
Research Report
KTC 91-6

ENGINEERING ESTIMATES
AND FHWA ACCURACY CRITERION

by

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College of Engineering
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in cooperation with
Kentucky Transportation Cabinet

and

Federal Highway Administration
US Department of Transportation

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July 1991



COMMONWEALTH OF KENTUCKY
TRANSPORTATION CABINET
FRANKFORT, KENTUCKY 40622

DON C. KELLY, P.E.
SECRETARY
AND
COMMISSIONER OF HIGHWAYS

BRERETON C. JONES
GOVERNOR

October 1, 1992

Mr. Paul E. Toussaint
Division Administrator
Federal Highway Administration
330 West Broadway
Frankfort, Kentucky 40602-0536

SUBJECT: Implementation Statement KYHPR 90-131, Cost Estimating Systems

Dear Mr. Toussaint:

Research Report KTC 91-6 entitled "Engineering Estimates and FHWA Accuracy Criterion" describes analyses undertaken during the course of the study. There were two overall objectives addressed during the study. The first was an investigation into procedures used by the Department's estimating staff to do an estimate and determine wherein the most probable error(s) in the process existed, if any. The second objective was to discuss advantages and disadvantages of determining a fair price for a construction project versus attempting to predict the low bid.

It was concluded that the Department's Estimating Staff possess the ability to do very thorough and accurate work. An actual cost estimation method is employed by the staff to calculate the worth of a project to the Department. The Estimating Staff generate a construction cost estimate which the Department considers to be a reasonable and equitable price for an average contractor to complete the proposed work in an approved manner. The percent of the engineer's estimates within +/- 10 percent of the low bid improved significantly during the period studied. However, there were two contractual areas identified where the accuracy of the engineer's estimates should be improved. Those two areas were identified as bituminous projects having more than one bidder, indicating strong competition for the work, and mowing projects. Researchers recommendations to utilize prior bid information obtained from recent internal records to adjust the engineer's estimate when strong competition is anticipated will be implemented. Revisions of mowing activity descriptions and/or specifications should enable the engineering cost estimator to generate a more viable cost estimate and those revisions are considered appropriate.

Sincerely,

A handwritten signature in cursive script, appearing to read "J. M. Yowell".

J. M. Yowell, P.E.
State Highway Engineer

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16. Abstract <p>The Federal Highway Administration requires the construction cost estimate of the highway engineer to be a projection of the low bid, and be within +/- 10 percent of the low bid for at least 50 percent of the projects awarded. Construction cost estimates developed by the Estimating Staff of the Kentucky Department of Highways have not always met this criterion in years past.</p> <p>The Estimating Staff of the Kentucky Department of Highways use an actual cost approach to generate construction cost estimates. It was concluded that the Department's estimating staff possess the ability to do very thorough and accurate work. The Estimating Staff produce a construction cost estimate for a project that is considered to be a reasonable and equitable price for an average contractor to complete the proposed work in an approved manner. The Kentucky Department of Highways considers the engineer's estimate to be a fair price for the project. The percent of the engineer's estimates within +/- 10 percent of the low bid improved during the period reviewed. Proper assessment of the affect of competition on the bids for bituminous projects would virtually guarantee compliance with FHWA's accuracy standard.</p> <p>Advantages and disadvantages of determining a fair price for a construction project versus predicting the low bid were examined.</p>			
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EXECUTIVE SUMMARY

There were two overall objectives addressed during this study. The first was an investigation of procedures used by the Department's Estimating Staff to do an estimate and determine wherein the most probable error(s) in the process existed, if any. The second objective was to compare the advantages and disadvantages of determining a fair price for a construction project versus predicting the low bid. The Federal Highway Administration requires the construction cost estimate of the highway engineer to be a projection of the low bid, and be within +/- 10 percent of the low bid for at least 50 percent of the projects awarded. Construction cost estimates developed by the Estimating Staff of the Kentucky Department of Highways have not always met this criterion in previous past.

Procedures used by the Estimating Staff of the Kentucky Department of Highways to generate construction cost estimates were examined. Those procedures are quite similar to those used by contractors. The engineering cost estimators have the ability to do very thorough and accurate work. An actual cost estimation method is employed to calculate the worth of a project to the Department. The Estimating Staff generate a construction cost estimate that is considered to be a reasonable and equitable price for an average contractor to complete the proposed work in an approved manner. The Kentucky Department of Highways considers the engineer's estimate to be a fair price estimate for the project.

Overall, the percent of the engineer's estimates within +/- 10 percent of the low bid significantly improved during the period studied. However, there are two contractual areas in which the accuracy of the engineer's estimates should be increased. The two areas were identified as bituminous projects, in which strong competition for work is anticipated, and mowing contracts. It is recommended that the Department utilize previous bid information obtained from recent internal records to adjust the engineer's estimate for bituminous work downward when strong competition is anticipated. Understandably, it is very difficult to estimate the cost of mowing. When assessing the cost of mowing, it appears that members of the Estimating Staff do not possess a firm working knowledge of all of the details involved in mowing activities. This difficulty in estimation may be attributed to slight differences in mowing types and related specifications. Appropriate changes of mowing activity descriptions and/or specifications are recommended to facilitate development of more accurate mowing cost estimates. Increases in the accuracy of the Department's estimates within these two contractual

areas would virtually ensure that the Department's estimate would satisfy FHWA's accuracy criterion.

Advantages and disadvantages of determining a fair price for a construction project versus predicting the low bid were discussed. Most often an actual cost approach, the approach used by the Department, is utilized to develop a fair price for contract work. To predict a low bid, the estimator will use historical bid data, unit prices, and quantities obtained from recently awarded contracts. These data are adjusted based upon specific project conditions, such as specific project quantities, location, overall project size, and general market conditions.

The advantages of determining a fair price for a construction job include a higher sensitivity to the specific requirements of a given construction job, providing the contracting agency and estimate reviewers a better idea of how much a project should cost, and, the engineer's estimate is not affected by price fixing or other non-competitive bidding practices. The disadvantages of determining a fair price for the anticipated work are manpower and high level of discipline required to produce this type of estimate. The manpower required to produce an estimate using this approach however, can be five to ten times higher than the historical based estimate. Estimators should possess a strong background in construction techniques and equipment, equipment production rates, how much to adjust quotes from suppliers, etc., as well as quantity take-offs and pricing experience.

Historical bid based estimates are used to predict prices that will be offered on future work. The greatest strength of this type of system is the economy of the method. The use of automated data systems counter the need for a large and well trained estimating staff. Disadvantages of this method are that predicting prices is very sensitive to market behavior such as price fixing or complementary bidding; historical bid based estimates are insensitive to short-term market conditions because the system is slow to react to changes in pricing trends; and, the system is not project specific but is based upon a typical project.

INTRODUCTION

This study was primarily the result of the Federal Highway Administration's (FHWA) current policy relative to the accuracy of construction cost estimates prepared by state highway agencies stated in Technical Advisory Memorandums 5080.4 and 5080.6, "Preparing Engineer's Estimate and Reviewing Bids." The technical advisories state that an engineer's estimate should reflect the amount which a state considers reasonable and is willing to pay for performance of the contemplated work. FHWA requires the engineer's construction cost estimate to be a projection of the low bid, and be within +/- 10 percent of the low bid for at least 50 percent of the projects awarded. Construction cost estimates developed by the Estimating Staff of the Kentucky Department of Highways have not always met this requirement in previous years.

There are three basic approaches to cost estimating that are recognized by FHWA. These methods include an actual cost estimation, use of historical data to develop a cost estimate, and an approach which is a combination of both methods. The Estimating Staff of the Kentucky Department of Highways uses an actual cost estimation method to generate a construction cost estimate. The actual cost estimation method analyzes components of the work, assigns costs to the various components based on current market conditions, and develops new unit cost estimates for each project. The estimator prepares a detailed quantity take-off of material, labor, and equipment, and then estimates the overhead and profit.

Historical bid based estimates are generally prepared to predict what the low bid will be, within a certain percentage. This would be largely acceptable if the competition were assumed to be perfect. The historical data approach is probably the most common method used to prepare a cost estimate. The estimator utilizes historical bid data, unit prices, and quantities obtained from recently awarded contracts to develop the cost estimate. The data are adjusted based upon specific project conditions, such as project quantities, location, overall project size, and general market conditions. The method provides a good estimate if it is properly adjusted. While the historical data method for all items of the estimate requires the least amount of personnel and time to develop, it is also easily influenced by outside factors. It has been shown that historical data can be artificially influenced by inflated bid prices.

Because most projects contain a small number of items that together comprise nearly 70 percent of the total cost, use of the combined approach is appealing. These major items include embankment, asphaltic concrete and portland cement concrete pavement,

structural steel, and structural concrete. In the combined approach, prices for these major bid items would be estimated from actual costs. Remaining items would be estimated on the basis of historical prices.

Construction cost estimators for the Kentucky Department of Highways use procedures similar to contractors when estimating the cost of a construction project; the actual cost approach. Generally, the best source of cost information an estimator may use comes from "in-house" records. A final estimate for the contract, showing the final quantities of all work accomplished, is completed after final inspection and acceptance of the work by the engineer. A good estimator of construction costs must possess a working knowledge of the details of construction work; experience in construction work; good judgment in regard to different localities, different jobs, and different workmen; a good method for preparing an estimate and the ability to do careful, thorough, painstaking, and accurate work; and, the ability to visualize all steps of the construction process. Furthermore, a good estimator must have available needed information relating to materials required, labor hours required, equipment needed, overhead, and the ability to collect, classify, and evaluate data relating to estimating.

To prepare a good estimate and reasonably anticipate the cost of work, the project must be broken down into small units of similar work in accordance with a specific plan of construction. Each unit must then be priced according to the expected productivity for the specific plan and site conditions associated with the project. Because an estimate is made before the work is performed, the estimated cost is never the actual cost. The difference between the estimated cost and the actual cost depends upon many factors. However, the estimator is expected to produce a fair price for the project. The Kentucky Department of Highways develops a construction cost estimate which is considered to be a reasonable and equitable price for an average contractor to complete the work in an approved manner. The actual price is firm because a contractor is willing to take a risk on it.

Cost estimates for construction projects are based primarily on the estimator's knowledge of costs associated with labor, materials, equipment, overhead, and profit. Labor costs are the most difficult to judge. If production rates for workers are estimated too conservatively (underestimated), then the engineer's cost estimate may be too high. Wage rates, on the other hand, for construction laborers have traditionally been very easy to estimate. In fact, workers wages are set by the Davis-Bacon Act for some federally funded projects. However, overestimating labor or the time required to perform a task may be common because of continued advancements in construction techniques and equipment.

The cost of materials also may vary due to last minute agreements between material suppliers and contractors or due to effects of rising or falling markets on material prices. ~~Current prices are sometimes not available to any estimator who is not buying.~~ Materials suppliers often say one thing to owners and designers, which is more or less public information, and price an item entirely different to bidding contractors who will be writing a purchase order or contract. These effects may result in inherent errors in the engineering cost estimate. Equipment costs are generally easier to estimate. However, if the estimator fails to exactly replicate the lower bidder in consideration of the cost of the equipment, either through rental costs, sinking fund costs, or depreciation costs, in a bid, then the estimate may be skewed.

Overhead costs are usually divided into two categories: general overhead costs and general job condition costs. General overhead is the cost of doing business and includes all costs that cannot readily be charged to a specific job. General overhead includes the contractors' home office costs, yard and shop costs, accounting costs, estimating costs, salaries of officers and key personnel (not assigned to a specific project) and similar items. General overhead costs of each contractor will vary and generally will be a higher percentage for a very small contractor than for a very large contractor. General job condition costs may include all costs which may readily be charged to the job but which cannot be charged to labor, materials, or equipment. Total overhead costs generally vary depending upon the kind of job, locality, and items included in the job. Estimating the cost of overhead requires extremely careful judgment on the part of the estimator.

Last, but not least in importance, is profit. Profit is usually expressed as a percentage of the total estimated cost of the job. The percentage usually varies from 8 to 15 percent, depending on the contractor's desire for work, what is considered reasonable, and what a contractor thinks he can get. The percentage of profit added also depends, to some extent, on risks and unforeseen difficulties of the job and on how often payments are to be made and in what amounts. Because of the uncertainty of the amount of profit a contractor is willing to accept, there is always a chance that the estimator may either overstate or understate the percentage of profit when estimating construction costs.

For some projects having unit price contracts, some contractors having experience and acumen may deliberately overprice some items of work in a schedule of unit prices because they believe the quantities of the overpriced items will increase and the quantities of the underpriced items will decrease, and in this way the contractor will make extra profit. Another common reason for overpricing some items and underpricing others in a schedule of unit prices is to receive overpayment at the outset of work by

overpricing the preliminary general requirement items and items of work to be performed first on the job and underpricing other items to be performed later. In this way, a contractor is able to partially finance work with the Department's money, and thus save on his own financing costs. A contractor also may "unbalance" his bid to take advantage of an erroneous estimate of quantities by the Department. To prevent an "unbalanced bid", the reviewer of the bid packages must try to assure that all lump-sum allowances for general conditions and all unit prices for major items at least, are realistic and that they are not distorted. This may not always be easy to do and it indicates that the engineer must have his/her own accurate and realistic estimate of costs of work.

The objectives of this study were a) to analyze the procedures of the Estimating Staff to do a complete study and determine wherein the most probable error(s) in cost estimating exist; and, b) to compare the advantages and disadvantages of determining a fair price for a construction project versus predicting the low bid.

BACKGROUND

The Federal Highway Administration does not appear to have a single policy statement regarding development of an engineer's estimate. The requirement for a cost estimate, however, was contained in the original legislation establishing the Federal-Aid highway system. The Federal-Aid Road Act of 1916 included the following statement:

"That any State desiring to avail itself of the benefits of this act shall, by its highway department, submit to the secretary project statements setting forth proposed construction if the secretary approves a project, the state highway department shall furnish to him such surveys, plans, specifications and estimates therefore as he may require"

Plans, specifications, and estimates are intrinsically linked. One rudimentary concept of the construction cost estimate is that it must be unique to a specific project's plans and specifications and must represent the expected costs for constructing a certain project in an approved way. Federal-Aid Highway Program Manual (FHPM) 6-3-3-1 contains requirements for Plans, Specifications, and Estimates. The manual states "an estimate shall reflect the anticipated cost of the project in sufficient detail to provide an initial prediction of the financial obligations to be incurred by the State and FHWA and to permit an effective review and comparison of the bids received." It may be seen from this

statement there are at least two intentions, or purposes, for an engineer's estimate. The first purpose is obvious. The engineer's estimate serves as a critical element in budgetary planning and the obligation process in Federal-aid. Secondly, the engineer's estimate is the baseline reference in the construction contract letting process. When bids for a project are received, only through a carefully and accurately prepared engineer's estimate can items such as bid rigging, complementary bids, and unbalanced bids be identified. A third, less tangible, purpose is that the engineer's estimate undoubtedly holds down construction costs by establishing a practical and reasonable price the contracting agency believes the work is worth.

In the late 1970's, record high inflation in highway construction costs caused FHWA to issue anti-inflation guidance (FHWA N5080.83 dated March 2, 1979). These guidelines, known as the 7-percent guidelines, required each low bid which exceeded the engineer's estimate by more than 7 percent to be critically reviewed to determine whether all applicable anti-inflation measures had been employed to the maximum extent possible, and whether any changes in the work, scheduling, basis of payment, etc., would likely produce lower and better bids if the project were re-advertised. The 7-percent criterion was the beginning of systematic, post-bid evaluations. Moreover, the guidelines focused attention on the accuracy and reliability of the engineer's estimates.

The impetus for this study was the fact that the Estimating Staff of the Kentucky Department of Highways have not always met FHWA's criterion for accuracy of the engineer's estimates in the past. It also was suggested that Kentucky had no established procedure for dealing with unbalanced bids. The work plan proposed that current estimating procedures be thoroughly analyzed to determine wherein the most probable error(s) existed in developing the cost estimate. Additionally, because Kentucky uses the actual cost approach as opposed to the historical bid-based approach, it was desirable to compare the advantages and disadvantages of determining a fair price for a construction project versus predicting the low bid. A task to develop procedures to identify unbalanced bids was removed from consideration because the Department's Estimating Staff already have procedural controls in place to identify bids which are unbalanced.

The Kentucky Department of Highways engineer's cost estimate has always been kept confidential. It has been argued that if the engineer's cost estimate were made public, the contractors' bids would nearly always be identical, or at least be very close, to the engineer's cost estimate. Consideration or evaluation of the Kentucky Transportation Cabinet's policy on confidentiality of the engineer's cost estimate was considered to be beyond the scope of this study.

EVALUATION OF THE ENGINEER'S ESTIMATE AND BID DATA TOTALS

Engineering cost estimate totals and bid totals for a number of construction projects were obtained from the Kentucky Department of Highways' Estimating Staff. Because of the sensitive nature and confidentiality of the engineer's estimate, all data were kept generic with regard to the specific project and geographic region. Bid data and engineer's estimates were obtained for a number of projects for the years 1987, 1988, and 1989. The data were categorized first by contract type. Specifically, data were arranged into the six following categories: bituminous contracts; bridge repair contracts; clean and paint bridge contracts; grade and drain contracts; mowing contracts; and, miscellaneous contracts. Contracts for work which could not be defined as bituminous, bridge repair, cleaning and painting of bridges, grade and drain, or mowing were denoted as miscellaneous contracts. After data were arranged by bid type or classification, the data for bituminous contracts were sorted according to the number of bids received and within dollar ranges based on the engineer's cost estimate. These ranges included less than or equal to \$250,000, greater than \$250,000 but less than or equal to \$500,000, and greater than \$500,000. Once sorting was completed, the percent difference between the engineer's cost estimate and the contract bid amount was calculated according to the following equation:

$$\text{Percent Difference} = \frac{\text{Award Amount} - \text{Engineer Estimate}}{\text{Engineer Estimate}} \times 100\% \quad (1)$$

Distributions of the percentage difference between the award amount and the engineer's estimate were determined and the results illustrated graphically. The graphs were examined to determine whether trends existed relative to increases in the percent of the engineer's estimate within +/- 10 percent of the low bid over the period studied. Graphic information also was developed and examined to determine if award amounts had normal distributions relative to the engineer's cost estimate.

