Cost Overruns on State of Washington Construction Contracts

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The completion of construction projects within budget is of paramount importance to most owners. Yet, it is common knowledge that numerous factors can cause the costs of construction to exceed the budget. Understanding the specific causes of cost overruns can serve as the beginning stage for controlling costs. Research was conducted to evaluate construction cost overruns on projects completed for the Washington State Department of Transportation. The objective was to identify factors that have the strongest association with construction cost overruns. Results of the analysis, which examined information from 468 construction projects, indicated that cost overruns, expressed as a percentage of the original contract amount, tend to increase with the size of the project. Evidence also suggests that the cost overrun rate increases with the number of bidders and with the increased dispersion of the various bids submitted per project.

In the early stages of the design of a project, the primary objective is to establish the parameters that must be met to meet the goals of the owner. Whereas the functional aspects of the owner's needs in a project receive paramount attention, the financial constraints imposed by the owner will weigh heavily in many design decisions. When the design is complete, the project is advertised and the construction documents are distributed to firms that will submit bids on the project. The construction contract is typically awarded to the lowest qualified bidder submitting a regular bid. Under ideal circumstances, the final or ultimate cost of the project to the owner will be the same as the amount stated in the construction contract. However, in reality, the final costs incurred on construction projects are rarely the same as stated in the contract.

On unit-price contracts, it is generally accepted that the final cost of a project will differ from the amount on which the low bidder was determined. This is because the number of units to be installed, excavated, placed, or removed cannot be determined with complete accuracy. If such accuracy were attainable, the projects would be awarded on the basis of fixed-price contracts. Other reasons for cost differences between the contracted amount and the final cost of construction include omissions of crucial information in construction documents, errors in construction documents, the discovery of changed conditions or differing site conditions, changes in the project that are authorized by the owner, interference in construction operations by personnel of the owner, and a variety of other reasons that will result in an increase in cost to the owner. Whatever the source of the change in construction costs, the increase is typically referred to as an overrun. The "overrun rate" is the change in the construction cost of a project, stated as a percentage, compared with the original contracted amount.

Are construction cost overruns random? Can cost overruns be predicted or modeled? If so, efforts can be better directed to decrease or at least control the overrun rates. Can some increased understanding of cost overruns be achieved? If so, budgetary decisions will be more enlightened and accurate. In response to these questions, a study was conducted through the Washington State Transportation Center at the University of Washington to provide insights into cost overruns on Washington State Department of Transportation (WSDOT) construction projects.

LITERATURE REVIEW

Several research efforts have been made to identify variables that are most closely associated with cost overruns. Despite the large number of researchers that have considered this topic, little consistency exists between the findings of various researchers.

Several studies have indicated that the cost overrun rate is influenced by the type or size of project. One study indicated that cost overruns were disproportionately larger when the project size was increased (*1*). Larger projects, associated with greater complexity, are subject to a greater number of change orders, which may be the cause of significant cost overruns (*2*). However, another study found that the change order rate was reduced on larger projects (*3*). One study indicated that cost overruns were less predictable on small projects, but that larger projects consistently encountered some but rarely excessively large overruns (*4*). Another researcher found that the type of project influenced the overrun rate (earthwork and paving projects had higher overrun rates) (*5*).

Other studies have indicated that the cost overrun rate is not necessarily related to the project itself but to the nature of the competition on the project. One measure of the competitive nature of the bidders is to compare the low bid with the owner's estimate or the engineer's estimate. Whereas it may be concluded that poor economic conditions will cause bids to be below the engineer's estimate (*6*), it has also been stated that the estimates generated by the owner are conservative in most cases (*7*). One study indicated that cost overruns were largest when the low bid was below the owner's estimate. The interpretation offered was that contractors may regard the difference between the low bid and the engineer's estimate as an untapped pool of available funds. Thus, the contractor

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may be inclined to aggressively pursue these funds through changes and claims. Since contractors generally do not learn of the owner's estimate until after the bids are opened, contractors are presumed to regard any residual amounts between the low bid and the engineer's estimate as funds that have already been appropriated for the project. If this is the case, contractors may be more aggressive in pursuing changes and claims when the contract award amounts are less than the owner's estimated amounts (*4*).

Another measure of competitiveness on a project relates to the number of bids submitted. The inference is that a larger number of bidders will cause the low bid price to go down. One study noted a clear pattern that caused bids to be below the owner's estimate by 2 to 4 percent when at least six bidders competed on a project (*8*). Another researcher reported that each additional bidder contributed to a further decrease in the low bid on a project (*7*).

