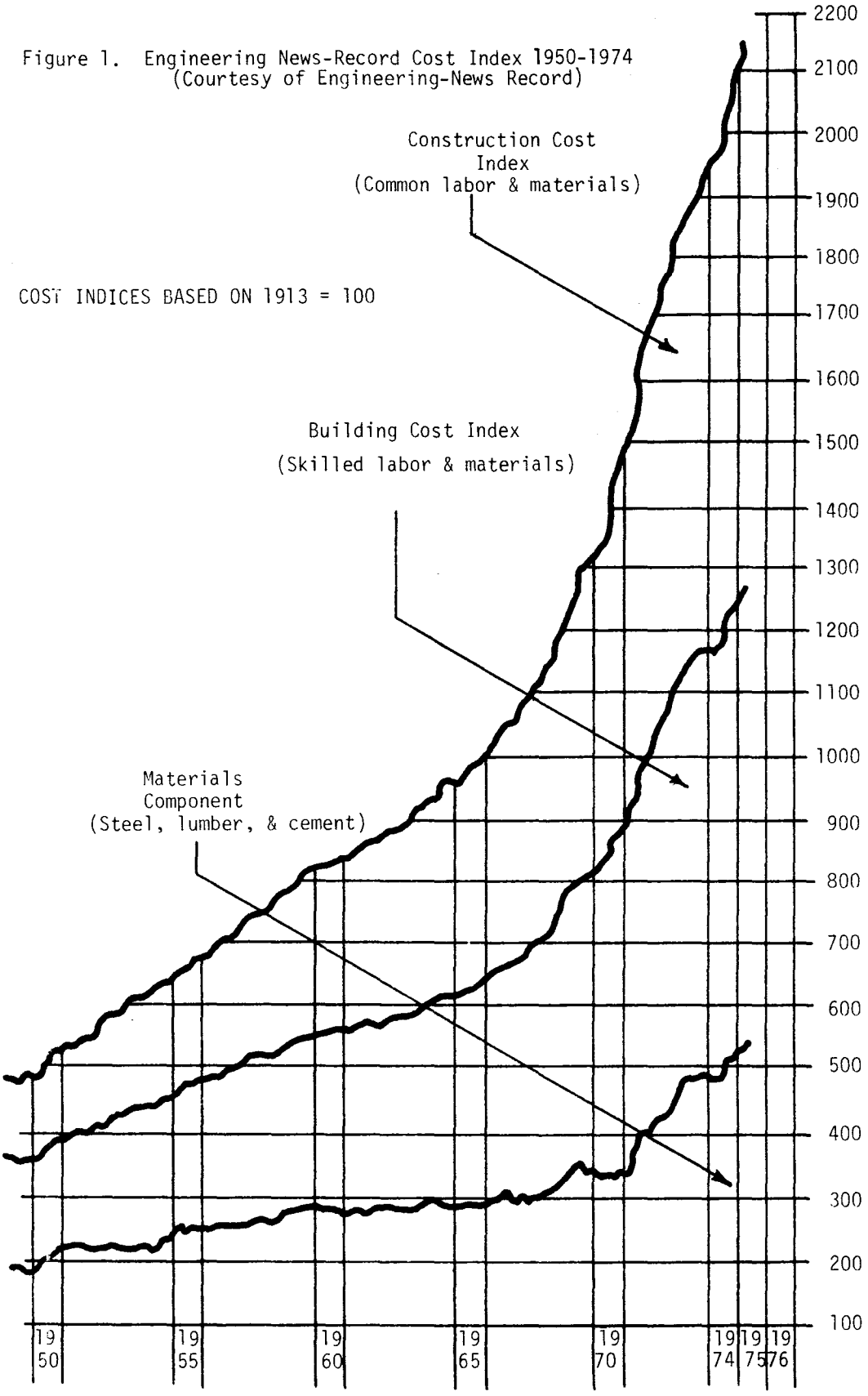
The ENR also compiles the Highway Bid Price Index from many of the states, and their compilations of the Texas bid prices is portrayed in Figure 2. Using this index and extrapolating, the July, 1975 price for the concrete pavement might be:

$$\$10.52 \times \frac{320}{144} \text{ (extrapolated)} = \$23.38/yd^2$$

This estimate is vastly different than that made from the main ENR Index and points to the difficulty in using indices. However, they are of value to the experienced estimator when used with engineering judgment.