Bituminous Contracts

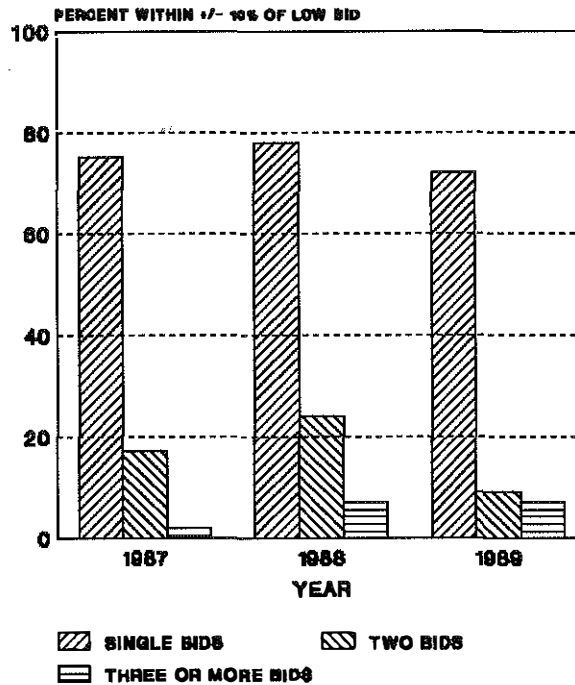
Generally, the Estimating Staff did very well when estimating costs of bituminous projects where only one bid was received for the project. The percent of the engineer's estimates within +/- 10 percent of the low bid was 75, 78 and 72 percent for 1987, 1988

and 1989, respectively, when only a single bid was received for the proposed work. However, as the number of bidders increased, indicating more intense competition for the work, the engineer's estimate was substantially higher than the bids received. Figure 1 illustrates the percent of the engineer's estimate within +/- 10 percent of the low bid for bituminous contracts wherein only a single bid, two bids, or three or more bids were received for projects awarded during the period studied, exclusive of contract amount.

As illustrated in Figure 1, for bituminous projects, the engineer's estimate was within +/- 10 percent of the low bid for greater than 70 percent of the projects wherein only a single bid was received. However, submission of a second bid or third bid for a project strongly affected the difference between the engineer's estimate and the low bid. For example, 120 bituminous contracts were let during 1987 in which the Kentucky Department of Highways received three or more bids. Of this number, only three of the engineer's estimates, or two percent, were within +/- 10 percent of the awarded low bid. Engineer's estimates for the remaining 117 projects were more than 10 percent above the low bid.

The engineer's estimate was compared to the second low bid and the average of the bids received for projects receiving multiple bids. The uncertainty of the estimator regarding the amount of profit a contractor is willing to accept prompted an examination of the second low bid for projects wherein at least two bids were received. Because the

BITUMINOUS CONTRACTS



ALL CONTRACT AMOUNTS CONSIDERED

Figure 1. Percent of the Engineer's Estimates within +/- 10% of the Low Bid for Bituminous Contracts Awarded during 1987, 1988 and 1989.

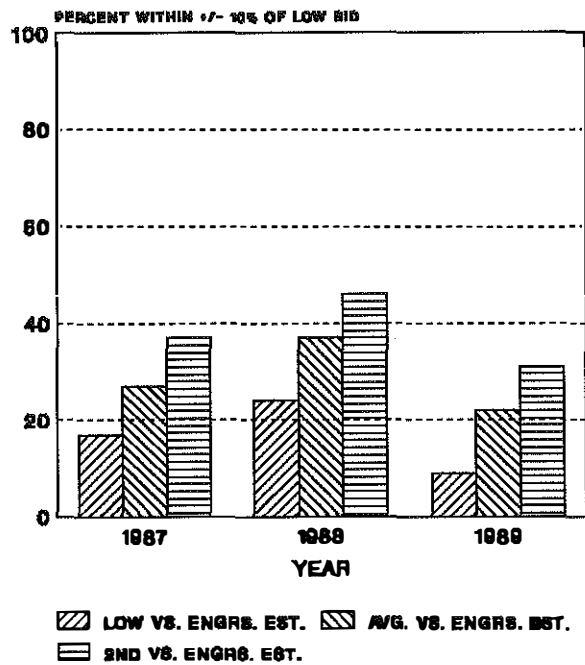
Estimating Staff of the Kentucky Department of Highways develops a construction cost estimate that is considered to be a reasonable and equitable price for an average contractor to complete the work in an approved manner, it was desirable also to compare the engineer's estimate to the average of all bids received for each project.

Figure 2 illustrates the percent of the engineer's estimates that were within +/- 10 percent of the second lowest bid received. Also shown is the percent of the engineer's estimates within +/- 10 percent of the average of bids received for a bituminous contract

awarded which had only two bidders for the work. A greater percent of the engineer's estimate was within +/- 10 percent of the second low bid, as expected. For example, during 1988, there were 112 bituminous projects for which only two bids were submitted for the proposed work. The engineer's estimate for these projects was within +/- 10 percent of the award amount for 24 percent of the projects. However, the percent of the engineer's estimate was within +/- 10 percent of the second bid on 51 projects, or 46 percent of the contracts in this category.

The percent of the engineer's estimates within +/- 10 percent of the second lowest bid received and the percent of the engineer's estimates within +/- 10 percent of the average of all bids received for bituminous contracts awarded, exclusive of contract amount, wherein at least three bids were submitted for work proposed during the years investigated are illustrated in Figure 3. For those bituminous projects where at least

BITUMINOUS CONTRACTS Proposals Receiving Two Bids

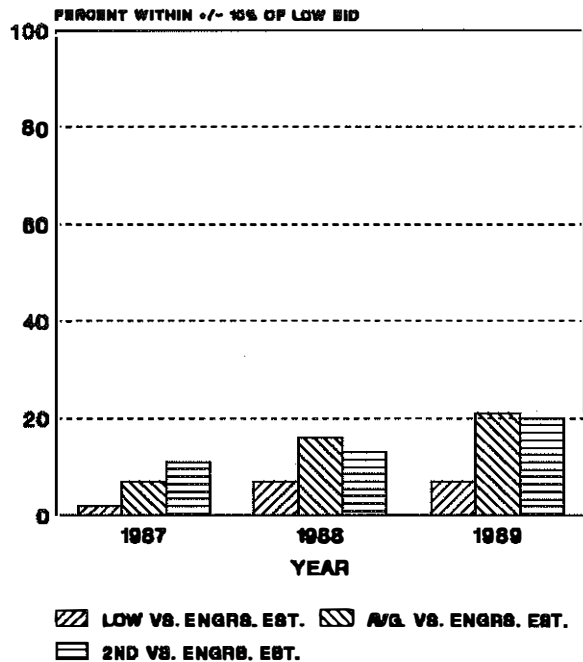


ALL CONTRACT AMOUNTS CONSIDERED

Figure 2. Percent of the Engineer's Estimate within +/- 10% of the Second Lowest and Average Bid for Bituminous Contracts Awarded during 1987, 1988 and 1989.

three bids were submitted for a project, the percent of the engineer's estimates within +/- 10 percent of the second lowest bid, although low, was nearly double the percent of the engineer's estimates within +/- 10 percent of the low bid for those projects. The percent of the engineer's estimate within +/- 10 percent of the average of the bids was slightly higher. For example, while the percent of the engineer's estimate was within +/- 10 percent of the low bid for only seven percent of the projects, it was within +/- 10 percent of the second lowest bid for 20 percent of the projects and within +/- 10 percent of the bid averages for 22 percent of the projects during 1988. The engineer's estimate for 100, or 93 percent, of these projects was more than 10 percent above the award amount.

BITUMINOUS CONTRACTS Proposals Receiving Three or More Bids



ALL CONTRACT AMOUNTS CONSIDERED

Figure 3. Percent of the Engineer's Estimates within +/- 10% of the Second Lowest and Average Bids for Bituminous Contracts Awarded during 1987, 1988 and 1989.

A pie-graph distribution of the engineer's estimates that were 10 percent greater, within +/- 10 percent, and 10 percent less than the low bid for all bituminous contracts issued during 1987, 1988, and 1989 is given in Appendix A. The data were sorted according to the range of the engineer's cost estimate and the number of bids received.

Bridge Repair Contracts

Sixty-two bridge repair contracts totaling \$5,410,956 were awarded during 1987. The average contract amount was \$87,273 while the average of the engineer's estimate was \$107,356, a difference of (-)18.7 percent. Of the 62 contracts awarded, only 12, or 19 percent of the engineer's estimates were within +/- 10 percent of the low bid. Coincidentally, during 1987, there were 12 contracts awarded wherein only one bid was received. Fifty contracts were awarded wherein two, or more bids were received for the proposed work. The engineer's estimate was within +/- 10 percent of the second low bid for only eight of these 50 projects, or for 16 percent of the projects. Meanwhile, the engineer's estimate was within +/- 10 percent of the average of all bids for 14 of the 50 projects, or 28 percent.

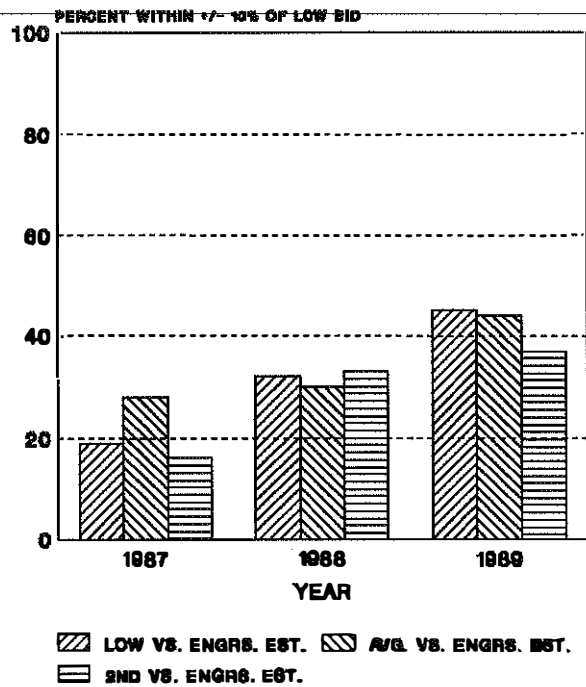
During 1988, there were 47 bridge repair contracts awarded totaling \$6,552,782. The average contract amount was \$139,421. The engineer's estimate for the 46 projects averaged \$149,249, an average difference of (-)6.6 percent. Of the 47 contracts awarded, 15 or 32 percent, of the engineer's estimates were within +/- 10 percent of the award amount. There were four contracts awarded wherein only one bid was received for the proposed work. Forty-three contracts were awarded which received two, or more bids for the work. Of the 43 contracts having two or more bidders, the engineer's estimate was within +/- 10 percent of the second low bid for 14 of the projects, or 33 percent. The engineer's estimate was within +/- 10 percent of the average of the bids received for 13 of the projects, or 30 percent of the jobs.

There were 49 bridge repair contracts awarded in 1989 totaling \$17,974,975. The average contract amount was \$366,863. The engineer's estimate for the 49 projects averaged \$351,156. The average difference between the low bid and the engineer's estimate was (+)4.5 percent during 1989. Of the 49 contracts awarded, 22 of the engineer's estimates, or 45 percent, were within +/- 10 percent of the low bid. There were eight contracts awarded wherein only one contractor submitted a bid. Forty-one contracts were awarded wherein two, or more bids were received for the work. Of these 41 contracts, the engineer's estimate was within +/- 10 percent of the second lowest bid for 15 of the projects, or 33 percent. The engineer's estimate was within +/- 10 percent of the average of all bids for 18 of the projects, or 44 percent.

The proximity of bids submitted for bridge repair work to the cost estimates developed by the Estimating Staff increased significantly during the period evaluated. As illustrated in Figure 4, the percent of the engineer's estimate within +/- 10 percent of the low bid

increased from 19 percent during 1987 to 45 percent in 1989. The overall increase in the percent of the engineer's estimates within +/- 10 percent of the low bid is even more significant when the total dollar amount of the contracts awarded is considered. The percent of the engineer's estimate within +/- 10 percent of the average of bids increased from 28 percent in 1987 to 44 percent in 1989. The distribution of bids received for bridge repair contracts is contained in Appendix B. The percent of the engineer's estimates that were greater than 10 percent, within +/- 10 percent, and less than 10 percent of the low bid, second lowest bid, and bid average, are graphically illustrated by pie charts. All contract amounts were included in the analyses.

BRIDGE REPAIR CONTRACTS



ALL CONTRACT AMOUNTS CONSIDERED

Figure 4. Percent of the Engineer's Estimate within +/- 10% of the Lowest, Second Lowest and Average Bid for Bridge Repair Contracts Awarded during 1987, 1988 and 1989.

Clean and Paint Bridge Contracts

Eight clean and paint bridge contracts totaling \$1,925,693 were awarded during 1987. The average contract amount was \$240,712 while the average engineer's estimate was \$312,557, a difference of (-)23.0 percent. Of the eight contracts awarded, only two of the engineer's estimates, or 25 percent, were within +/- 10 percent of the low bid. The remaining awarded bids were more than 10 percent below the engineer's estimate. All proposed work had at least two bids submitted for consideration. The engineer's estimate was within +/- 10 percent of the second low bid for two of the eight projects, or for 25

percent of the projects. The second lowest bid for two projects was more than 10 percent greater than the engineer's estimate. The second lowest bid on four projects was more than 10 percent below the engineer's estimate. The engineer's estimate for cleaning and painting bridges during 1987 was within +/- 10 percent of the average of the bids for only one, or 13 percent, of the eight projects. The average bids for five of the projects were more than 10 percent below the engineer's estimates.

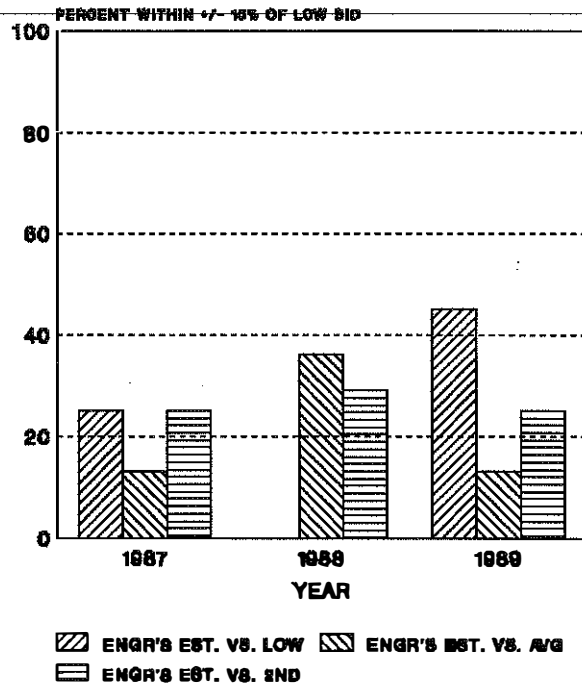
In 1988, there were 14 clean and paint bridge contracts awarded totaling \$2,252,750. The average contract amount was \$160,911. The engineer's estimate for the 14 projects averaged \$193,392, an average difference of (-)16.8 percent. Of the 14 engineer's estimates developed for these projects, none were within +/- 10 percent of the lowest bid. Nine of the bid amounts were more than 10 percent above, and five were more than 10 percent below the engineer's estimate. All proposed work had at least two bidders. The engineer's estimate was within +/- 10 percent of the second low bid for four of the projects, or 29 percent. The engineer's estimate was within +/- 10 percent of the average of the bids for five of the projects, or 36 percent.

Nine clean and paint bridge contracts were awarded during 1989 totaling \$1,567,712. The average contract amount was \$174,134. The engineer's estimate for the nine projects averaged \$197,190. The average difference between the low bid and the engineer's estimate was (-)11.7 percent during 1989. Of the nine engineer's estimates developed for the contracts awarded, four of them, or nearly 45 percent, were within +/- 10 percent of the low bid for the project. Eight of the contracts that were awarded had at least two bids submitted for the work. The engineer's estimate, for projects receiving multiple bids, was within +/- 10 percent of the second lowest bid for only two, or 25 percent of the projects. Four of the second lowest bids were more than 10 percent above the engineer's estimate. The engineer's estimate was within +/- 10 percent of the average of the bids for only one project, or 13 percent. The average of all bids for five of the projects was more than 10 percent above the engineer's estimate.

The cost estimates generated by the Estimating Staff demonstrated general improvement during the period studied when compared to the awarded amounts for clean and paint bridge contract work. Figure 5 illustrates the percent of the engineer's estimate within +/- 10 percent of the low bid, second lowest bid, and the bid average for cleaning and painting contracts issued in 1987, 1988, and 1989. The percent of the engineer's estimate within +/- 10 percent of the low bid increased from 25 percent in 1987 to nearly 45 percent in 1989, although it was zero percent in 1988. The difference between the engineer's estimate and the low bid for bids received for clean and paint bridge contracts

improved from (-)23.0 percent in 1987 to (-)11.7 percent in 1989. The percent of the engineer's estimate within +/- 10 percent of the average of bids was 13 percent both in 1987 and 1989 but was 36 percent in 1988. The distribution of bids received for bridge clean and paint contracts is contained in Appendix C. The percent of the engineer's estimates that were more than 10 percent above, within +/- 10 percent, and more than 10 percent below the low bid, second lowest bid, and bid average, are graphically illustrated by pie charts. All contract amounts were included in the analyses.

