Multiparameter Bidding System—Innovation in Contract Administration

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Abstract: The vast majority of construction contracts are procured using the low-bid system. In the low bid system price is the sole basis for determining the successful bidder. This traditional approach has certain drawbacks. In recent years, several innovative modifications to the low bid system have been tried. This paper presents the results of these trials and proposes a more comprehensive approach to bid award criteria. A presentation of a multiparameter bidding system is made. The multiparameter bid award system would include various owner-selected parameters, such as cost, time, and quality. Quantification of these parameters and bidder evaluation methodology are included. Finally, a discussion of the advantages and disadvantages of a multiparameter bid award criteria system is also presented.

Introduction

In recent years, we witnessed a trend toward looking for new innovations in contract administration. This phenomenon was caused by a long list of failures in past projects, especially in the public sector. The major disappointments in project performance were: extensive delays in the planned schedule, cost overruns, very serious problems in quality, and an increased number of claims and litigation. A common opinion is that the consumer (the public) does not get the best product for the money.

To change this situation, many public and private agencies are trying to find new methods to improve the current procedures. The writers (Ellis and Herbsman 1990) and other researchers (Bower 1989; Harp 1990) are convinced that one of the major factors behind those failures is the current bidding system used in the public sector. To analyze why this system creates so many problems, one has to understand the historical background of the development of this sytem, which is commonly known as competitive bidding, or the lowest bidder award system.

Overview of Competitive Bidding

The competitive bidding concept is rooted very deeply in the American tradition. Harp (1988) shows that competitive bidding has been in practice in New York state since 1847. The principal statutes for highway and bridge contracting in New York state date back to 1898 legislation, which required competitive bidding.

The basic idea behind this concept was that the lower bidder system protected the public from extravagance, corruption, and other improper practice by public officials. The original function of the competitive bidding requirement was to ensure that the public received the full benefit of Amer-

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ica's free enterprise system by providing public construction at the lowest price offered by competitive bidding (Cohen 1961; Netherton 1959).

Over the years, a few modifications to the initial concept occurred. The terms "responsible bidder" and "public interest" have been added to the statutes that control the authority to let and award public works contracts. Other modifications created the concept of prequalified bidder lists, and so on. However, the original concept from the 19th century remains intact. It is very important to understand that not every country around the globe is using this concept in the public works sector. Many nations use non-lower bidder systems.

Non-Lower Bidder Systems

A few countries, such as Italy, Portugal, and Peru, are using a system in which the successful bidder is not the lowest one. The philosophy behind this concept is that the best bid is the most reasonable one, not the highest, not the lowest, but the one closest to some average. There are many variations of this concept. The Peruvian government bidding system provides an example of one such variation (Henriod and Lanteran 1988). The procedures are as follows:

1. When three or more bids have been received:
   a. The average of all bids and the base budget will be calculated.
   b. All bids that lie 10% above and below this average will be eliminated.
   c. The average of the remaining bids and the base budget will then be calculated.
   d. The contract will be awarded to the bid immediately below the second average or, should none of the bids lie below the second average, to the bid that more closely approximates the average.
2. If fewer than three bids are received, the bidding agency may cancel the process and award the contract to the lowest bidder, or to the only bidder if this were the case.

Another similar practice is that of "bracketing," i.e., considering only those bids that lie within a certain range above and below the engineer's estimate. In this system, the lowest responsive bid within the range gets the award.

Countries such as France and Portugal (Henriod and Lanteran 1988) try to disqualify what they call abnormally low bids. They define abnormal as "any bid whose price appears abnormally low and consequently may cause implementation problems."

The writers analyzed these systems and came to the conclusion that even though these methods have their merits, they would not be generally accepted in the United States because of 150 years of a traditional competitive bidding system.

Advantages and Disadvantages of Competitive Bidding Concept

The competitive bidder system has one major advantage. It assumes that the bidding process will be independent from any sort of pressure (political, social, economic). Its objectivity is ensured because price is the sole criteria for evaluating bids. For many participants in the construction industry, this reason alone makes it all worth the disadvantages related to this practice. However, the disadvantages are numerous. The major one is that the selection process is based only on one element—cost. Other elements, such as quality and time, are not accounted for. Many other problems have occurred during the last 150 years: unreasonably low bids, bid rigging, unqualified contractors, and so on. To compensate for these handicaps, a few adjustments have been made during the years, such as qualification lists, deleting "abnormal" low bids, etc., but many construction participants agree that these are temporary solutions and a major change is needed.