3. In line with Item 2 above, the State Department of Highways and Public Transportation, through their maintenance purchases, 12-month moving averages, and 3-month moving averages, has the necessary information to develop a more definitive cost index directly related to highway construction.

Figure 1. Engineering News-Record Cost Index 1950-1974
(Courtesy of Engineering-News Record)



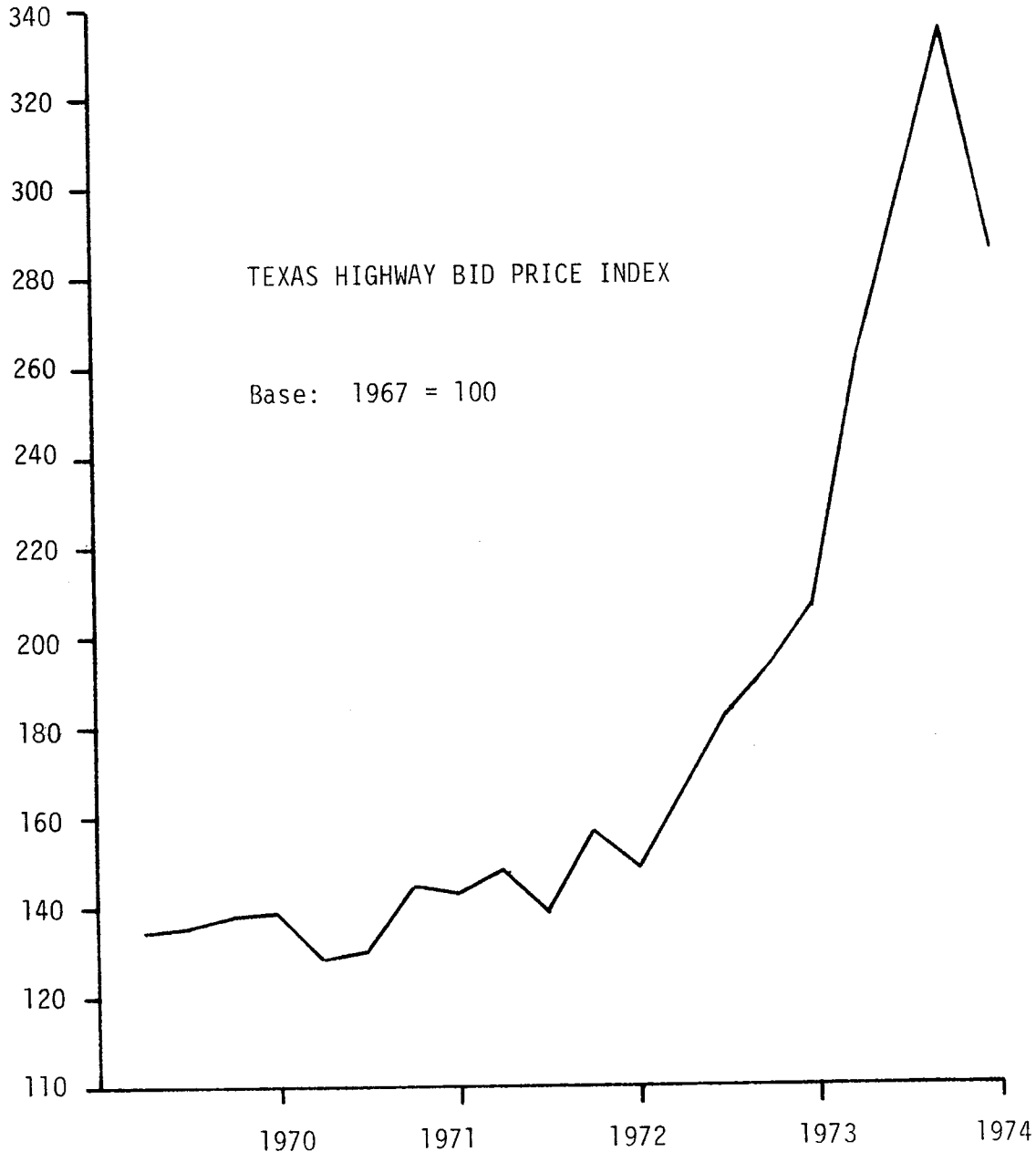


Figure 2. Texas Highway Bid Price Index

To be most useful, such an index should combine the costs of subunits of a major materials/systems: i.e., the costs of aggregate and asphalt (see hint number 1); such cost factors as cost/lane foot for various pavement structure types; ratio of pavement structure system unit cost to the total highway unit cost; costs of materials versus total cost of construction (from force account work); etc.