CLEAN AND PAINT CONTRACTS



ALL CONTRACT AMOUNTS CONSIDERED

Figure 5. Percent of the Engineer's Estimate within +/- 10% of the Lowest, Second Lowest and Average Bid for Clean and Paint Bridge Contracts Awarded during 1987, 1988 and 1989.

Grade and Drain Contracts

There were 158 grade and drain contracts awarded in 1987. The total award amount was \$279,154,665. The average contract amount was \$1,766,802 while the average engineer's estimate was \$2,176,181, a difference of (-)18.8 percent. Of the 158 engineer's estimates for grade and drain contracts awarded, 50, or 32 percent, were within +/- 10 percent of the low bid. Sixty-two of the low bids were more than 10 percent below the engineer's estimate. There were 11 contracts awarded wherein only one contractor submitted a bid. One-hundred and forty-seven contracts were awarded in which there were multiple bids received for the work. The engineer's estimate for those 147 contracts was within +/- 10 percent of the second lowest bid submitted for 62 of the projects, or 42 percent. The

engineer's estimate was within +/- 10 percent of the average bid for 61, or 41 percent of the projects.

During 1988, there were 103 grade and drain contracts awarded totaling \$176,715,732. The average contract amount was \$1,715,687. The engineer's estimate for the 103 projects averaged \$1,984,079, an average difference of (-)13.5 percent. The engineer's estimates for these 103 contracts were within +/- 10 percent of the low bid for 38 projects, or 37 percent. There were only two projects which received single bids. The engineer's estimate was within +/- 10 percent of the second low bid for 46 of those 101 projects receiving multiple bids, or 46 percent. The engineer's estimate was within +/- 10 percent of the average of the bids received for 45 of the projects, or 45 percent.

Grade and drain contracts awarded during 1989 totaled \$278,022,284. The average contract amount for the 157 contracts awarded was \$1,770,843. The engineer's estimate for the 157 projects averaged \$1,848,907. The average difference between the low bid and the engineer's estimate was (-)4.2 percent during 1989. Of the 157 contracts awarded, 61 engineer's estimates for those projects, or 39 percent, were within +/- 10 percent of the low bid. One-hundred and fifty-one of the contracts awarded had two, or more bidders. For the contracts awarded, which received multiple bids, the engineer's estimate was within +/- 10 percent of the second low bid for 78 of the projects, or 52 percent. The engineer's estimate was within +/- 10 percent of the average bid for 85 projects, or 56 percent. Twenty-seven percent of the averaged bids were more than 10 percent below the engineer's estimate and 17 percent were more than 10 percent above the engineer's estimate.

The accuracy of the engineer's cost estimates for grade and drain work, though not entirely acceptable when compared to bids submitted for this work, shows improvement during the period studied. Shown in Figure 6 are the percent of the engineer's estimates within +/- 10 percent of the low bid, second lowest bid, and the averaged bid for grade and drain projects. The percent of the engineer's estimate within +/- 10 percent of the low bid increased from 32 percent in 1987, to 37 percent in 1988, and to 39 percent in 1989. The overall percent difference between the low bid and the engineer's estimate improved from (-)18.8 percent in 1987 to (-)4.2 percent in 1989. The percent of the engineer's estimate within +/- 10 percent of the average bid on grade and drain projects increased from 41 percent in 1987 to 56 percent in 1989. The distribution of bids received for grade and drain contracts is contained in Appendix D. The percent of the engineer's estimates that were more than 10 percent above, within +/- 10 percent, and more than 10 percent below the low bid, second lowest bid, and bid average, are graphically illustrated by pie

charts. All contract amounts were included in the analyses.

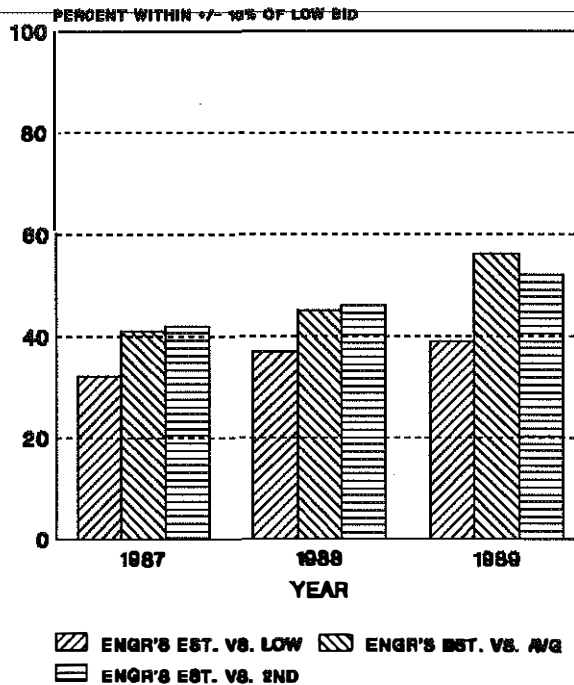
Mowing Contracts

During 1987, there were 13 mowing contracts awarded. The total award amount was \$424,423. The average contract amount was \$32,648 while the average of the engineer's estimate was \$45,363, a difference of (-) 28.0 percent. Out of the 13 contracts awarded, the engineer's estimate was never within +/- 10 percent of the low bid. Eleven of the 13 contracts awarded had low bids which were more than 10 percent below the engineer's estimate. Two of the

contracts awarded had low bids which were more than 10 percent above the engineer's estimate. There were three contracts awarded in which only one contractor submitted a bid. Of the ten projects receiving multiple bids, the engineer's estimate was within +/- 10 percent of the second lowest bid submitted for two of the projects, or 20 percent. Seven of the second lowest bids were more than 10 percent below the engineer's estimate. The engineer's estimate was within +/- 10 percent of the average bid for two of the projects, or 20 percent.

During 1988, there were only four mowing contracts awarded. The total award amount was \$163,686. The average contract amount was \$40,922. The engineer's estimate for the four projects averaged \$30,000, an average difference of (+)36.4 percent. None of the engineer's estimates generated for 1988 mowing contracts were within +/- 10 percent of the low bid. Furthermore, all bids were more than 10 percent above the engineer's

GRADE AND DRAIN CONTRACTS



ALL CONTRACT AMOUNTS CONSIDERED

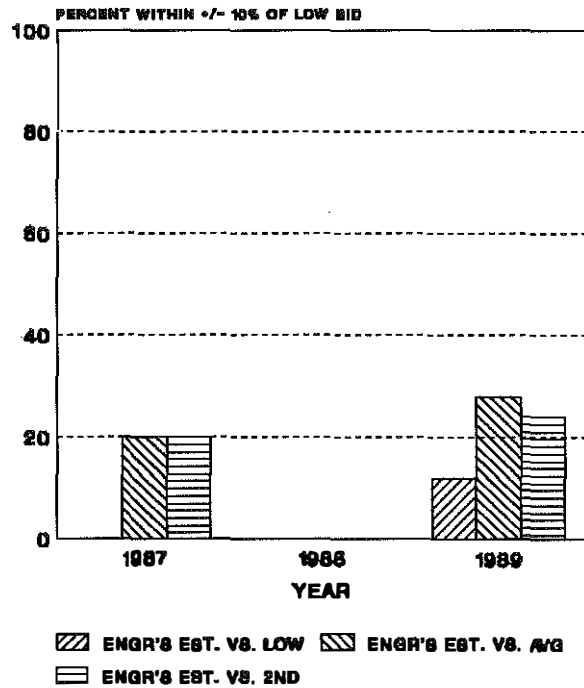
Figure 6. Percent of the Engineer's Estimate within +/- 10% of the Lowest, Second Lowest, and Average Bid for Grade and Drain Contracts Awarded during 1987, 1988 and 1989.

estimate. All mowing projects received at least two, or more bids for the work. The engineer's estimate was not within +/- 10 percent of the second lowest bid or the average bid received for any project.

The number of mowing contracts awarded during 1989 increased and totaled \$4,865,882. The average contract amount of the 49 contracts awarded was \$99,304. The engineer's estimate for these 49 projects averaged \$136,144. The average difference between the low bid and the engineer's estimate was (-)27.1 percent. Of the 49 contracts awarded, only six of the engineer's estimates, or 12 percent, were within +/- 10 percent of the low bid. Eighty percent of the awards were more than 10 percent below the engineer's estimate. Only 29 of the 49 contracts awarded had multiple bids. For those contracts awarded having at least two, or more bidders, the engineer's estimate was within +/- 10 percent of the second lowest bid for seven of the projects, or 24 percent. The engineer's estimate was within +/- 10 percent of the bid average for eight of the projects, or 28 percent.

The cost estimates developed by the Estimating Staff for mowing projects varied greatly when compared to the bids submitted for the work. Figure 7 illustrates the percent of the engineer's estimates within +/- 10 percent of the low bid, the second lowest bid, and the averaged bid. The percent of the engineer's estimates within +/- 10 percent of the low bids increased from zero percent in 1987 to only 12 percent in 1989. The difference between the engineer's estimates and the low bids

MOWING CONTRACTS



ALL CONTRACT AMOUNTS CONSIDERED

Figure 7. Percent of the Engineer's Estimate within +/- 10% of the Lowest, Second Lowest and Average Bids for Mowing Contracts Awarded during 1987, 1988 and 1989.

received for mowing work fluctuated greatly from (-)28.0 percent in 1987 to (+)36.4 percent in 1988 and to (-)27.1 percent in 1989. The average low bid increased from \$32,648 in 1987 to \$99,304 in 1989 while the number of awards increased from 13 to 49. The percent of the engineer's estimate within +/- 10 percent of the average bid was not significant. The percent of the engineer's estimates within +/- ten percent of the averaged bid increased from 20 percent in 1987 to 28 percent in 1989. The distribution of bids received for mowing contracts is contained in Appendix E. The percent of the engineer's estimates that were more than 10 percent above, within +/- 10 percent, and more than 10 percent below the low bid, second lowest bid, and bid average, are graphically illustrated by pie charts. All contract amounts were included in the analyses.

Miscellaneous Contracts

There were 100 contracts awarded during 1987 for miscellaneous work. Work was classified as miscellaneous if it could not be placed in one of the categories given previously. The total award amount for miscellaneous contracts awarded in 1987 was \$28,762,800. The average contract amount was \$287,628 while the average of the engineer's estimates was \$358,722, a difference of (-)19.8 percent. Of the 100 contracts awarded, only 14 engineer's estimates were within +/- 10 percent of the low bid. Eighty-four percent of the contracts awarded had bids which were more than 10 percent below the engineer's estimate. There were four contracts awarded in which only one contractor submitted a bid. Multiple bids were received for the remaining 96 projects. For those projects having two or more bids, the engineer's estimate was within +/- 10 percent of the second lowest bid for 25 projects, or 26 percent. Seventy-two percent of the second lowest bids submitted were more than 10 percent below the engineer's estimate. The engineer's estimate was within +/- 10 percent of the bid average for 22 projects, or 23 percent. The bid average was more than 10 percent below the engineer's estimate for 74 percent of the contracts awarded that received multiple bids.

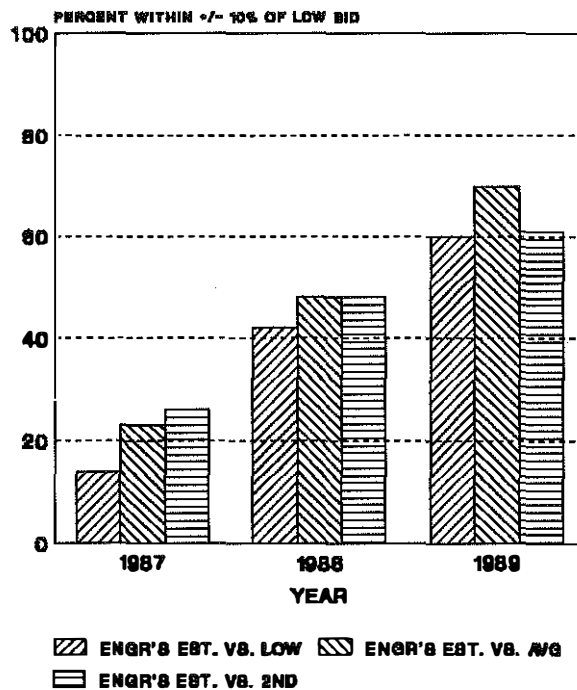
During 1988, there were 116 miscellaneous contracts awarded. The total award amount was \$19,905,064. The average contract amount was \$171,595. The engineer's estimate for the 116 projects averaged \$164,187, an average difference of (+)4.5 percent. Forty-eight of the engineer's estimates, or 42 percent, were within +/- 10 percent of the low bid. Fifty-three percent of the contracts awarded had bids which were more than 10 percent below the engineer's estimate. There were two contracts awarded wherein only one bid was submitted. Multiple bids were received for 114 projects. For the 114 projects receiving two or more bids, the engineer's estimate was within +/- 10 percent of the

second lowest bid submitted for 55 projects, or 48 percent. Forty-four of the second lowest bids received were more than 10 percent below the engineer's estimate. The engineer's estimate was within +/- 10 percent of the average of all the bids received for 55 projects, or 48 percent.

Miscellaneous contracts awarded during 1989 totaled only \$8,378,571. The average contract amount for the 58 contracts awarded was \$144,458. The engineer's estimate for the same 58 projects averaged \$162,740. The average difference between the low bid and the engineer's estimate was (-)11.2 percent during the year. Of 58 contracts awarded, 35 of the engineer's estimates, or 60 percent, were within +/- 10 percent of the low bid. Thirty-eight percent of the bids were more than 10 percent below the engineer's estimate. Fifty-six of 58 contracts awarded had multiple bids. For contracts awarded that had two, or more bids, the engineer's estimate was within +/- 10 percent of the second lowest bid for 34 projects, or 61 percent. Twenty-three percent of the second lowest bids were more than 10 percent below the engineer's estimate and 16 percent were more than 10 percent above. The engineer's estimate was within +/- 10 percent of the averaged bid for 39 projects, or 70 percent. The average of all bids received for a project was more than 10 percent above the engineer's estimate for 14 percent of the jobs.

Cost estimates developed by the Estimating Staff for miscellaneous contracts improved greatly over the period studied. Analysis of the bid data indicated increases in the percent of

MISCELLANEOUS CONTRACTS



ALL CONTRACT AMOUNTS CONSIDERED

Figure 8. Percent of the Engineer's Estimate within +/- 10% of the Lowest, Second Lowest and Average Bids for Miscellaneous Contracts Awarded during 1987, 1988 and 1989.

the engineer's estimates within +/- 10 percent of the low bid. Figure 8 illustrates the percent of the engineer's estimates within +/- 10 percent of the low bid, second lowest bid, and of the average bid received for any particular contract. The percent of the engineer's estimate within +/- 10 percent of the low bid increased significantly, from 14 percent in 1987 to 60 percent in 1989. The difference between the low bid and the engineer's estimate for bids received fluctuated from (-)19.8 percent in 1987 to (+)4.5 percent in 1988 to (-)11.2 percent in 1989. The percent of the engineer's estimate within +/- 10 percent of the average of all bids received was significant also. The percent of the engineer's estimate within +/- 10 percent of the average bids for a project increased from 23 percent in 1987 to 70 percent in 1989. The distribution of bids received for miscellaneous contracts is contained in Appendix F. The percent of the engineer's estimates that were more than 10 percent above, within +/- 10 percent, and more than 10 percent below the low bid, second lowest bid, and bid average, are graphically illustrated by pie charts. All contract amounts were included in the analyses.

DETERMINING FAIR PRICE VERSUS PREDICTING LOW BID

Although the Kentucky Department of Highways has no desire to alter the processes used to generate the cost construction estimate, it was still desirable to discuss the advantages and disadvantages of determining a fair price for a construction project versus predicting the low bid. Most often an actual cost approach, such as used by the Department, is utilized to develop a fair and equitable price for the specified work. Cost estimates for construction projects are based primarily on the estimator's knowledge of costs associated with labor, materials, equipment, overhead, and profit. To predict a low bid, the estimator utilizes historical bid data, unit prices, and quantities obtained from recently awarded contracts. The data are adjusted based upon specific project conditions, such as project quantities, location, overall project size, and general market conditions.

The advantages of determining a fair price for a construction job include a higher sensitivity to the specific requirements of a given construction job. Generally, the expected cost of the materials to be delivered to the job site at the time a project is built, the market conditions on materials availability, labor market conditions, and profit demands of the bidder are taken into consideration in the actual cost approach. The actual cost approach provides the contracting agency and estimate reviewers a better idea of how much a project should cost. Further, the exercise of seeking quotes for a project and allocating equipment and manpower to complete the work not only provides

the contracting agency with a reasonable cost estimate, but fosters an understanding of how the job is to be constructed. Because previous bid information is not used in the actual cost approach method of estimating, the engineer's estimate is not affected by price fixing or other non-competitive bidding practices.

The advantages of the actual cost approach method used to generate a fair price for the anticipated work are largely offset by the manpower and high level of discipline required to produce this type of estimate. The manpower required to produce an estimate using this approach can be five to ten times greater than the historical based estimate. Estimators must possess a strong background in construction techniques and equipment, equipment production rates, how much to adjust quotes from suppliers, etc., as well as quantity take-offs and pricing experience.