Other factors have also been identified as being associated with cost overrun rates. Inadequate site investigations or poor interpretation of the results of site investigations have given rise to increased cost overruns (*5*). Lack of consideration for the influence of existing utilities, right-of-way constraints, and drainage patterns have resulted in increased cost overruns (*9*). Poorly prepared contract documents, especially as related to scheduling requirements, time extensions, and differing site conditions, may result in increased cost overruns (*10*). Documents such as the technical specifications must be tailored to the project to avoid cost overruns (*11,12*). Similar comments have been made about ambiguous documents or conflicts between the plans and specifications (*13*).

RESEARCH METHODOLOGY

A study was conducted in which bid tabulations and cost information were reviewed and the sources or causes of cost overruns were investigated. The data were retrieved from projects completed for WSDOT. Although complete information was not available for all projects, in most cases information was compiled on such topics as project identification, project type, location of project (district), engineering effort involved (planning and construction), bidding information (bids submitted by each bidder), and cost history (engineer's estimate, award amount, and final cost). The data included 468 WSDOT projects undertaken from July 1985 through July 1989.

The data were analyzed to determine the degree of association between variables. Of particular interest was the degree to which selected variables were associated or correlated with the cost overrun rate. For this study, the cost overrun rate or overrun rate is defined as the amount (expressed as a percentage) by which the final cost of a project exceeds the original contracted amount. Analysis was conducted with the use of the Statistical Package for the Social Sciences (SPSS) using Kendall's correlation tests to evaluate the degree to which selected variables were related, and linear regression analysis was conducted to determine the extent to which project costs could be modeled.

RESULTS

The average cost overrun rate for the 468 WSDOT projects was 5.12 percent. Whereas there were some outliers, most project overruns and underruns were in the range of −20 to +40 percent (i.e., two projects had underrun rates below −50 percent, and four projects had overrun rates above +50 percent). One-third of the projects had final costs below the originally contracted or award amount. Ten percent of the projects had cost underrun rates below −7.5 percent. Cost underrun rates were encountered on projects in which the number of actual units on a unit price contract were below the engineer's estimate or in which deductive changes were made on the project. Twenty-five percent of the projects had overrun rates above 10 percent, and 10 percent had overrun rates above 18.5 percent. Because the data were relatively normal in distribution, when averages are presented in tabular form, the extreme outliers (below −50 percent and above +50 percent) are excluded to provide information that is more descriptive of "typical" data. With these outliers removed, the average cost overrun rate for the data was reduced from 5.12 to 4.68 percent. The average overrun rate in this study is considered to be 4.68 percent, which excludes the six extreme outlying values.

The project sizes ranged from as small as $37,000 to as large as $65,000,000. The average contracted amount was $1,866,000 (Table 1). The projects consisted of those completed between July 1985 and July 1989. For these projects, the average contract award amount was below the average of the owner's estimates by about 6 percent. On the other hand, the average of the final construction costs (contract award plus overruns) was very near the average of the owner's estimates. Thus, the overall history of the projects indicates that the owner's estimates are typically above the low bid or contract amount, but that they are a close approximation of the final costs to be experienced.

TABLE 1 Summary of WSDOT Project Construction Costs

Type of Cost	Number of Projects	Average Dollar Amount
Engineer's Estimate	468	$1,988,000
Contract Award	468	$1,866,000
Final Project Cost (Contract Award Plus 4.68% Overruns)	468	$1,992,000

Project Size

The projects represented in this study can be categorized as ranging from small to large. Since the median size of project was $625,000, most projects can be characterized as small. With the range of project sizes being large, comparisons could be made to determine the extent to which cost overrun rates were influenced by project size (Table 2). Results indicate, in general, that cost overrun rates tend to increase with increasing project size (correlation coefficient = 0.28, $p < 0.001$). A perfect correlation between variables would result in a coefficient of 1.0. The value of p is an indication of the probability that the association of the two variables is attributable to chance. Thus, a small value of p, typically below .05, is considered to be indicative of a statistically significant relationship.

Project Type

Cost overrun rates were examined to determine how they are related to the type of project. The four broad categories of project type included new construction, resurfacing (existing roadways), bridge (new and rehabilitation), and safety (safety improvements as traffic control or guardrails on existing roadways). Although no clear pattern of overrun rates was identified, it is apparent that in general the average engineer's estimate for each type of project was consistently above the average contract award amount (Table 3). The average of the engineer's estimates was above the average contract amount for resurfacing projects in all districts. For new construction projects and safety projects the same pattern was evident, with the exception of one district for each project type. The history in three of the six districts for bridge projects indicated that the engineer's estimates were below the actual contracted amounts.