The Automation Division is continually studying different ways to improve cost tabulations and currently is making a special study of the Districts' needs in this area. If the consensus of the Districts is that new types of cost tabulations are needed, the Automation Division will provide them. For example, action on the proposal that the twelve-month moving average program be modified to include a test of the bid prices to eliminate those that are not reasonable can be accomplished if the Districts express a need for such a modification. Also, the Automation Division can develop additional computer packages for preparing preliminary project cost estimates if it is the consensus of the Districts that these are needed.

4. Also available to the Districts on special request from the Automation Division is a compilation of average bid prices on selected projects. Thus, if the cost estimator knows of several other projects that are somewhat similar to his and wants to know the average low bid unit price for items in those projects, he can acquire such information by simply contacting the Automation Division and entering a minimal amount of information in his terminal (See Appendix). This may be especially useful since recent contractors' unit prices in a particular area should provide good estimates. These unit prices also can be used for updating preliminary estimates and may be better than a statewide index when used for such purposes.

5. Out of approximately 20 to 50 bid items found on every project, often only 5 items represent more than 80 percent of the total project cost. If the estimator can closely estimate these 5 items, he will be fairly sure his estimate is realistic. Therefore, a "helpful hint" would be to remind the highway estimator to continue following the practice of closely analyzing these key items. If this process is unsuccessful, he might then consider determining the actual cost of these items from ongoing projects. Daily records are generally kept to provide information essential for monitoring the partial payment to the contractor for work completed. This information can be amplified by gathering data on equipment production rates, crew sizes and productivity, and materials costs. From these data, an accurate estimate of the direct cost (labor, materials, equipment) of each item can be made. Next, the costs of job overhead, general overhead, contingencies, and profit can be estimated on the basis of established percentages of direct costs (for example: 12 percent for job overhead, 7 percent for general overhead, 2 to 3 percent for contingencies, and 5 percent for profit - or 26 to 27 percent of direct costs). This suggestion involves considerable effort to implement because it takes considerable time to develop and maintain the data. Therefore, this effort may be justified only in those cases where costs cannot be estimated by easier means.

6. Another way to reduce variations in unit price bids is to provide separate pay items for all types of work involving significant expenditure of funds. This method includes separate pay items for detours and traffic handling, erosion control, excavation on slopes required to be at a certain angle of repose to meet OSHA regulations etc. This practice already is followed on many items by many of the Districts.

7. The Districts queried believe that greater emphasis on prebidding conferences, during which the intent of the Department is completely communicated to the contractors, will result in lower bid spreads between competition. Lower bid spreads imply a reduction in cost as well as the accomplishment of realistic estimates. Occasionally such a practice will permit additional contractors to bid. This, in turn, may result in lower costs.

8. Although it is a cost-saving hint and not strictly a "helpful hint" for cost estimating, highway engineers may consider increasing the use of options, whenever feasible, in their projects. Options are usually more difficult to estimate but there are indications that a savings in cost might be possible. The savings comes from the contractor knowing at the time he bids that he can later select, at his option, more than one material and/or system for a given portion of work. This should allow competition to keep prices as low as practicable as the contractor obtains competitive quotes from suppliers. Use of options requires additional planning and engineering. Before deciding to use options, the engineer should carefully evaluate the possible advantages and disadvantages associated with options in each specific situation.

9. Another cost-saving hint which is receiving increased attention is the standardization, insofar as is practicable, of such repetitive items of work as curb and gutter sections, and entry ramp configurations. This process helps to reduce uncertainties in the cost estimation.