The concept of historical bid based estimates is that by tracking the prior pricing pattern, one may accurately predict the prices that will be offered on future work. The greatest strength of this type of system is the economy of the method. The use of automated data systems counter the need for a large and well trained estimating staff. It has been said that a single estimator having a well designed system could fulfill the needs of a construction program of about \$500,000,000 per year. A disadvantage of this system is that predicting prices is very sensitive to market behavior such as price fixing or complementary bidding. Also, historical bid based estimates may be insensitive to short-term market conditions because the system is slow to react to changes in pricing trends. Another principal disadvantage of this method is that this system is not project specific. The historical data approach is based upon a typical project and can not address the unique problems that each project can produce.

SUMMARY

There were two objectives addressed during this study. The first was to study the procedures used by the Department's Estimating Staff to do an estimate and determine wherein the most probable error(s) in the process existed. The second objective was to compare the advantages and disadvantages of determining a fair price for a construction project versus predicting the low bid.

Procedures used to generate construction cost estimates by the Estimating Staff of the Kentucky Department of Highways have been examined. Procedures used by the

Department's estimators are quite similar to those used by contractors. An actual cost approach is utilized to estimate the cost of each project. The Department's estimators have the ability to do careful, thorough, and accurate work. In preparing the estimate, the estimator generally breaks the project down into small units of similar work in accordance with a specific plan of construction. Each unit is then priced according to the expected productivity for the specific plan and site conditions associated with the project. It must be understood, however, that the estimated cost is never the actual cost because the cost estimate is made before the work is ever performed. The difference between the estimated cost and the actual cost depends upon many factors.

Cost estimates for construction projects are based primarily on the estimator's knowledge of costs associated with labor, materials, equipment, overhead, and profit. Labor costs are often the most difficult to judge. If production rates for workers are underestimated, the engineer's cost estimate may be too high. Conversely, if labor production rates are overestimated, then the engineer's estimate will most likely be low. The costs of materials also vary. Last minute agreements between material suppliers and contractors or the effects of rising or falling markets on material prices may result in inherent errors in the engineer's cost estimate. Equipment costs are often easier to estimate. However, if the estimator does not precisely duplicate the lower bidder with regard to the cost of the equipment, either through rental costs, sinking fund costs, or depreciation costs, then the estimate may be skewed. Overhead costs include the cost of general overhead and the cost of general conditions. General overhead is the cost of doing business and includes all costs that cannot readily be charged to a specific job. General overhead costs of each contractor varies and usually will be a higher percentage for a very small contractor than for a very large contractor. General job condition costs include all costs which may readily be charged to the job but which cannot be charged to labor, materials, or equipment. Total overhead costs generally vary depending upon the kind of job, locality, and items included in the job. Estimating the cost of overhead requires judgment on the part of the estimator. A contractor's profit for a job is usually expressed as a percentage of the total estimated cost of the work. This percentage depends on the contractor's desire for work, what is considered reasonable, and what a contractor thinks is possible. Because of the uncertainty of the amount of profit a contractor is willing to accept in order to keep people and equipment working, there is always a chance that the estimator may overstate or understate the profit percentage when estimating construction costs. The Kentucky Department of Highways' Estimating Staff generates a construction cost estimate that is a reasonable and equitable price for an average contractor to complete the proposed work in an approved manner. The engineer's estimate is considered to be a fair price for the project.

Information relative to a number of projects awarded during the years 1987, 1988, and 1989 were made available to the researcher by the Kentucky Department of Highways' Estimating Staff. However, it was obligatory to keep all data generic with regard to the specific project and geographic area due to the sensitive nature of the data and the confidentiality of the engineer's estimate. Only a summation of the bids submitted and the engineer's estimates was obtained for available projects for the years 1987, 1988, and 1989. The bid sum and engineer's estimate was categorized by contract type: bituminous contracts; bridge repair contracts; clean and paint bridge contracts; grade and drain contracts; mowing contracts; and, miscellaneous contracts. After the data were re-arranged by contract type, data for bituminous contracts were sorted further according to the number of bids received for a project and within pre-determined ranges based on the engineer's cost estimate. The percent difference between the engineer's cost estimate and the contract bid amount was determined. The percent of the engineer's estimate within +/- 10 percent of the low bid was examined. The uncertainty regarding the profit percentage a contractor will accept prompted an examination of the second lowest bid for those projects receiving two or more bids. Also, it was decided to compare the engineer's estimate to the average of the bids received for each project because typically, the engineer's estimate is generated for the average, or fiftieth percentile, contractor which will perform the work in an approved manner.

Analyses performed on the data provided by the Department revealed that the engineer's estimates were within +/- 10 percent of the low bid on more than 70 percent of the bituminous contracts which received only one bid for the work. However, when a second bid was submitted for bituminous work, the percent of the engineer's estimate within +/- 10 percent of the low bid was reduced drastically - - to at best 26 percent in 1988. At the same time, the percent of the engineer's estimates within +/- 10 percent of the second bid was 46 percent. Obviously, the lack of competition among contractors for certain bituminous projects enabled the only bidding contractor to submit a bid which was higher than it would be had there been competition for the work. During the period studied, the Department received only one bid for nearly 58 percent (961 of 1,658) of the bituminous contracts awarded. Single-bid bituminous contracts awarded during the three-year study period amounted to approximately \$152,358,113. The engineer's estimate for this bituminous work amounted to \$155,311,322. The overall percent difference between the award amount and the engineer's estimate was a very low (-)1.9 percent. The engineer's estimate was within +/- 10 percent of the low bid on 723 projects, or for 75 percent of the projects. This is well above the FHWA's accuracy criterion.

When a second bid or third bid was submitted to the Department, the affects of competition on the low bid were obvious. There were 697 bituminous contracts awarded during the three-year period which received multiple bids. Those contracts totaled \$145,831,786. The engineer's estimates for this bituminous work totaled \$189,596,924. The overall percent difference between the award amount and the engineer's estimate for these projects was (-)23.1 percent. This indicates the low bid was, on average, 23.1 percent below the engineer's estimate. The engineer's estimate was within +/- 10 percent of the low bid on only 78 projects, or 11.2 percent of the projects. This is far below the prescribed FHWA accuracy criterion for the engineer's estimate. The low bid for 75 percent of the bituminous projects having multiple bidders was more than 10 percent below the engineer's estimate. There were 335 bituminous contracts awarded during the three years in which only two bids were received for the work. The engineer's estimate was within +/- 10 percent of the low bid on 58 of these 335 projects, or 17 percent. However, the engineer's estimate was within +/- 10 percent of the second bid on 128 of these projects, or 38 percent. The remaining 362 bituminous projects had three or more bidders for the work. Only 20 of the engineer's estimates were within +/- 10 percent of the low bid for those projects receiving three or more bids (six percent). When comparing the engineer's estimate to the average for bids, it was found that only 15 percent of the engineer's estimates were within +/- 10 percent of the averaged bid.

It is nearly impossible to comprehend the large difference between the engineer's estimate and the low bid for bituminous projects having multiple bidders. The Department must be paying more than necessary for those contracts having only a single bidder, or they are getting excellent reductions on those bituminous contracts where the competition is strong. When the engineer's estimate exceeds the low bid by more than 10 percent, it would appear that a number of projects cannot be planned because the engineer's estimate serves as a crucial element in the budgetary planning and obligation process for Federal aid.

The accuracy of the engineer's cost estimate when compared to the low bid for bridge repair work improved vastly during the three years studied. The percent of the engineer's estimates within +/- 10 percent of the low bid improved from 19 percent in 1987 to 45 percent in 1989. At the same time, the percent of the engineer's estimates within +/- 10 percent of the average of the bids increased from 28 percent in 1987 to 44 percent in 1989. There were \$29,938,713 awarded for bridge repair work during the three years. The engineer's estimate for this work totaled \$30,877,439, a net difference of only (-)3.0 percent. When the engineer's cost estimate is compared to the low bid for cleaning and painting bridge projects, the percent within +/- 10 percent of the low bid improved from

25 percent in 1987 to 45 percent in 1989. The percent of the engineer's estimates within +/- 10 percent of the average of the bids remained unchanged during the period. There were \$5,745,649 awarded for bridge cleaning and painting during the three years evaluated. The engineer's estimate for this work totaled \$6,982,647, a net difference of (-)17.7 percent.

Grade and drain contracts involved the greatest expenditure per contract awarded by the Department. In 1987, monies spent on grade and drain contracts constituted 70 percent of all contract expenditures. Over the three-year study period, grade and drain contracts averaged 65 percent of the total contract amounts. The percent of the engineer's estimates within +/- 10 percent of the low bid improved from 32 to 39. At the same time, the percent of the engineer's estimates within +/- 10 percent of the average of the bids increased from 41 percent in 1987 to 56 percent in 1989. The average percent difference between the engineer's estimate and the award amount for grade and drain projects also improved, averaging (-)18.8 percent in 1987, (-)13.5 percent in 1988, and (-)4.5 percent in 1989. There were \$733,892,681 awarded for grade and drain contracts during the three-year period. The engineer's estimate totaled \$838,475,150, an average net difference of (-)12.5 percent.

The engineer's estimates for mowing were not very accurate when compared to the low bids submitted for the work and the accuracy did not improve during the study period. During 1987, 13 mowing contracts were awarded. Eleven of the low bids for those contracts were more than 10 percent below the engineer's estimate while two low bids were more than 10 percent above the engineer's estimate. The average engineer's estimate for the 13 projects was \$45,363 and the average of low bids was \$32,648, a net percent difference of (-)28.0. In 1988, four mowing contracts were awarded. The low bid for each project was more than 10 percent above the engineer's estimate. The average for the engineer's estimate for the four projects was \$30,000. The average low bid on the four projects was \$40,992. This resulted in a net difference of (+)36.4 percent. In 1989, the engineer's estimates for mowing work were similar to those in 1987. Of the 49 mowing contracts awarded during 1989, 39 contracts had low bids that were more than 10 percent below the engineer's estimate. The average for the engineer's estimate for mowing contracts awarded in 1989 was \$136,144. The average low bid on the 49 mowing contracts was \$99,304. The percent difference between the engineer's estimate and the low bid was (-)27.1 percent.

Contracts for work which could not be defined as bituminous, bridge repair, cleaning and painting of bridges, grade and drain, or mowing were denoted as miscellaneous contracts.

The engineer's estimates for miscellaneous contracts improved significantly from 1987 to 1989. The engineer's estimate was within +/- 10 percent of the low bid for only 14 percent of the projects during 1987 but increased to 60 percent during 1989. The engineer's estimate was within +/- 10 percent of the average of the bids for 23 percent of the projects in 1987 and 70 percent of the projects in 1989. The total amount awarded decreased from just over \$28 million in 1987 to about \$8 million in 1989. There were \$57,046,435 awarded for miscellaneous contracts during the three-year period. The engineer's estimate totaled \$64,356,775, a net difference of (-)11.4 percent.

CONCLUSIONS AND RECOMMENDATIONS

It may be concluded that the Estimating Staff of the Kentucky Department of Highways does reasonably proficient work in estimating construction costs. Their accuracy and efficiency improved in most categories during the study period. Recent data released by the Federal Highway Administration show that the Department's staff have increased the accuracy of the engineering cost estimates. The percent of the engineer's estimates within +/- 10 percent of the low bid increased from 28 in 1987 to 50 in 1989. However, these percentages could not be verified using data supplied to the researcher by Department officials for this study. Data supplied by the Department established the percent of the engineer's estimates which were within +/- 10 percent of the low bid to be 38 in 1987, 47 in 1988 and 44 in 1989.

The largest contract expenditure is for grade and drain work. Grade and drain contracts constituted approximately 70 percent of the total expenditures in 1987, 55 percent in 1988, and 67 percent in 1989. The largest number of contracts are awarded for bituminous work which also comprises the second largest expenditure. In 1987, these two contract types combined to command approximately 91 percent of the total contract dollars awarded. The engineer's estimate was within +/- 10 percent of the low bid for 43 percent of all grade and drain, and bituminous projects awarded during 1987. However, the engineer's estimate was within +/- 10 percent of the low bid for only 15 percent of the remaining contracts awarded in the remaining categories. During 1988, the grade and drain, and bituminous contracts again garnered 91 percent of the total contract dollars awarded. The engineer's estimate was within +/- 10 percent of the low bid for 50 percent of these contracts. Of the contracts awarded in the other categories, the percent of the engineer's estimate within +/- 10 percent of the low bid improved to 35. Grade and drain, and bituminous contracts controlled 92 percent of the total contract dollars awarded

during 1989. The percent of the engineer's estimate within +/- 10 percent of the low bid was 44 for combined grade and drain, and bituminous contracts awarded in 1989. Of the contracts awarded in the other categories, the percent of the engineer's estimate within +/- 10 percent of the low bid increased to 41. This is illustrative of the improvement in the accuracy of the engineer's cost estimate made by the Estimating Staff.

Overall, the Estimating Staff has significantly increased the percent of the engineer's estimates within +/- 10 percent of the low bid. However, there are two contractual areas which, if improved upon, would ensure that the engineer's estimate satisfies FHWA accuracy criterion for the engineer's estimate. Those two areas are bituminous contracts having strong competition for the work and mowing contracts.

Should the Department's Estimating Staff alter the process used to develop the cost estimate for a project when heavy competition is anticipated? Should the Estimating Staff try to predict what effect the competition will have on the bids for a project or try to predict the percentage profit a contractor is willing to take in order to keep work for a company? Probably not, but properly assessing the effect of competition on the bids submitted for bituminous projects would practically insure compliance with FHWA's accuracy criterion. The Department should utilize historical bid information obtained from departmental records to adjust the estimate in anticipation of strong competition.

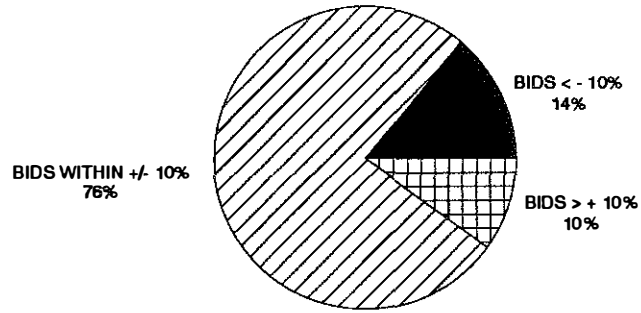
It is understood that it is difficult to estimate the cost of mowing. It is apparent that the engineer estimating mowing costs does not have an established working knowledge of all the details involved in mowing activities. This is most likely due to differences in mowing types and related specifications. It was observed in another research study that Contract Mowing Type-3 performed within each highway district, for example, often varied considerably. By definition, this activity should include all sickle, rotary and batwing mowing along with any slope mowing, litter removal, and hand trimming if necessary. Most contracts were found to include hand trimming but some did not. Most contracts excluded litter removal but some did not. Most contracts included slope mowing but in some contracts this was a separate bid item. Changes in the descriptions of the mowing activities and/or more uniform specifications are suggested.