Number of Bidders

It is often stated that the "lowest bidder is the contractor who made the biggest mistake." Whereas this is typically said in jest, there is some basis for the remark. It is generally assumed that the owner benefits from a lower price as the number of bidders increases for a particular project. The lower price is typically attributed to the increased competition. The existence of a larger number of bidders on a project generally is assumed to indicate that fewer projects are available for the qualified contractors. Thus, in an effort to maintain their construction volume, contractors are required to pursue construction projects more aggressively. Consequently, an increase in the number of bidders is often associated with a reduction in contract award amounts.

The data were examined to determine the influence of the number of bidders on various parameters. The number of bidders appears to increase with the size of the project (correlation coefficient = 0.26, $p < 0.001$). This trend was reasonably consistent for the data with the exception of those projects on which six or more bids were submitted. These projects tended to be slightly smaller than the average size of project on which five bidders compete. It appears that when the size of project approaches some given amount, fewer contractors are able to undertake the work (Table 4).

As postulated earlier, the number of bidders appears to be associated with the level of competition. The range of bids on each project was examined to see how this related to the number of bidders. It was determined that the range of bid amounts, expressed as a percentage by which the high bid exceeded the low bid, increased with the number of bidders (correlation coefficient = 0.51, $p < 0.001$).

The results indicate that the cost overrun rate tends to go up with the increase in the number of bidders. Only conjecture can be offered to explain this phenomenon. One explanation is that the larger number of bidders causes the competition to be keener and the bids to be noticeably reduced. If the bid was deliberately reduced to compensate for the increased competition, it is possible that the award recipients will have a greater incentive to seek compensation in excess of the contracted amount. Thus, the increased overrun rate associated with more bidders may not be a reflection of the influence of the bidders themselves, but rather that both are symptoms of a more competitive contracting environment. A contractor who has been awarded a contract based on an excessively reduced bid will possibly be more aggressive in "mining" the contract for sources of additional funds.

Range or Spread of Submitted Bid Amounts

When bids are evaluated, particular attention is often given to the extent of dispersion of the bid amounts. This dispersion,

TABLE 2 Project Size and Overrun Rates

Project Value (Average Value)	Number of Projects	Overrun Rate (%)
Under $250,000 ($132,000)	120	2.55
$250,000 to $500,000 ($354,000)	80	3.60
$500,000 to $1,000,000 ($719,000)	105	4.67
$1,000,000 to $2,500,000 ($1.52 Mil.)	102	5.93
$2,500,000 and Over ($9.66 Mil.)	62	7.91

TABLE 3 Engineer's Estimate and Contract Award by Project Type and District (Thousands of Dollars)

Project History	Project Type: New Constr.	Resurfacing Projects	Bridge Projects	Safety Projects
DISTRICT 1				
Engr's Est.	*7,209	*651	938	*208
Award Amt.	6,611	603	975	201
(Number)	(59)	(48)	(11)	(34)
Overrun	7.84%	4.98%	2.75%	2.90%
DISTRICT 2				
Engr's Est.	*1,311	*927	*490	*200
Award Amt.	1,256	827	488	177
(Number)	(4)	(23)	(3)	(4)
Overrun	13.34%	1.46%	-5.12%	-5.86%
DISTRICT 3				
Engr's Est.	*3,828	*840	1,238	*222
Award Amt.	3,818	736	1,241	199
(Number)	(35)	(28)	(15)	(11)
Overrun	5.75%	3.44%	4.49%	-1.10%
DISTRICT 4				
Engr's Est.	*3,689	*875	*2,089	434
Award Amt.	2,847	867	1,908	489
(Number)	(8)	(27)	(14)	(4)
Overrun	4.68%	9.35%	3.96%	7.82%
DISTRICT 5				
Engr's Est.	3,226	*972	1,457	*224
Award Amt.	3,318	923	1,499	197
(Number)	(15)	(22)	(8)	(16)
Overrun	7.59%	4.83%	5.49%	5.30%
DISTRICT 6				
Engr's Est.	*2,311	*1,334	*688	*186
Award Amt.	1,974	1,202	582	162
(Number)	(7)	(32)	(10)	(6)
Overrun	2.59%	1.63%	4.64%	1.51%
ALL DISTRICTS				
Engr's Est.	*5,100	*897	*1,262	*218
Award Amt.	4,767	828	1,217	205
(Number)	(129)	(184)	(62)	(78)
Overrun	6.92%	4.30%	3.72%	2.47%

* Denotes where the average Engineer's estimate exceeded the average contract award.

or difference between the lowest and highest bidder, is often referred to as the "bid spread" and may be indicative of the clarity of the bidding documents, the nature of the competitive climate, the unknowns perceived to exist in a project, or some other variable that might cause bids to vary. For example, the submission of bids that are all closely clustered by several bidders might imply that estimating was consistent between bidders because of particular clarity in the bidding documents or that the bidders were consistent in their assessment of the cost to perform the work. Close clustering of bids is preferred by most owners.