The competitive bidding system is very deeply rooted in the American free enterprise tradition. The writers and others are convinced that a total change from the lower bidder system would not be feasible in the short range and would be even more difficult to sustain in the long range. Only a major modification that would remain in the form of the competitive bidding concept would be accepted.

Multiparameter Bidding System

The proposed system is based on the idea that the selection process of the contractor will be based on more parameters than just cost. The successful bidder will be selected according to the lower combined bidding value. Most logically, this number will be represented by a dollar value, but it can be represented using points, percentages, etc.

The major parameters will be: Cost, C; time, T; and quality, Q.

Secondary parameters can also be incorporated into the system, such as: Safety, S; durability, D; security; S; maintenance, M; and a few more.

The number of parameters and their related weights will be chosen by the sponsor. Let us demonstrate this concept with an example. The public agency decides to use four parameters. These parameters and their assigned weights are given in Table 1.

The successful bidder will be the one that has the lowest combined bidding value of the four parameters.

The multiparameter bidding system remains within the framework of the competitive bidding concept. A few legal experts have stated that as long as the parameters, their system of measurements, and their relativity weights are specified in the bid documents, this concept complies with the existing legal status of the current competitive bidding system.

Quantification of Parameters

The quantification of the parameters is the major problem in developing the multiparameter concept. There is no clear-cut answer as to which is the best method, and many variations can be developed. When additional research has been done, better and more accurate techniques will be established. The following pages describe a few of the options for some of the parameters.

TABLE 1. Parameter List

Number (1)	Parameter (2)	Weight (3)
1	Cost	70%
2	Time	15%
3	Quality	12%
4	Safety	3%

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Cost

Cost refers to the bid price submitted by the bidder. As in the traditional low bid system, cost will be measured in dollars.

Time

The writers have done extensive research related to this parameter (Herbsman 1988) and concluded that there is a very easy, systematic way that can be used. The time element can be quantified using a time value. The owner would establish the value of the time and the contractor would bid a performance time. For example, if the contractor bid 250 calendar days and each day is valued at \$10,000, the time will be 250 × \$10,000 = \$2,500,000, and this figure would be added to the cost value. If the owner chooses only two parameters to bid, then it becomes a cost-time bidding system. The cost-time system has been tested in a few states and the writers have gathered data on 16 projects that were bid using this cost-time concept. This can be demonstrated using a real example from a project in Mississippi. The time value was established by the owner as \$7,000 per day. The bid tabulation is given in Table 2.

The time value is established by the owner. There are many ways to figure the value. For example, in highway construction it is done routinely by transportation economists. The following is an example, a project in Kentucky, where the value was calculated as \$5,400 per day.

The highway road user cost (RUC) formula is as follows. RUC = (gasoline consumption × \$1.50/gal.) + (VMT × \$0.17/mi/vehicle) + (0.90 VHT × \$0.50/vehicle/hr) + (0.10 VHT × \$7.00/vehicle/hr), where (1) gasoline consumption is shown in Table 2; (2) \$1.50/gal. estimated price for 1985; (3) VMT is vehicle mile of travel as shown in previous table; (4) \$0.17 mi/vehicle is vehicle operating cost excluding price of gasoline, taxes, tolls, and parking; (5) 0.9 VHT is vehicle miles of travel attributed to passenger vehicles; (6) \$0.50/vehicle/hr is updated value of noncommercial or nonbusiness auto trip time; (7) 0.10 VHT is vehicle miles of travel attributed to commercial vehicles (trucks); and (8) \$7.00 vehicle/hr is updated value of commercial truck trip time.

Without sections 2A and 2B: RUC = (1,292,000 gal. × \$1.50/gal.) + (16,336,490 vehicle mi × \$0.17/mi/vehicle) + (0.90 × 708,897 vehicle hr × \$0.50/vehicle/hr) + (0.10 × 708,897 vehicle hr × \$7.00/vehicle/hr); RUC = \$1,938,000 + \$2,777,203 + \$319,004 + \$496,226; RUC = \$5,530,435.

With sections 2A and 2B: RUC = (1,291,000 gal. × \$1.50/gal.) + (16,358,302 vehicles mi × \$0.17/mi/vehicle) + (0.90 × 702,296 vehicle hr × \$0.50/vehicle/hr) + (0.10 × 702,296 vehicle hr × \$7.00/vehicle/hr); RUC = \$1,936,500 + \$2,780,911 + \$316,033 + 491,607 = 5,525,051.