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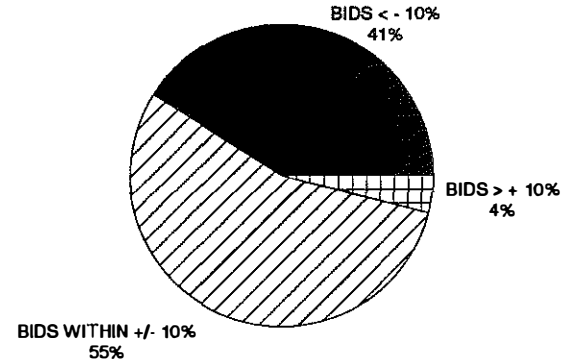
APPENDIX A
Bituminous Projects

**1987 BITUMINOUS CONTRACTS
LOW BID VERSUS ENGINEER'S EST.
CONTRACT AMOUNT
LESS THAN OR EQUAL TO \$250,000**



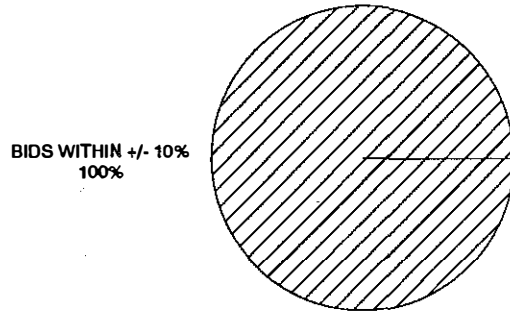
SINGLE BID: 290 TOTAL CONTRACTS

**1987 BITUMINOUS CONTRACTS
LOW BID VERSUS ENGINEER'S EST.
CONTRACT AMOUNT
GREATER THAN \$250,00
AND LESS THAN OR EQUAL TO \$500,000**



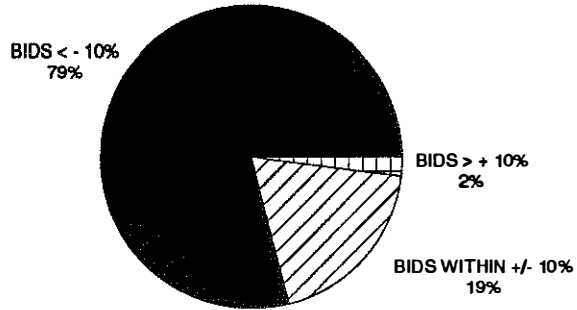
SINGLE BID: 22 TOTAL CONTRACTS

**1987 BITUMINOUS CONTRACTS
LOW BID VERSUS ENGINEER'S EST.
CONTRACT AMOUNT GREATER THAN \$500,000**



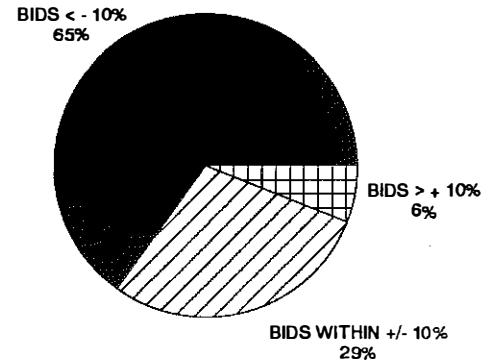
SINGLE BID: 8 TOTAL CONTRACTS

**1987 BITUMINOUS CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**



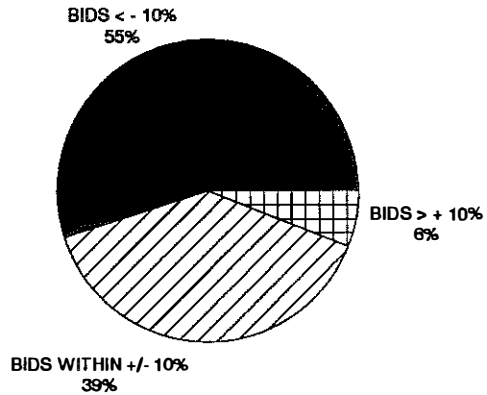
TWO BIDS: 109 TOTAL CONTRACTS

**1987 BITUMINOUS CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**



TWO BIDS: 109 TOTAL CONTRACTS

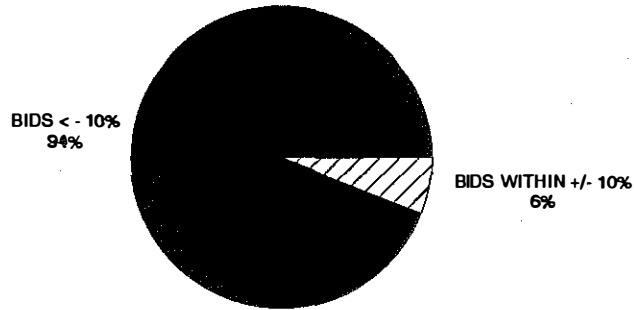
**1987 BITUMINOUS CONTRACTS
SECOND LOWEST BID VERSUS ENGINEER'S EST.**



TWO BIDS: 109 TOTAL CONTRACTS

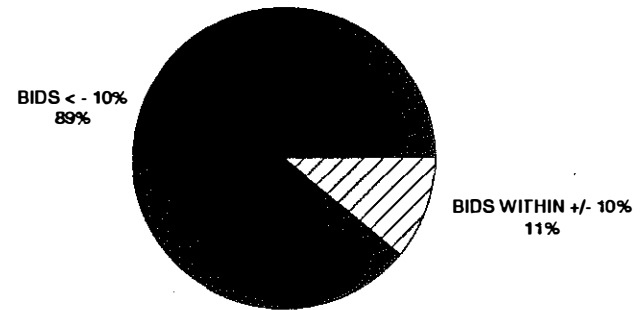
**CONTRACT AMOUNT
LESS THAN OR EQUAL TO \$250,000**

**1987 BITUMINOUS CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**



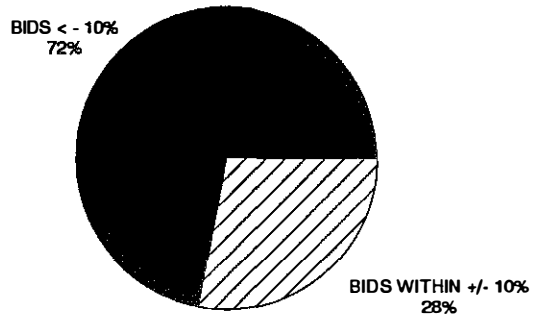
TWO BIDS: 18 TOTAL CONTRACTS

**1987 BITUMINOUS CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**



TWO BIDS: 18 TOTAL CONTRACTS

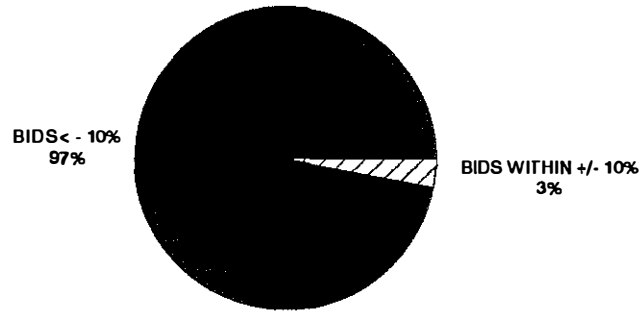
**1987 BITUMINOUS CONTRACTS
SECOND LOWEST BID VERSUS ENGINEER'S EST.**



TWO BIDS: 18 TOTAL CONTRACTS

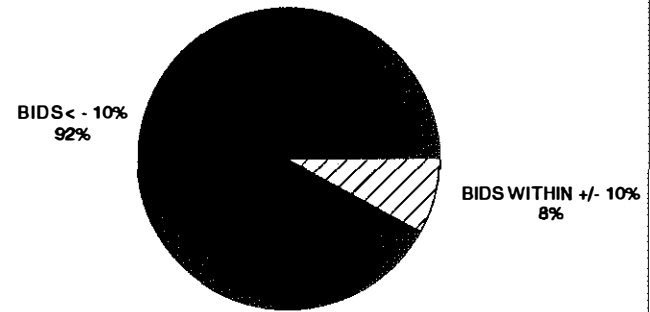
**CONTRACT AMOUNT
GREATER THAN \$250,000**

**1987 BITUMINOUS CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**



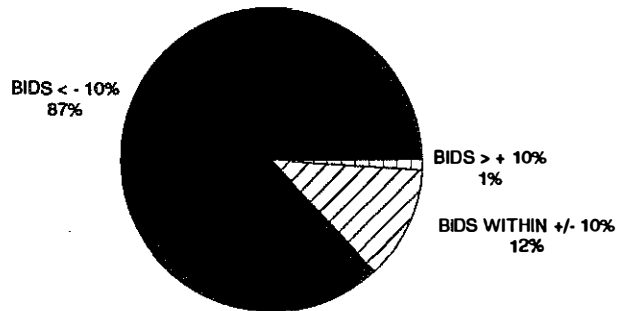
THREE OR MORE BIDS: 104 TOTAL CONTRACTS

**1987 BITUMINOUS CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**



THREE OR MORE BIDS: 104 TOTAL CONTRACTS

**1987 BITUMINOUS CONTRACTS
SECOND LOWEST BID VERSUS ENGINEER'S EST.**

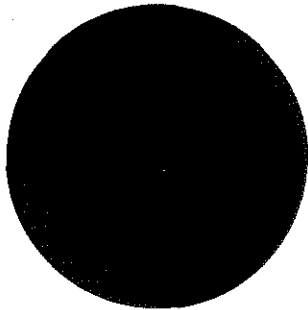


THREE OR MORE BIDS: 104 TOTAL CONTRACTS

**CONTRACT AMOUNT
LESS THAN OR EQUAL TO \$250,000**

**1987 BITUMINOUS CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**

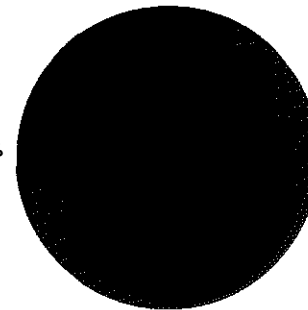
BIDS < - 10%
100%



THREE OR MORE BIDS: 9 TOTAL CONTRACTS

**1987 BITUMINOUS CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**

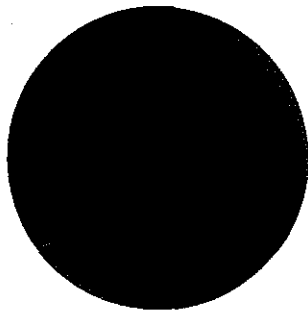
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THREE OR MORE BIDS: 9 TOTAL CONTRACTS

**1987 BITUMINOUS CONTRACTS
SECOND LOWEST BID VERSUS ENGINEER'S EST.**

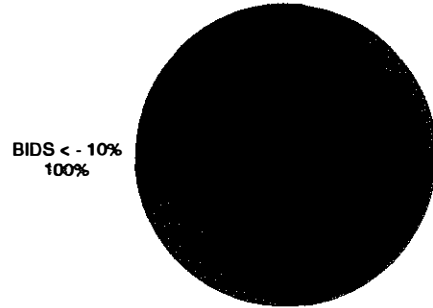
BIDS < - 10%
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THREE OR MORE BIDS: 9 TOTAL CONTRACTS

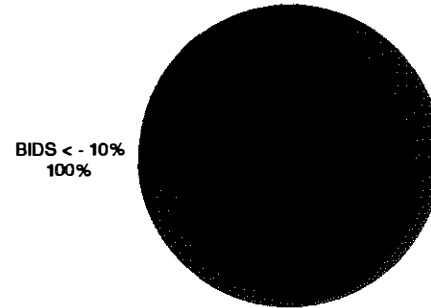
**CONTRACT AMOUNT
GREATER THAN \$250,000
AND LESS THAN OR EQUAL TO \$500,000**

**1987 BITUMINOUS CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**



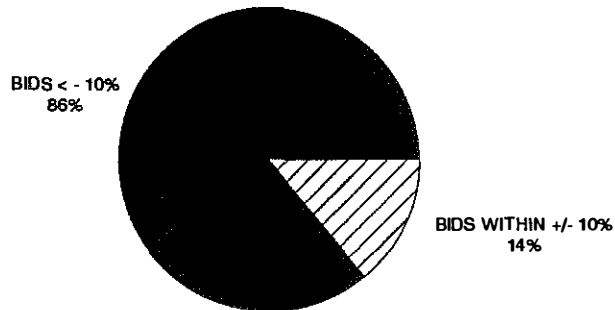
THREE OR MORE BIDS: 7 TOTAL CONTRACTS

**1987 BITUMINOUS CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**



THREE OR MORE BIDS: 7 TOTAL CONTRACTS

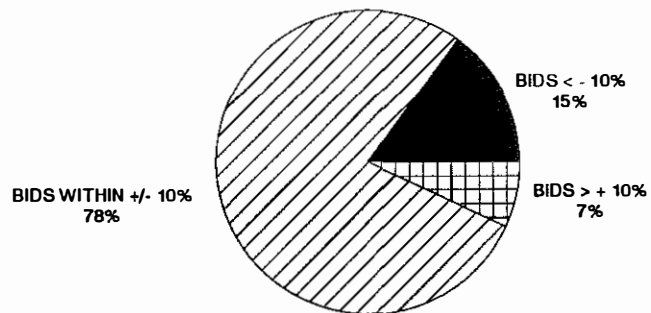
**1987 BITUMINOUS CONTRACTS
SECOND LOWEST BID VERSUS ENGINEER'S EST.**



THREE OR MORE BIDS: 7 TOTAL CONTRACTS

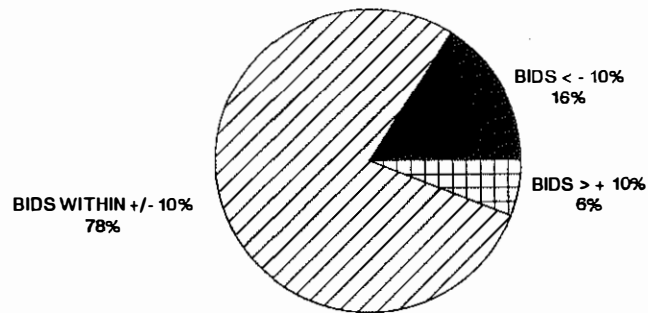
CONTRACT AMOUNT
GREATER THAN \$500,000

**1988 BITUMINOUS CONTRACTS
LOW BID VERSUS ENGINEER'S EST.
CONTRACT AMOUNT
LESS THAN OR EQUAL TO \$250,000**



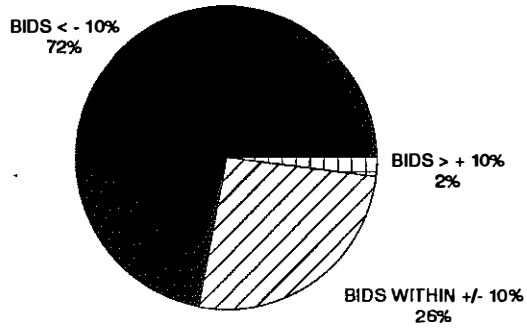
SINGLE BID: 311 TOTAL CONTRACTS

**1988 BITUMINOUS CONTRACTS
LOW BID VERSUS ENGINEER'S EST.
CONTRACT AMOUNT GREATER THAN \$250,000**



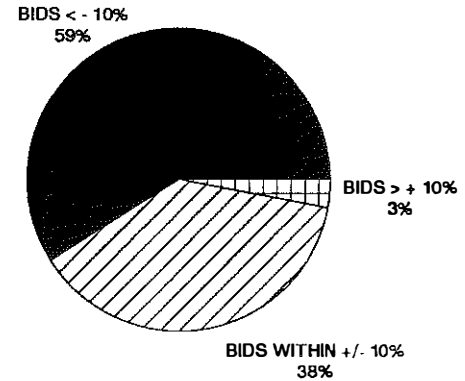
SINGLE BID: 37 TOTAL CONTRACTS

**1988 BITUMINOUS CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**



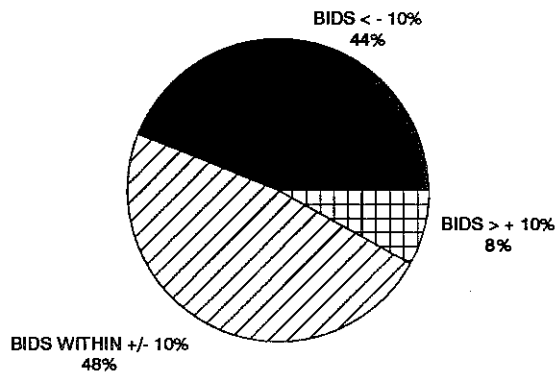
TWO BIDS: 100 TOTAL CONTRACTS

**1988 BITUMINOUS CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**



TWO BIDS: 100 TOTAL CONTRACTS

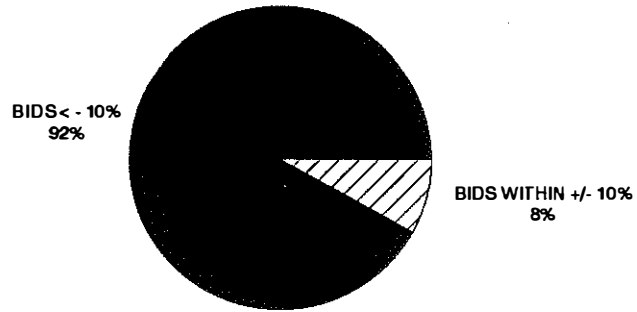
**1988 BITUMINOUS CONTRACTS
SECOND LOWEST BID VERSUS ENGINEER'S EST.**



TWO BIDS: 100 TOTAL CONTRACTS

CONTRACT AMOUNT
LESS THAN OR EQUAL TO \$250,000

**1988 BITUMINOUS CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**



TWO BIDS: 12 TOTAL CONTRACTS

**1988 BITUMINOUS CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**



TWO BIDS: 12 TOTAL CONTRACTS

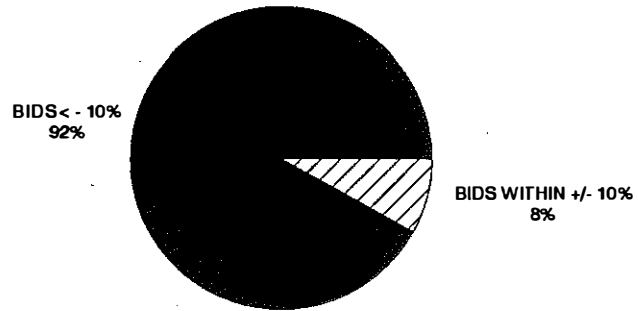
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SECOND LOWEST BID VERSUS ENGINEER'S EST.**



TWO BIDS: 12 TOTAL CONTRACTS

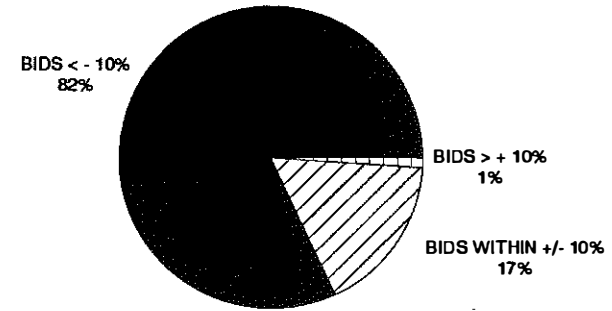
**CONTRACT AMOUNT
GREATER THAN \$250,000**