If the bids are widely dispersed, some negative implications might be drawn. For example, a wide dispersion of bids might mean that some bidders were not serious competitors or that they deliberately submitted high bids to ensure high profits if they are awarded the contract. A wide range in bids might also mean that the bidders had different interpretations of the anticipated costs to construct the project. The differences might be the result of poor contract documents, projects that may be subject to differing site conditions, projects that might be undertaken in a variety of ways, or projects on which the number of unknowns as perceived by the bidders is high. A wide dispersion of bids leaves doubt for the owner about the true construction costs of the project.

From the results it is clear that the range of bids is related to the number of bidders (i.e., the range of bids increases as

TABLE 4 Influence of Number of Bidders on Project Cost Overruns

Number of Bidders	Number of Contracts	Avg. Contract Award Amount ($ Millions)	Range of Bids (% above low)	Overrun Rate (%)
1	13	.46	N.A.	5.61
2	85	.98	12.3	2.88
3	100	1.70	16.7	4.44
4	105	1.93	21.7	5.83
5	55	3.21	30.9	8.05
6+	93	2.24	33.5	3.00
All	451	1.88	22.44	4.66

the number of bidders increases). The range of bids is also associated with costs, because the cost overrun rate increases with an increase in the range of bids (Table 5).

When bids are considered, in addition to assessing the total dispersion of bids, particular attention is given to the difference between the lowest bid and the second-lowest bid. It is often surmised that if the second-lowest bid is close to the lowest bid, the contract award is made at a reasonable amount. On the other hand, if the second-lowest bid is considerably above the low bid, questions may arise as to the cause for the variation. Of considerable concern to the owner is the fact that the low bidder may have made an error in the preparation of the bid. A bidder who leaves a large sum of "money on the table" may elect to try to withdraw the low bid by claiming that an error of fact was made in the preparation of the bid. Even if the low bidder enters into a contract with the owner, the owner may be concerned about the possibility that the contractor will encounter financial difficulty on the project. Such problems for the contractor will usually adversely affect the progress of the construction project.

The bid data were examined with a particular focus on the difference between the low bid and the second-lowest bid, expressed as the percentage above the low bid. (Table 6). One clear pattern was that the difference between the low and second-lowest bids increases with the total range of the bids. However, this difference does not appear to be related to the number of bidders, nor is it clear how this difference relates to the cost overrun rate. The largest cost overruns appeared on projects that were smaller and had fewer bidders.

The existence of a relationship between the cost overrun rate and the amount of dispersion between the low bid amount and the average bid amount was assessed. The results indicate that no apparent relationship exists between the cost overrun rate and the difference between the low bid amount and the average bid amount.

Cost Overruns Attributed to Specific Contractors

It has often been stated by some WSDOT personnel that certain contractors develop reputations for "mining construction contracts" to extract every possible overrun from the owner. Although low bids submitted by these contractors will invariably result in cost overruns, the public policy of awarding contracts to the lowest bidder precludes the owner from disqualifying them for this reason.

It was presumed that contractors with such a reputation must undertake a significant number of WSDOT projects. The data were examined to identify contractors who had been awarded at least 12 construction contracts. Seven contractors that received at least 12 of the WSDOT contracts examined in the study were identified. (Table 7). Of these contractors, two were identified as having average cost overrun rates that were significantly higher than the overall sample rate of 4.68

TABLE 5 Influence of Range of Bids on Project Cost Overruns

Range of Bids (% above low)	Number of Bids (Avg.)	Number of Contracts	Avg. Engr's Est. ($Mil)	Avg. Award Amt. ($Mil)	Overrun Rate (%)
Up to 10%	2.98	100	2.25	2.20	3.82
10% to 30%	4.33	247	2.32	2.14	5.37
30% and over	5.78	93	1.10	1.00	6.42

TABLE 6 Influence of Difference Between Low Bidder and Second-Lowest Bidder on Cost Overruns

Difference Between Low and Second Low Bidder	Number of Projects	Overrun Rate (%)	Number of Bidders	Contract Award Amt. ($Mil)	Range of Bids (%)
less than 2%	112	3.62	4.75	2.23	19.8
2% to 4%	73	4.72	4.81	1.97	20.9
4% to 6%	66	6.08	4.52	1.81	21.1
6% to 8%	55	4.52	4.15	1.62	21.2
8% to 10%	40	2.57	4.15	2.73	22.0
10% to 15%	55	6.27	3.96	2.22	26.8
15% +	51	4.67	3.17	0.42	33.2