The preceding "helpful hints" are offered for guidance purposes only. Accurate cost estimation is, at best, only an educated guess, based largely on engineering judgment and insufficient information. These hints should be used only in those cases where they are applicable.

Summary

More accurate cost estimating together with comparison of alternatives can reduce costs. Cost estimating and choice of letting strategy, highway design, materials, and construction methods are all part of the overall strategy of ensuring that the best highway per dollar is built. The principal "helpful hint" is to consider several alternatives that provide the desired level of effectiveness and allocate enough time to estimating costs so that the most cost-effective alternatives can be chosen. Other helpful hints are:

- Look at several bid prices and use judgment to determine the best price to use.
- Use cost index trends to update items that have not been used recently.
- It may be possible to construct new cost indices for use in updating cost estimates for some items.
- The Automation Division will provide a special compilation of average bid prices on selected projects upon request.
- Determine the most costly items on a project and estimate their cost as precisely as possible.
- Provision of separate pay items for all types of work involving significant expenditures, such as detours, should reduce variation in other bid items and lead to better overall estimates.
- Use of bidding conferences may be helpful in reducing project costs and improving cost estimates.
- Increased simplicity and standardization reduces both the absolute cost and cost variability.

APPENDIX

User Instructions for Special Automation Division Cost Analysis - Requested Average Low Bid Unit Price Program

For any selected month(s) with its associated letting codes, the average low bid unit price and activity indicator (number of usages) can be computed by this program for all items included in the project.

As many as 9 separate requests may be run together (batched) if each batch is given a unique numeric batch number (0-9) in card column 10. If only one batch is to be processed this card column may be left blank (the default is batch number 0).

The input requests for each batch will be listed separately as will the Average Low Bid Unit Price report.

The format for the card input is as follows:

	Columns	Data In Columns
Contract Number	1	Blank
	2-3	Numeric month requested
	4-5	Numeric year requested
	6-9	Letting Code
	10	Numeric batch number (or blank)
	11-20	Blank
	21-60	Project number and/or user comments. (optional)

Example Inputs and Output for Requested
Average Low Bid Unit Price Program

```
1-10      11-20      21-30      31-40      41-50      51-60      61-70      71-80
1234567890123456789012345678901234567890123456789012345678901234567890123456789012345678
01710024 T 9029(2)
03710024 T 9030(2)
05710023 T 9020(3)
08710018 T 9002(2)
09710002 T 9038(2), T 9040(5)
```

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BATCH 1

AVERAGE LOW BID UNIT PRICES
OF PROJECTS REQUESTED

THE PROJECTS REQUESTED WERE

MONTH	YEAR	JOB	PROJECT
01	71	0024	T 9029(2)
03	71	0022	T 9030(2)
05	71	0023	T 9020(3)
08	71	0018	T 9002(2)
09	71	0002	T 9038(2), T 9040(5)

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BATCH 1

AVERAGE LOW BID UNIT PRICES
OF PROJECTS REQUESTED

ITEM NO	DESCRIPTION	UNITS	QUANTITY	AVG BID	USAGE
100 SERIES					
100 002	PREP R O W	STA	18.000	35.00000	1
102 001	CLEAR AND GRUB	AC	.570	1,140.00000	1
104 002	REMOV OLD CONC (SLAB)	SY	804.000	2.00000	1
104 003	REMOV OLD CONC (CURB OR C AND G)	LF	3,217.000	1.84500	2
104 004	REMOV OLD CONC (MED)	SY	9,171.000	1.14000	1
104 007	REMOV OLD CONC (PAV)	SY	3,790.000	2.00000	1
110 002	UNCL RD EXCAV (DENS CONT)	CY	4,760.000	1.26000	1
110 005	COM RD EXCAV (ORD COMP)	CY	534.000	2.50000	1
110 006	COM RD EXCAV (DENS CONT)	CY	11,530.000	1.70000	1
120 002	UNCL CHAN EXCAV (DENS CONT)	CY	391.000	1.26000	1
120 005	COM CHAN EXCAV (ORD COMP)	CY	3,143.000	1.70000	1
162 005	MULCH SOD	CY	5,200.000	4.00000	1
164 007	BRDCST SEED (TY 7)	SY	20,900.000	.06000	1