**1988 BITUMINOUS CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**



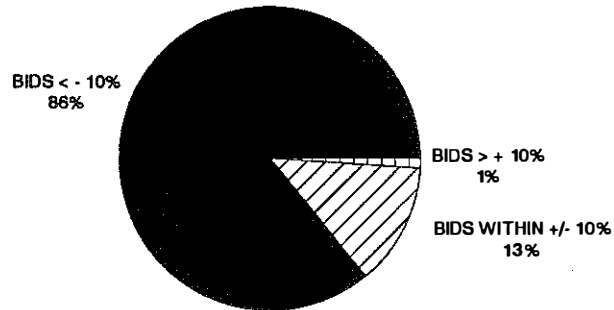
THREE OR MORE BIDS: 114 TOTAL CONTRACTS

**1988 BITUMINOUS CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**



THREE OR MORE BIDS: 114 TOTAL CONTRACTS

**1988 BITUMINOUS CONTRACTS
SECOND LOWEST BID VERSUS ENGINEER'S EST.**

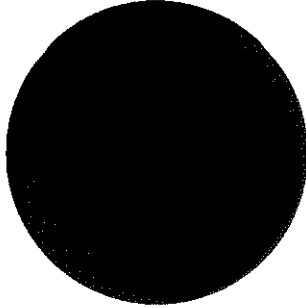


THREE OR MORE BIDS: 114 TOTAL CONTRACTS

**CONTRACT AMOUNT
LESS THAN OR EQUAL TO \$250,000**

**1988 BITUMINOUS CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**

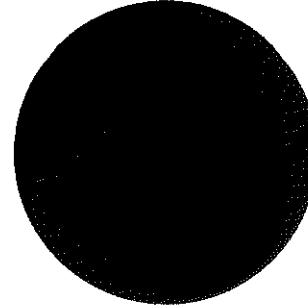
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THREE OR MORE BIDS: 8 TOTAL CONTRACTS

**1988 BITUMINOUS CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**

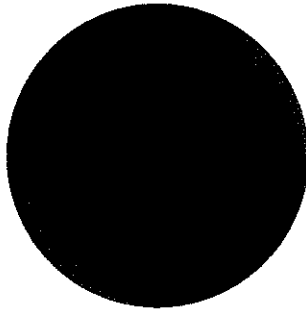
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THREE OR MORE BIDS: 8 TOTAL CONTRACTS

**1988 BITUMINOUS CONTRACTS
SECOND LOWEST BID VERSUS ENGINEER'S EST.**

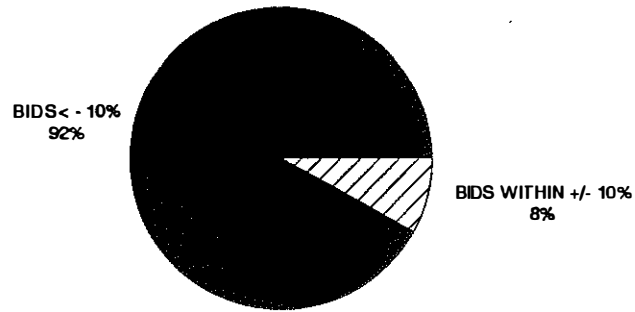
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THREE OR MORE BIDS: 8 TOTAL CONTRACTS

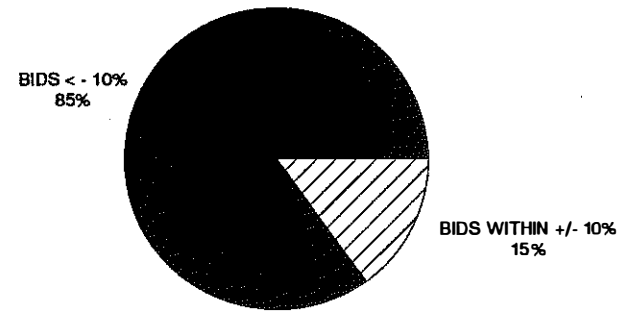
CONTRACT AMOUNT
GREATER THAN \$250,000
AND LESS THAN OR EQUAL TO \$500,000

**1988 BITUMINOUS CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**



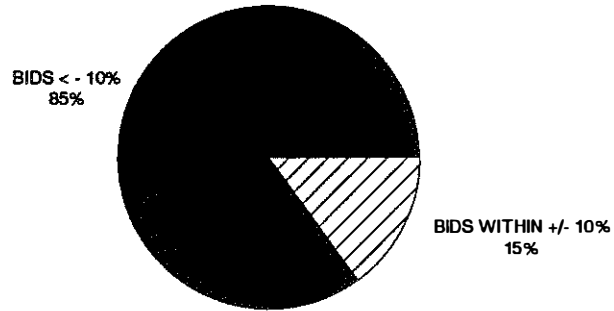
THREE OR MORE BIDS: 13 TOTAL CONTRACTS

**1988 BITUMINOUS CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**



THREE OR MORE BIDS: 13 TOTAL CONTRACTS

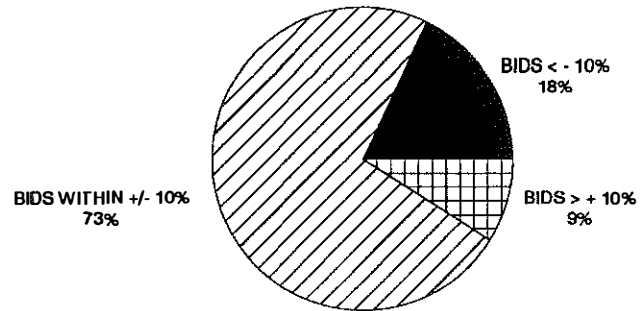
**1988 BITUMINOUS CONTRACTS
SECOND LOWEST BID VERSUS ENGINEER'S EST.**



THREE OR MORE BIDS: 13 TOTAL CONTRACTS

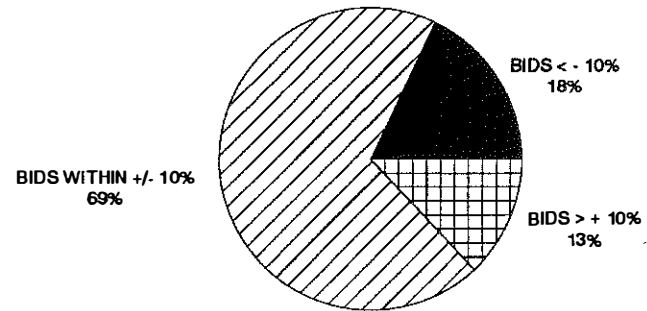
**CONTRACT AMOUNT
GREATER THAN \$500,000**

**1989 BITUMINOUS CONTRACTS
LOW BID VERSUS ENGINEER'S EST.
CONTRACT AMOUNT
LESS THAN OR EQUAL TO \$250,000**



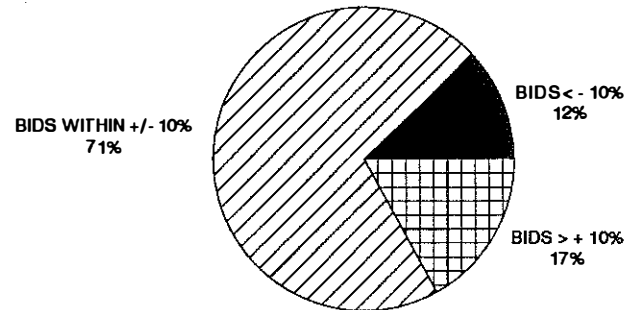
SINGLE BID: 221 TOTAL CONTRACTS

**1989 BITUMINOUS CONTRACTS
LOW BID VERSUS ENGINEER'S EST.
CONTRACT AMOUNT
GREATER THAN \$250,00
AND LESS THAN OR EQUAL TO \$500,000**



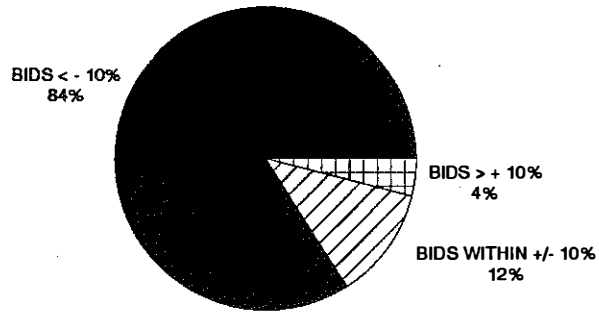
SINGLE BID: 55 TOTAL CONTRACTS

**1989 BITUMINOUS CONTRACTS
LOW BID VERSUS ENGINEER'S EST.
CONTRACT AMOUNT GREATER THAN \$500,000**



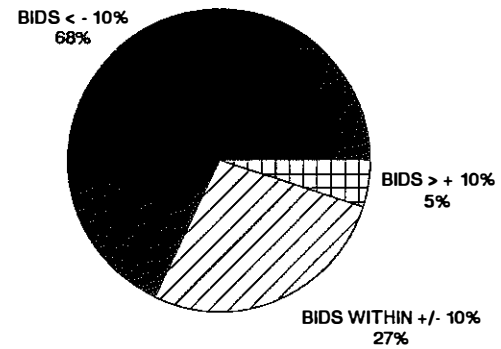
SINGLE BID: 17 TOTAL CONTRACTS

**1989 BITUMINOUS CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**



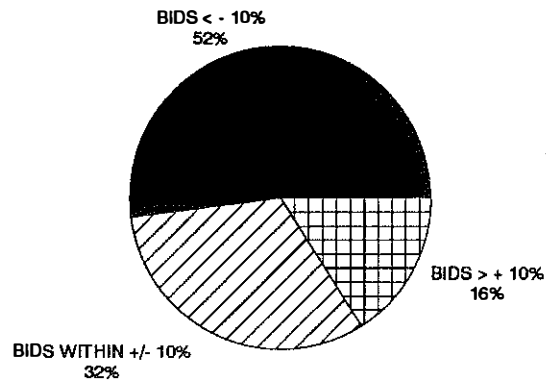
TWO BIDS: 75 TOTAL CONTRACTS

**1989 BITUMINOUS CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**



TWO BIDS: 75 TOTAL CONTRACTS

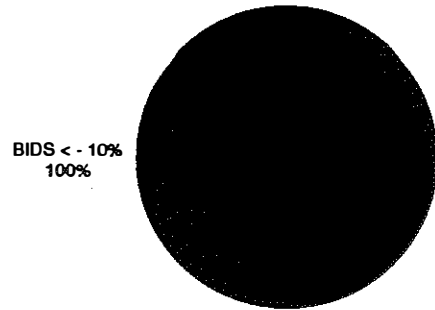
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SECOND LOWEST BID VERSUS ENGINEER'S EST.**



TWO BIDS: 75 TOTAL CONTRACTS

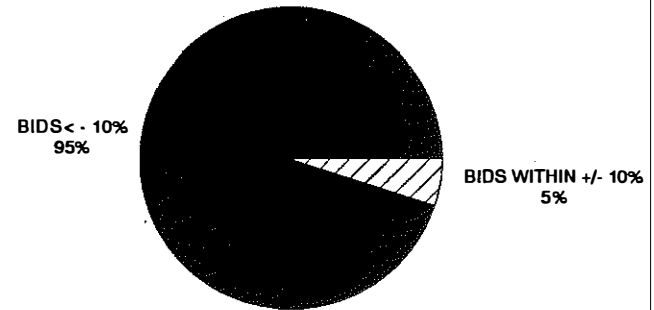
**CONTRACT AMOUNT
LESS THAN OR EQUAL TO \$250,000**

**1989 BITUMINOUS CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**



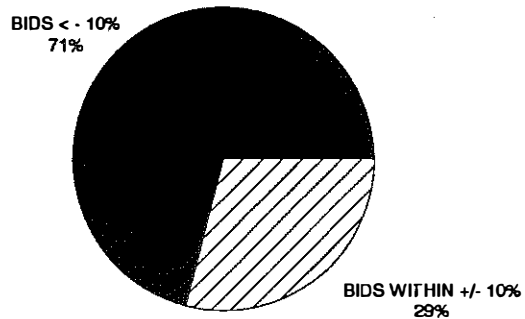
TWO BIDS: 21 TOTAL CONTRACTS

**1989 BITUMINOUS CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**



TWO BIDS: 21 TOTAL CONTRACTS

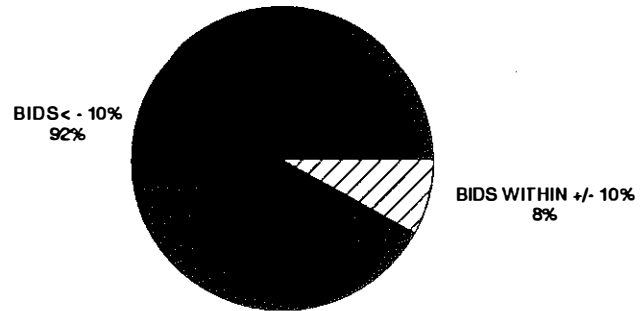
**1989 BITUMINOUS CONTRACTS
SECOND LOWEST BID VERSUS ENGINEER'S EST.**



TWO BIDS: 21 TOTAL CONTRACTS

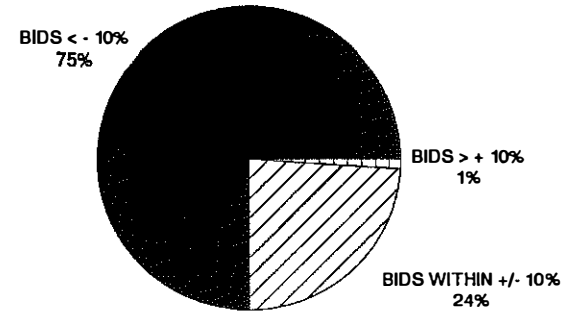
**CONTRACT AMOUNT
GREATER THAN \$250,000**