TABLE 7 Cost Overrun Rates of Contractors with Several WSDOT Construction Contracts

Contractor Designation	Number of Contracts	Sum of All Contracts ($Millions)	Overrun Rate (%)
A	13	18.18	1.36
B	12	15.31	1.81
C	15	13.64	4.40
D	12	12.65	4.67
E	27	23.68	4.96
F	13	33.20	7.52
G	12	6.05	9.82

percent. These contractors, designated as Contractors F and G, accounted for 4.58 percent of the total dollar volume of the construction contracts completed between July 1985 and July 1989 and were associated with 7.48 percent of the amount spent on overruns. For their combined 25 construction contracts, Contractors F and G had cost overrun rates above the sample mean of 4.68 percent on 18 of their projects. By using the test of two means, only the cost overrun history of Contractor G proves to be significantly different ($p < .05$) from the sample mean.

Time Overruns

Just as cost overruns occur on construction projects, time overruns may also occur. Project duration is commonly quantified as the period beginning on the date stipulated in the notice to proceed and ending with the date of substantial completion of the project. Time overruns are defined as the ratio of the actual project duration less the original contract duration divided by the original contract duration, expressed as a percentage. It is possible to have a negative value in the event that the actual duration is less than the originally contracted duration. Information was available with which to compute the time overrun rates. They were compared with the cost overrun rates (Table 8). From the results it is clear that cost overrun rates increase with time overrun rates, and vice versa. Rather than implying a causal association between these variables, it is inferred that factors causing the costs of construction to go up will also tend to cause the time of construction to increase.

Regression Analysis

The results of the correlation tests indicated that several of the variables were related. An attempt was made to develop

TABLE 8 Cost Overrun Rates as Related to Time Overrun Rates on WSDOT Construction Contracts

Time Overrun Rate (%)	Number of Contracts	Cost Overrun Rate (%)
Less than -10	100	2.36
-10% to 0%	82	2.63
0% to +10%	66	6.27
+10% and over	104	7.78

a model in which all the variables were included. The intent of the model was to have a means of predicting cost overrun rates by using such information as the size of the project, the number of bidders, the range of the bids, and so forth. The results of the regression analysis yielded no viable model by which cost overruns could be predicted. For example, one attempt included the variables of overrun rate (dependent variable), size of project, number of bidders, range of bids, design hours, and the engineer's estimate. The R^2 value for this attempt was less than 0.02, a number far too small to yield any meaningful result. Numerous other combinations of variables were attempted with no greater success in predicting the overrun rates.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Results indicate that cost overruns tend to increase with an increase in project size. An increase in the number of bidders on projects is associated with an increase in the range or spread in the bid amounts, and this is associated with increased overrun rates. The difference between the low bid and the second-lowest bid does not appear to provide any measure by which cost overruns can be predicted. Whereas individual contractors may be associated with particular patterns of cost overruns, no general findings were noted. In general, it appears that cost overruns on WSDOT construction projects are modest. Although the average cost overrun rate on WSDOT projects is about 4.68 percent, the eventual total cost of these projects generally is near the engineer's original estimate. This occurs because the contract award amounts are typically below the engineer's estimates by about the same value as the overall overrun rate. Whereas overruns cannot be readily modeled or predicted, indications are that costs are controlled well on most projects. Despite the information obtained on 468 construction projects, the issue of overruns is more complex than can be explained by the introduction of a few simple variables. Little is explained by considering only such topics as the size of the project, the number of bidders, the range of the bid amounts, and other data that are available near contract award.

The research appears to indicate that some contractors are more likely than others to be associated with cost overruns. It also appears that cost overruns may be associated with or related to the particular districts in which the projects are performed. It is not clear whether there are unique practices in given districts, the site conditions in different jurisdictions have a varying influence on overrun rates, or the individual personalities of contracting personnel influence overrun rates. To successfully answer these inquires, an in-depth study of considerable magnitude would have to be conducted. Such a study, if conducted through the cooperative efforts of several states, could be informative in further defining the factors that influence cost overrun rates on state highway projects.

Individual state agencies might also conduct internal studies to further investigate the sources of cost overruns. Such studies should be carefully formatted to ensure that all available information is documented. Of particular importance is the documentation of the sources of cost overruns. That is, cost overruns should be categorized by the cause of the cost increase (differing site conditions, changes, delays, etc.). If the sources of the cost overruns are identified, the cost overruns can be modeled, and they are then much more subject to being controlled.

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