TABLE 2. Results of Bid Tabulation Using Cost-Time Concept

Bidder number (1)	Bid cost base (2)	Days bid (3)	Time value (4)	Total amount (5)
1	\$15,636,180.56	450	\$2,250,000.00	\$17,886,180.56[a]
2	\$16,070,558.46	426	\$2,130,000.00	\$18,200,558.46
3	\$15,628,815.06	523	\$2,615,000.00	\$18,243,815.06
4	\$16,231,527.80	646	\$3,230,000.00	\$19,461,527.80
5	\$15,835,768.22	780	\$3,900,000.00	\$19,735,768.22

[a]The lowest combined bidder.

Daily road user benefit (DRUB) is then calculated as DRUB = \$5,530,435 − \$5,525,051 = \$5,384. From these calculations, the daily road user benefit to the motoring public from the construction of sections 2A and 2B of the Jefferson Freeway is \$5,400 per day.

Normally the amount specified as liquidated damages is set at the time value. Therefore, late performance results in liquidated damages in the amount of the time value per day.

An incentive may also be specified for early completion. However, some administrators believe that is is inappropriate to offer an incentive bonus for early completion on a contract in which the contractor has established the contract time.

The writers researched the results of bids conducted by seven state transportation agencies using the cost-time bidding system (Ellis and Herbsman 1990). A total of 14 projects were included in this study. Use of the cost-time bidding system resulted in a significant savings in porject time and a corresponding cost savings to the owner on 11 of the 14 projects. The results of this study are summarized in Table 3.

The savings to the owner have been calculated taking into account the contractor's price and proposed time, as compared with the owner's cost estimate and normal time. The owner's established time value was used to calculate the value of any time savings.

Quality

This parameter is the most complicated and difficult to quantify. There are two approaches to the subject.

Past Performance

This approach takes into consideration past performance and uses subjective opinions to evaluate the performance on a scale. The details of the evaluation process vary at different organizations, but all use the same concept. For example, the Florida Department of Transportation uses it on a permanent basis by using the resident engineer as the evaluator. Although it is based largely on subjective opinion, it is very rare that the contractor

TABLE 3. Summary of Case Study Results

Case study number (1)	State (2)	Successful bid price (\$) (3)	Savings to owner (\$) (4)	Time savings to owner (days) (5)
1	Delaware	3,034,765	250,000	50
2	Kentucky	17,886,181	1,387,635	219
3	Mississippi	4,721,599	166,331	49
4	Kentucky	16,329,262	2,885,000	577
5	Kentucky	12,583,349	315,000	63
6	Kentucky	9,186,877	1,620,000	324
7	Kentucky	18,554,123	715,000	143
8	Delaware	2,306,380	175,000	35
9	Maryland	35,087,606	0	0
10	Missouri	1,637,015	(460,000)	(23)
11	Georgia	1,361,009	(147,000)	(21)
12	Texas	39,833,648	150,000	30
13	Texas	39,781,121	300,000	60
14	Texas	15,867,833	55,000	11

(who has a right to appeal) challenges the evaluation. A better quantification method for past quality performance can be based on past test results. This way the evaluation will be less subjective. The details of the quantification system have to be developed using existing standard testing procedures, such as concrete strength, pavement strength, tolerance measurements, etc.

Future Performance

A few researchers (Byrd 1989; Marek 1989; Yarbrough 1990) are against any subjective evaluation, and they prefer bidding on quality the same way that the contractor will bid on cost and time. This approach has its merit, although it needs more research for various tests. A demonstration of this concept would be the following example: One of the most important factors in highway construction is the roughness of the pavement. This item is measured by inch/mile using a "profiler." The contractor can bid on the quality of the road by using the parameter (inch/mile). An 8-in./mi would be better than a 13-in./mi. The state decides the value of every in./mi (within certain limitations). Similar measurements can be developed for various types of work.

Both of the two approaches have their merits and handicaps, and more research needs to be done. Even with all the problems associated with quantification of quality, this parameter has to be an essential part of the multiparameter system.

Measuring Quality

An example of quality quantification is provided by the Construction Quality Assessment System (CONQUAS) now in use by the Construction Industry Development Board in Singapore. The CONQUAS system consists of a structured program for inspecting, measuring, and recording the quality performance of contractors. Under this system, contractors are assigned quality performance scores on past jobs. A contractor's quality record becomes an essential part of the contractor's performance record. For public projects, contractor's with superior quality scores are given a pricing advantage on competitive bids.

The philosophy of Singapore's Construction Industry Development Board is summarized by Chow Kok Fong, General Manager: "Construction quality is taken too frequently as an abstract notion." And, he adds, "A commitment to construction quality is only possible if progress in this front can be registered in some manner" (Fong 1990). According to the CIDB, the

TABLE 4. Bid Parameters

Number (1)	Description (2)	Weight (%) (3)	Quantification method (4)
1	Cost	60	Actual cost value
2	Time	20	Based on $2,000/calendar day
3	Quality	15	Past performance in points[a]
4	Safety	5	Historical accident records[b]
Total	—	100%	—

[a]Based on average performance in the last 36 months represented in points per hundred, i.e., 97/100, 85/100, and so on.