**1989 BITUMINOUS CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**



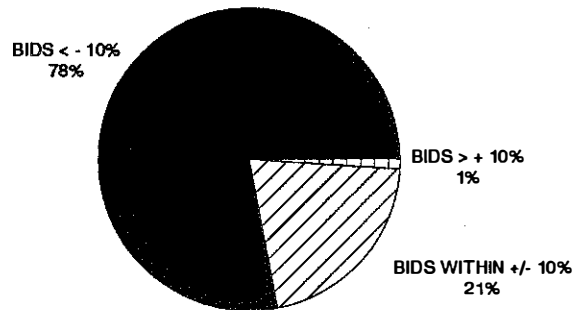
THREE OR MORE BIDS: 89 TOTAL CONTRACTS

**1989 BITUMINOUS CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**



THREE OR MORE BIDS: 89 TOTAL CONTRACTS

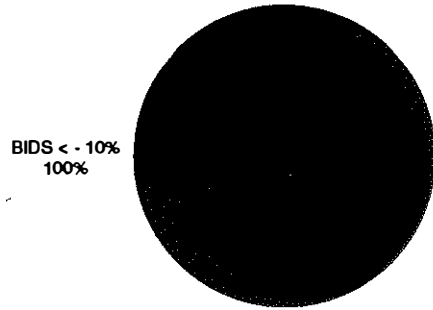
**1989 BITUMINOUS CONTRACTS
SECOND LOWEST BID VERSUS ENGINEER'S EST.**



THREE OR MORE BIDS: 89 TOTAL CONTRACTS

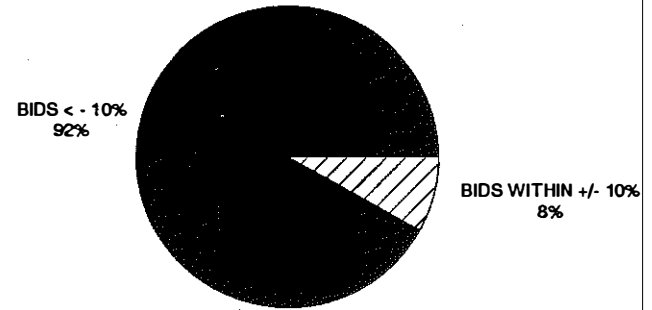
**CONTRACT AMOUNT
LESS THAN OR EQUAL TO \$250,000**

**1989 BITUMINOUS CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**



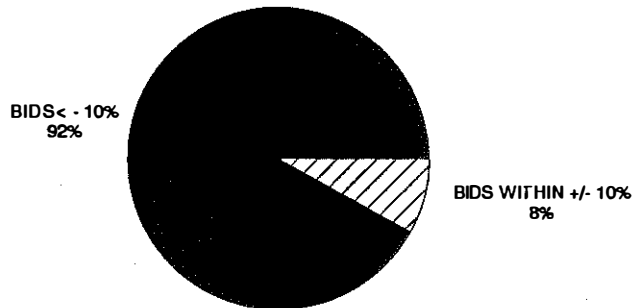
THREE OR MORE BIDS: 13 TOTAL CONTRACTS

**1989 BITUMINOUS CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**



THREE OR MORE BIDS: 13 TOTAL CONTRACTS

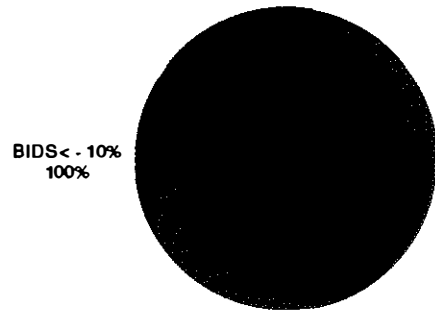
**1989 BITUMINOUS CONTRACTS
SECOND LOWEST BID VERSUS ENGINEER'S EST.**



THREE OR MORE BIDS: 13 TOTAL CONTRACTS

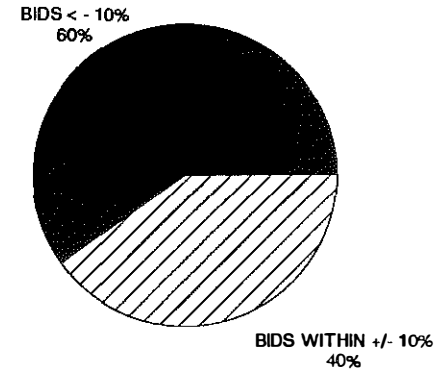
**CONTRACT AMOUNT
GREATER THAN \$250,000
AND LESS THAN OR EQUAL TO \$500,000**

**1989 BITUMINOUS CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**



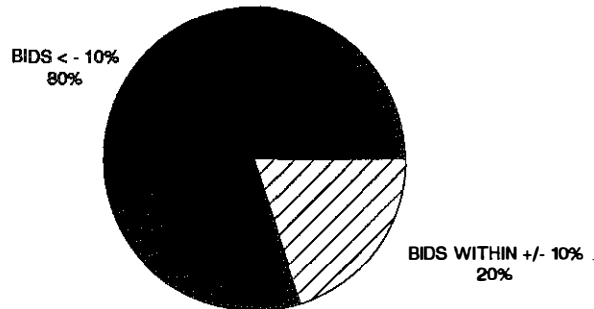
THREE OR MORE BIDS: 5 TOTAL CONTRACTS

**1989 BITUMINOUS CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**



THREE OR MORE BIDS: 5 TOTAL CONTRACTS

**1989 BITUMINOUS CONTRACTS
SECOND LOWEST BID VERSUS ENGINEER'S EST.**



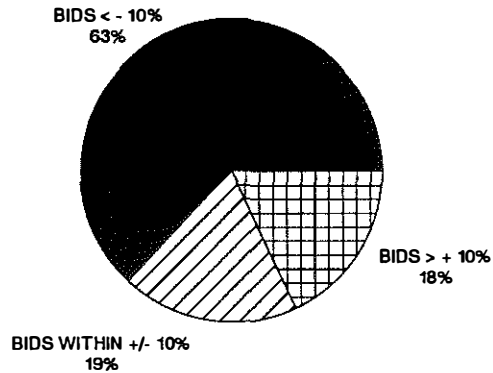
THREE OR MORE BIDS: 5 TOTAL CONTRACTS

**CONTRACT AMOUNT
GREATER THAN \$500,000**

APPENDIX B

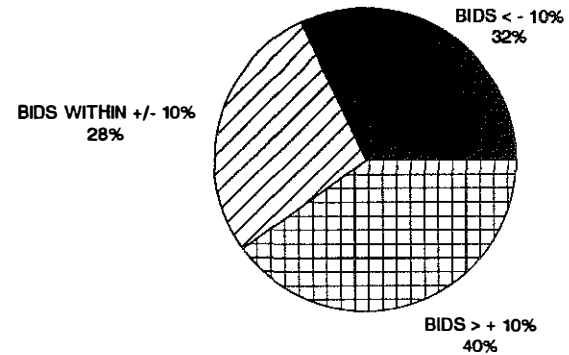
Bridge Repair Projects

**1987 BRIDGE REPAIR CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**



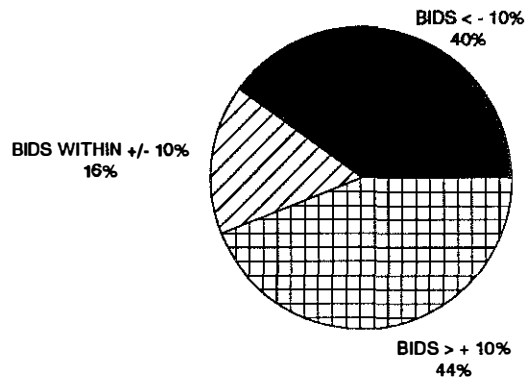
62 TOTAL CONTRACTS

**1987 BRIDGE REPAIR CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**



50 TOTAL CONTRACTS

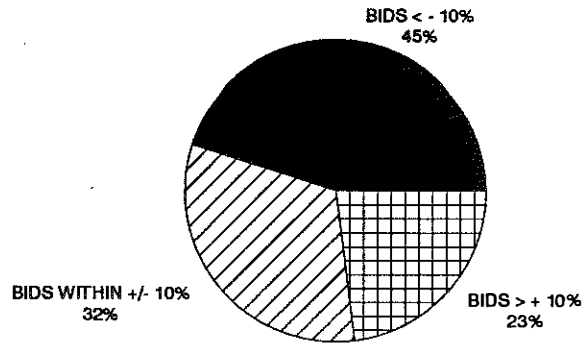
**1987 BRIDGE REPAIR CONTRACTS
SECOND LOWEST BID VERSUS ENGINEER'S EST.**



50 TOTAL CONTRACTS

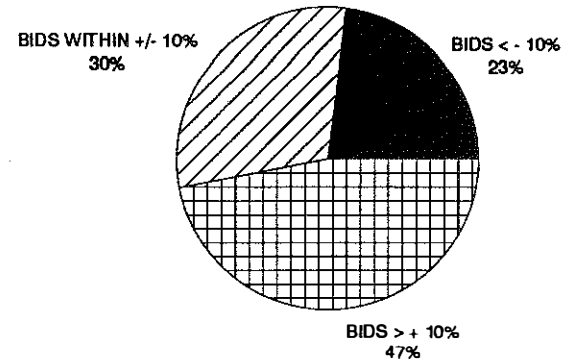
ALL CONTRACTS INCLUDED

**1988 BRIDGE REPAIR CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**



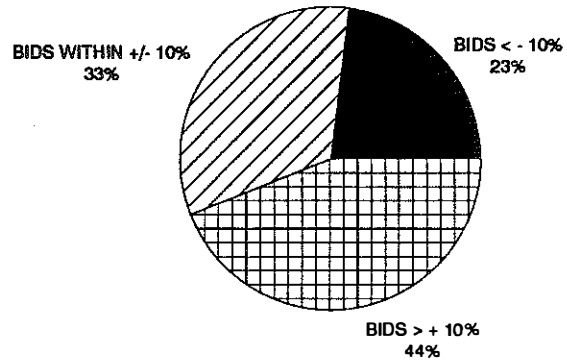
47 TOTAL CONTRACTS

**1988 BRIDGE REPAIR CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**



43 TOTAL CONTRACTS

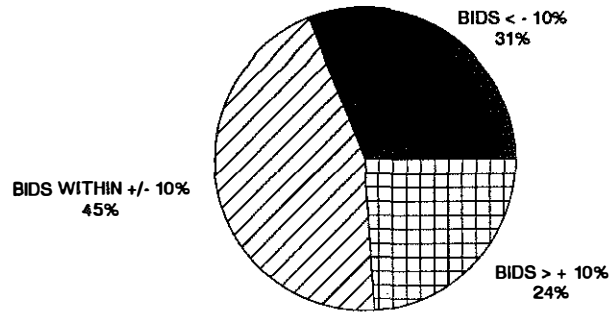
**1988 BRIDGE REPAIR CONTRACTS
SECOND LOWEST BID VERSUS ENGINEER'S EST.**



43 TOTAL CONTRACTS

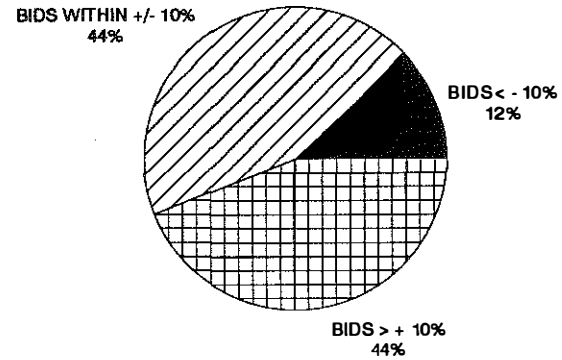
ALL CONTRACTS INCLUDED

**1989 BRIDGE REPAIR CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**



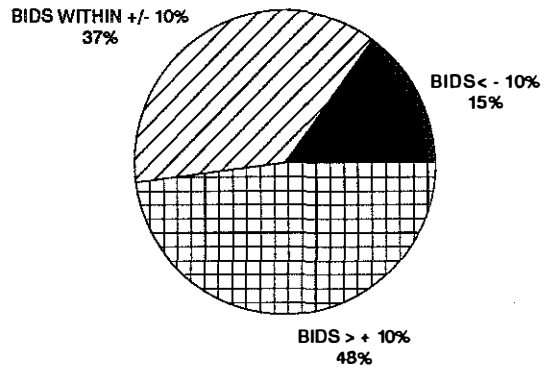
49 TOTAL CONTRACTS

**1989 BRIDGE REPAIR CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**



41 TOTAL CONTRACTS

**1989 BRIDGE REPAIR CONTRACTS
SECOND LOWEST BID VERSUS ENGINEER'S EST.**



41 TOTAL CONTRACTS

ALL CONTRACTS INCLUDED

APPENDIX C

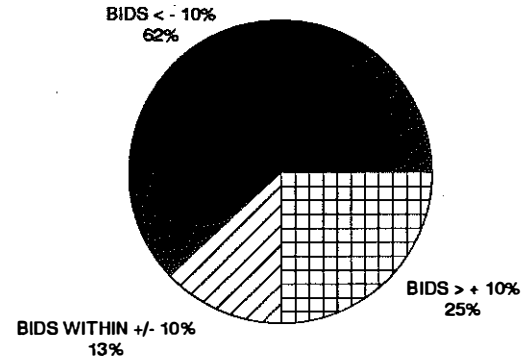
Clean and Paint Bridge Projects

**1987 CLEAN AND PAINT BRIDGES CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**



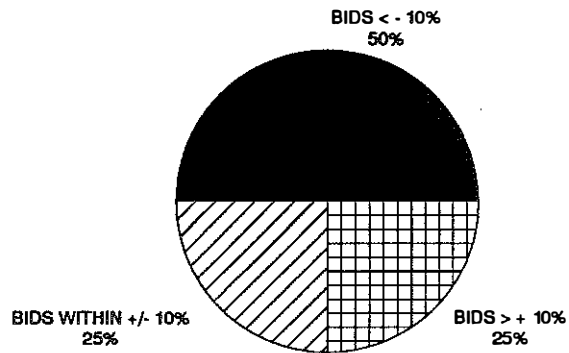
8 TOTAL CONTRACTS

**1987 CLEAN AND PAINT BRIDGES CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**



8 TOTAL CONTRACTS

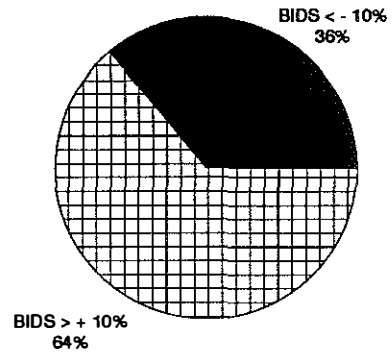
**1987 CLEAN AND PAINT BRIDGES CONTRACTS
SECOND LOWEST BID VERSUS ENGINEER'S EST.**



8 TOTAL CONTRACTS

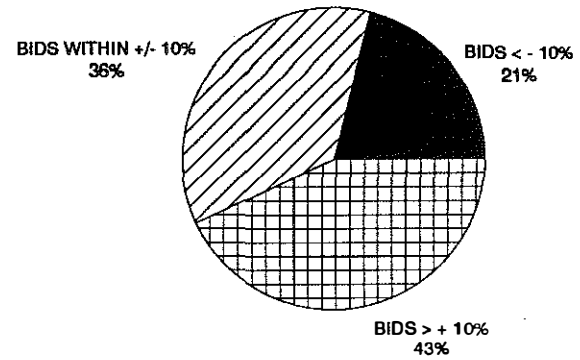
ALL CONTRACTS INCLUDED

**1988 CLEAN AND PAINT BRIDGES CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**



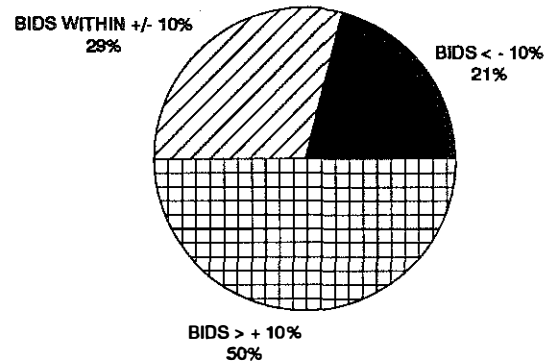
14 TOTAL CONTRACTS

**1988 CLEAN AND PAINT BRIDGES CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**



14 TOTAL CONTRACTS

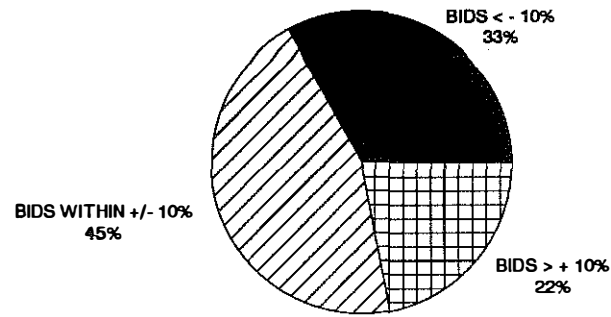
**1988 CLEAN AND PAINT BRIDGES CONTRACTS
SECOND LOWEST BID VERSUS ENGINEER'S EST.**



14 TOTAL CONTRACTS

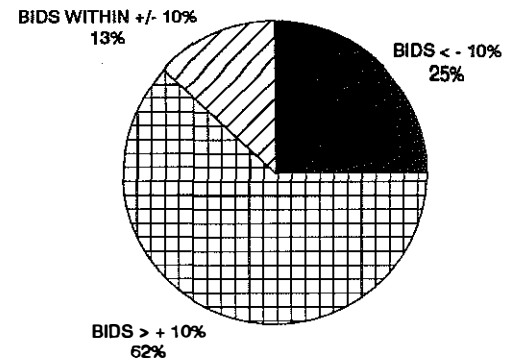
ALL CONTRACTS INCLUDED

**1989 CLEAN AND PAINT BRIDGES CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**



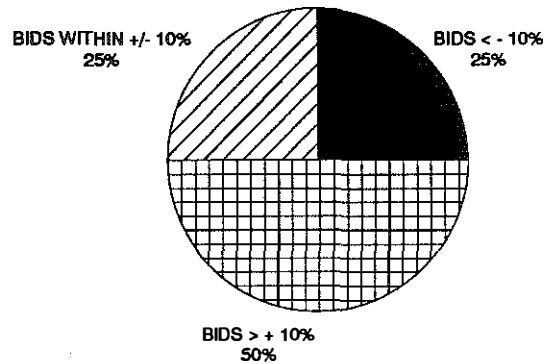
9 TOTAL CONTRACTS

**1989 CLEAN AND PAINT BRIDGES CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**



8 TOTAL CONTRACTS

**1989 CLEAN AND PAINT BRIDGES CONTRACTS
SECOND LOWEST BID VERSUS ENGINEER'S EST.**



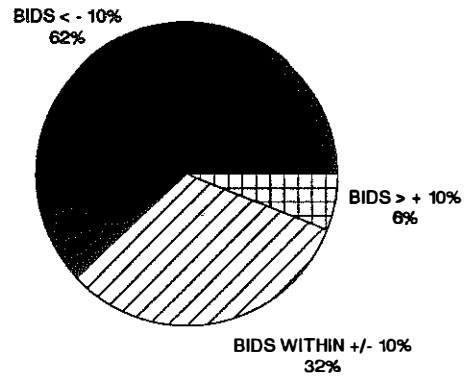
8 TOTAL CONTRACTS

ALL CONTRACTS INCLUDED

APPENDIX D

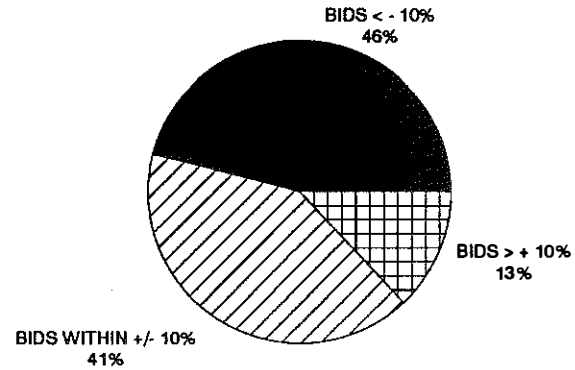
Grade and Drain Projects

**1987 GRADE AND DRAIN CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**



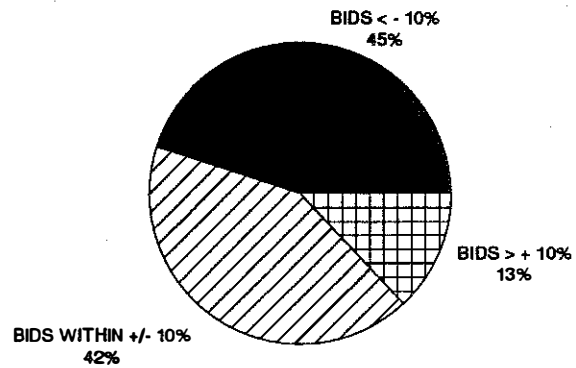
158 TOTAL CONTRACTS

**1987 GRADE AND DRAIN CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**



147 TOTAL CONTRACTS

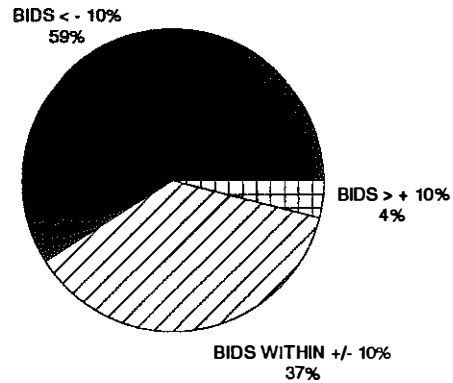
**1987 GRADE AND DRAIN CONTRACTS
SECOND LOWEST BID VERSUS ENGINEER'S EST.**



147 TOTAL CONTRACTS

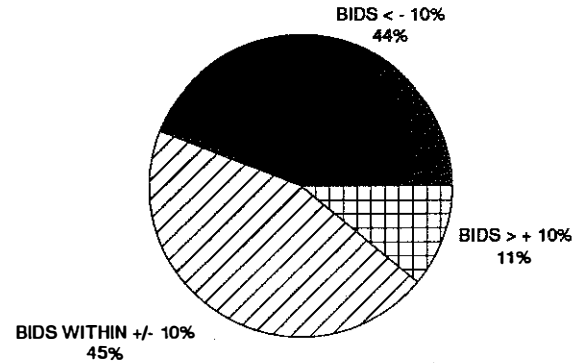
ALL CONTRACTS INCLUDED

**1988 GRADE AND DRAIN CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**



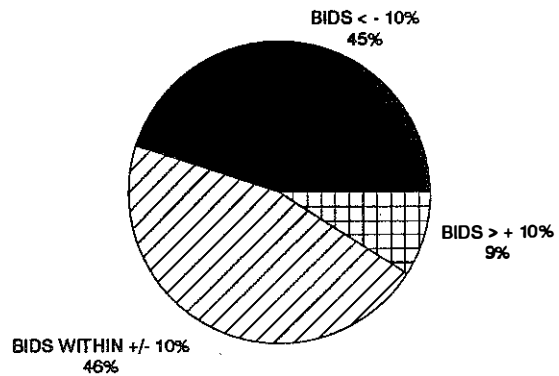
103 TOTAL CONTRACTS

**1988 GRADE AND DRAIN CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**



101 TOTAL CONTRACTS

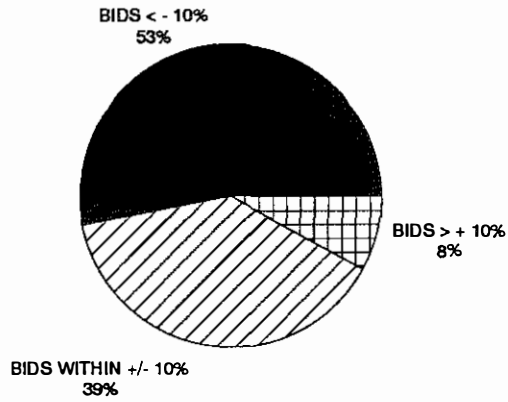
**1988 GRADE AND DRAIN CONTRACTS
SECOND LOWEST BID VERSUS ENGINEER'S EST.**



101 TOTAL CONTRACTS

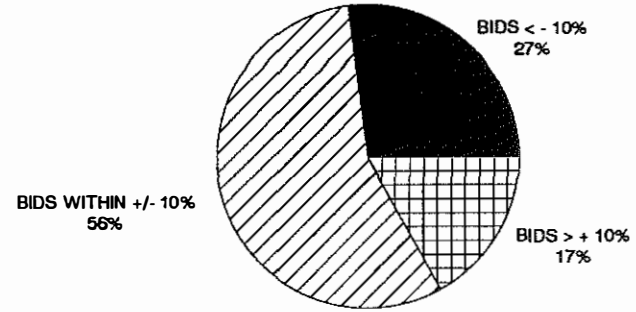
ALL CONTRACTS INCLUDED

**1989 GRADE AND DRAIN CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**



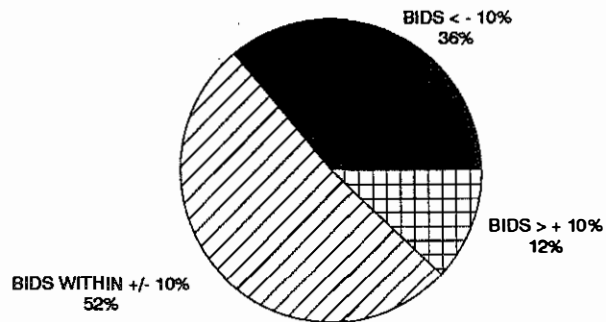
157 TOTAL CONTRACTS

**1989 GRADE AND DRAIN CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**



151 TOTAL CONTRACTS

**1989 GRADE AND DRAIN CONTRACTS
SECOND LOWEST BID VERSUS ENGINEER'S EST.**

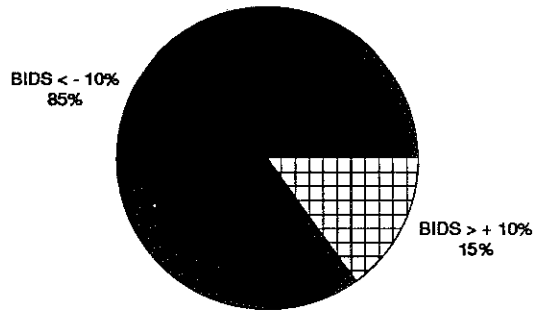


151 TOTAL CONTRACTS

ALL CONTRACTS INCLUDED

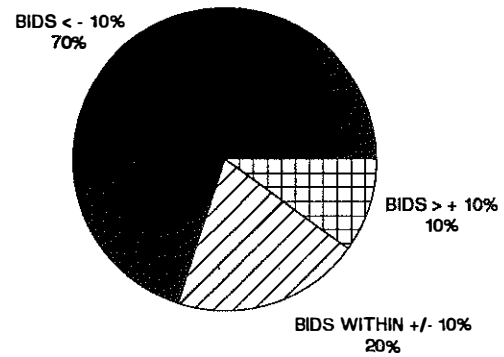
APPENDIX E
Mowing Projects

**1987 MOWING CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**



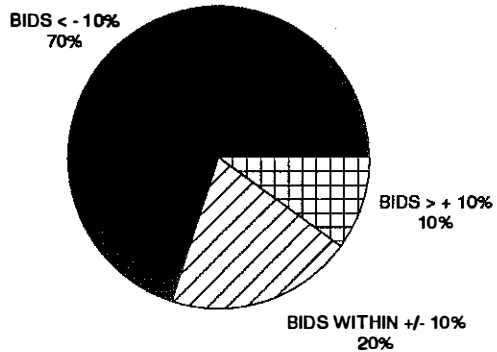
13 TOTAL CONTRACTS

**1987 MOWING CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**



10 TOTAL CONTRACTS

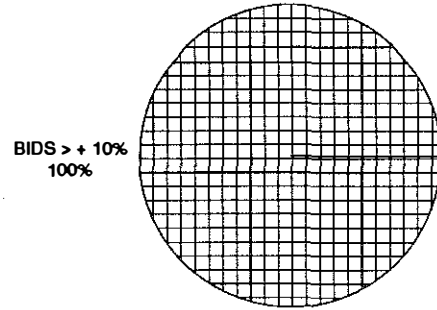
**1987 MOWING CONTRACTS
SECOND LOWEST BID VERSUS ENGINEER'S EST.**



10 TOTAL CONTRACTS

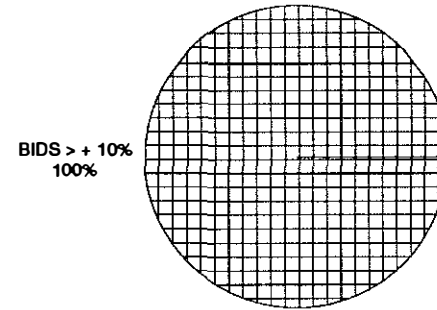
ALL CONTRACTS INCLUDED

**1988 MOWING CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**



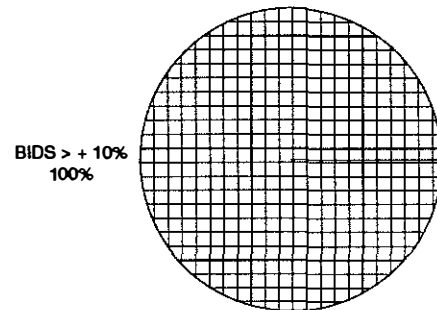
4 TOTAL CONTRACTS

**1988 MOWING CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**



4 TOTAL CONTRACTS

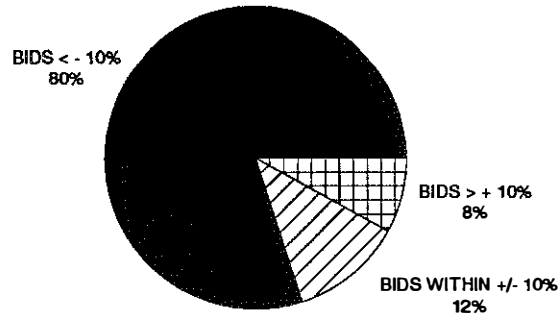
**1988 MOWING CONTRACTS
SECOND LOWEST BID VERSUS ENGINEER'S EST.**



4 TOTAL CONTRACTS

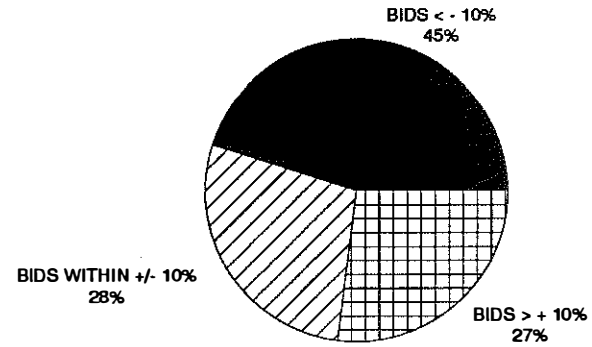
ALL CONTRACTS INCLUDED

**1989 MOWING CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**



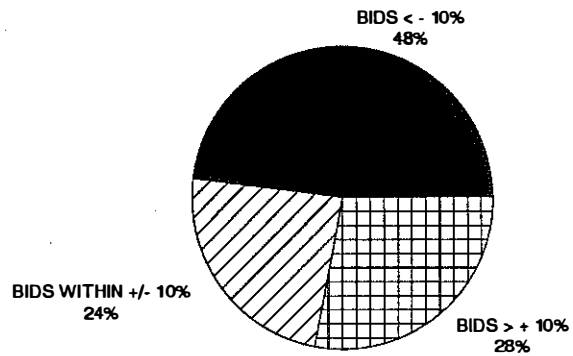
49 TOTAL CONTRACTS

**1989 MOWING CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**



29 TOTAL CONTRACTS

**1989 MOWING CONTRACTS
SECOND LOWEST BID VERSUS ENGINEER'S EST.**

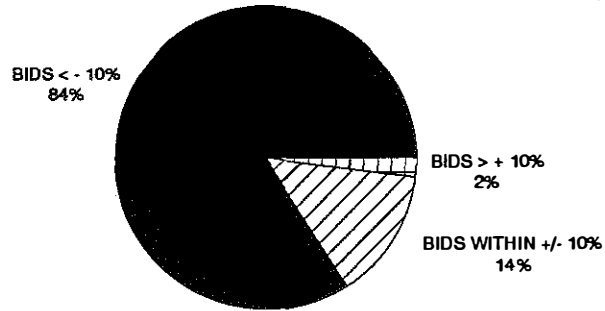


29 TOTAL CONTRACTS

ALL CONTRACTS INCLUDED

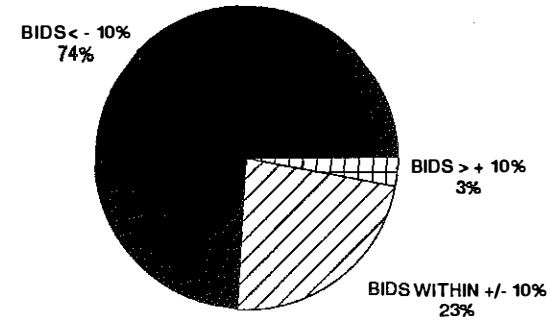
APPENDIX F
Miscellaneous Projects

**1987 MISCELLANEOUS CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**



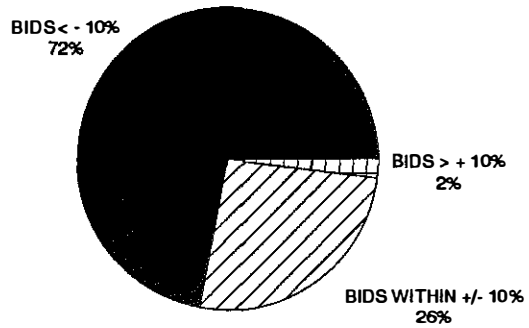
100 TOTAL CONTRACTS

**1987 MISCELLANEOUS CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**



96 TOTAL CONTRACTS

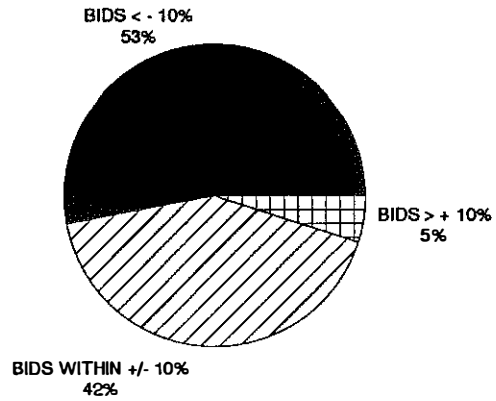
**1987 MISCELLANEOUS CONTRACTS
SECOND LOWEST BID VERSUS ENGINEER'S EST.**



96 TOTAL CONTRACTS

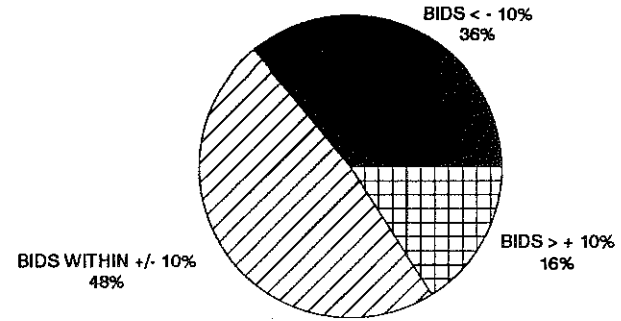
ALL CONTRACTS INCLUDED

**1988 MISCELLANEOUS CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**



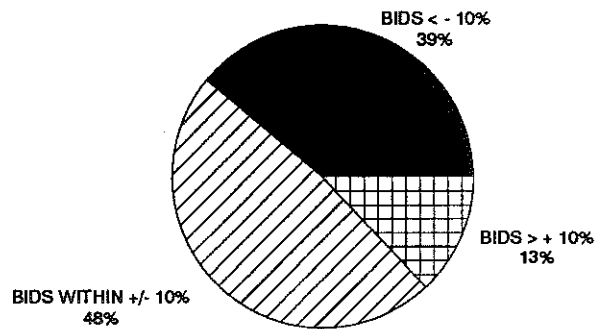
116 TOTAL CONTRACTS

**1988 MISCELLANEOUS CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**



114 TOTAL CONTRACTS

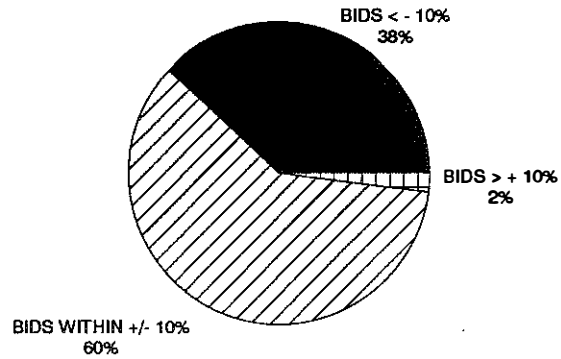
**1988 MISCELLANEOUS CONTRACTS
SECOND LOWEST BID VERSUS ENGINEER'S EST.**



114 TOTAL CONTRACTS

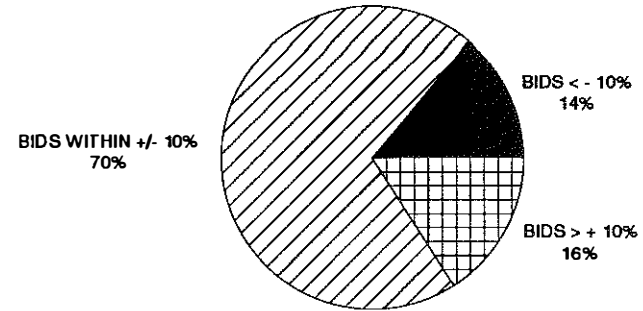
ALL CONTRACTS INCLUDED

**1989 MISCELLANEOUS CONTRACTS
LOW BID VERSUS ENGINEER'S EST.**



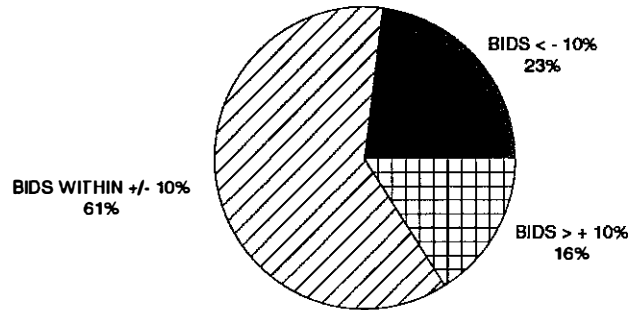
58 TOTAL CONTRACTS

**1989 MISCELLANEOUS CONTRACTS
BID AVERAGES VERSUS ENGINEER'S EST.**



56 TOTAL CONTRACTS

**1989 MISCELLANEOUS CONTRACTS
SECOND LOWEST BID VERSUS ENGINEER'S EST.**



56 TOTAL CONTRACTS

ALL CONTRACTS INCLUDED