[b]Based on number of accidents per $1,000,000 cost and depending upon the severity of the accidents.

CONQUAS system has been applied to more than 120 private and public sector projects.

Minor Parameters

In addition to the major three parameters (cost, time, quality), there may be more parameters that can be incorporated into the system. Most of these parameters would be specific to particular industries, and these agencies would have the responsibility of figuring the weights and the quantification methods for these parameters.

Such additional parameters could include safety (very important in tunnel and dam projects), security (in military projects), and aesthetic quality (shopping centers), among others. It must be emphasized that new parameters can be added all the time, and their relative importance can be measured by adjusting the weights.

TOTAL SYSTEM

The multiparameter bid system would be designed by the owner to include those parameters considered to be most essential. It seems likely that the selected parameters might vary with different owners and with different

TABLE 5. Bid Tabulation

Bidder (1)	Cost ($) (2)	Time (Cal-Days) (3)	Quality (points per 100) (4)	Safety (number of accidents per 1,000,000)[a] (5)
A	1,100,000	250	89	12
B	1,300,000	230	97	9
C	1,250,000	240	91	17
D	1,100,000	300	85	25

[a]The number of accidents were weighted on a scale: severe accidents (3 points), medium (2 points), and light (1 point).

TABLE 6. Bid Calculations

Bidder (1)	Cost value (C) (2)	Time[a] value (T) (3)	Quality[b] value (Q) (4)	Safety[c] value (S) (5)	Total[d] (B) (6)
A	1,100,000	500,000	121,000	12,000	1,733,000
B	1,300,000	460,000	39,000	9,000	1,808,000
C	1,250,000	480,000	112,500	17,000	1,859,500
D	1,100,000	600,000	165,000	25,000	1,890,000

The calculation are based on the following formulas:

[a]Time value calculation based on calendar day × \$2,000/day = C_T.

[b]Quality value calculation based on 100-points/100 × C_L = C_Q.

[c]Safety value calculation based on number of accidents (1, 2, 3 points) × \$10,000 = C_S.

[d]Total combined cost $C_B = C_C \times C_Q + C_T + C_S$.

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projects. Regardless of the parameters chosen, all bidders would be fully advised of the basis for successful bidder selection prior to bid preparation.

The total system can be demonstrated with an example. In this case, the owner has established a bidding system based on four parameters. These parameters and their assigned weights are listed in Table 4. This information is provided to the prospective bidders as a part of each bid package.

Table 5 presents a tabulation of the bid results. The cost amount is the bid price proposed by the bidders. The time amount is the time in calendar days proposed by the bidders for performance of the work. The quality and safety items have been established from the bidders previous performance records.

Given this bidding result, the total bid scores for determining award are listed in Table 6. In this example, bidder A appears to have made the best proposal. If the project was awarded to bidder A, the contract amount would be $1,100,000 and the specified duration would be 250 calendar days.

Summary and Conclusions

The existing bidding system, which is the competitive bid (or low bidder) system, has created many problems in past years. Many modifications have been added to the original concept but the system remains basically unchanged. The successful bidder is chosen by the lowest, responsible cost. Other factors such as time, quality, etc., have not been taken into consideration. Many practitioners believe that the current bidding system has caused many failures in the form of delays, low quality, and numerous other claims. However, an attempt to totally change the current bidding system could face major resistance from various sectors of the construction industry.

The paper introduced a modified bidding system within the legal and conceptional frame of the current practice.

In the modified multiparameter bidding system, the award would be granted to the total combined cost of a few parameters, such as cost, time, and quality.

The weight of each parameter would be decided by the owner, so he can give a relative opinion of the importance of each parameter. Quality can be a 30% value in one bid and 50% in another. As long as the weights and quantification method are known in advance by each bidder, the proposed system is legally very sound.

The writers have analyzed a limited version of the new system, bidding on cost and time, and the results show a significant savings in time without any major increase in cost. For the other parameters such as quality, more research must be done on quantification methods. It will not be easy, but it can be done, as has been shown in the case of time quantification (road-user cost). The proposed multiparameter system has the potential of improving construction performance in the United States by giving advanced contractors an incentive to use all of their abilities to give the owner a better product. Its strength is the flexibility of the system, while it remains within the framework of the competitive bidding system.

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