Changing Environment for Highway Construction: The Utah Experience with Construction Cost Overruns

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A study of cost overruns in construction projects performed under contract with the Utah Department of Transportation (UDOT) is reported in this paper. The approach looks at historical patterns through largely quantitative and descriptive information covering more than 800 projects completed between 1980 and 1989. Interviews were also conducted with current UDOT personnel, representatives from the State Attorney General's office, and private contractors and their legal counsel to determine current perceptions and assessments of the construction claims environment. Findings suggest that the climate of construction management has changed in recent years. As the Interstate system has neared completion, rehabilitation and reconstruction projects have increased both in number and as a percentage of all projects. These projects are found to be more likely to involve cost overruns. During the same period, UDOT preconstruction staffing levels fell, contributing to numerous design and other preconstruction errors, and an increased opportunity for contractors to seek additional compensation. Lack of cooperation between divisions within UDOT contributed to the decline in relationships between UDOT and the contracting community. Contractors were found to be more willing to file and pursue claims due to an increasingly competitive bidding process and increased access to legal counsel.

In recent years, the dollar amount of cost overruns on construction contracts administered by the Utah Department of Transportation (UDOT) has risen sharply. Figure 1 shows these cost overruns and underruns as a percentage of the original contract amount for 1968 through 1988. The general objective of this study was to conduct a thorough evaluation of the record, attempt to determine those factors leading to cost overruns, and formulate recommendations for actions to reduce the amount of cost overruns. To achieve these objectives, a three-pronged approach was undertaken, involving a review and evaluation of claims, interviews with key participants, and a comparative study of surrounding states. This paper reports on the first two aspects of the study. The complete report may be obtained from the authors.

A review was made of construction contracts completed during 1980–1988 in order to identify and isolate patterns, common causal factors, and so on. Overruns, amount of overrun, events from inception of problem to resolution of overrun, amount of settlement, and methods of administering claims were examined. This review included supplemental agreements, change orders, force account work, and contract claims over a 9-year period, including a representative sample of projects from the period before the upsurge in overruns. The focus was to determine the differences that existed before and after 1985 that could have an impact on final project costs. In accomplishing this and all other tasks, a high level of cooperation was afforded the research team at all levels of UDOT, the Utah Attorney General's Office, and contractors and attorneys in the private sector. Some of the desired data, however, did not exist or could not be found. The procedures and results of the data analysis task are presented in detail in the next part of this paper.

Interviews were held with representatives of all groups involved in the construction process, including personnel from UDOT administration and the preconstruction and construction divisions. In addition, representatives from the Claims Review Board, the Utah Attorney General's Office, the contracting community, and attorneys for contractors were interviewed. Their observations were sought and evaluated on reasons why there has been an increasing trend in construction cost overruns. These groups understand what the problems are, and many have definite opinions about how to solve them. Findings of the interview portion of this study are discussed in the second part of this paper.

Cost overruns and underruns in highway construction projects arise from several sources and result from many factors (*1*). Nearly every unit price item has the potential to overrun or underrun to some degree because the nature of highway construction is such that the final pay quantities are somewhat different than the estimated quantities (*2*). A reasonable amount of this should be expected. Mistakes and errors in judgment are also made and result in cost changes. When materials provided largely through the acts of nature (e.g., soil) are used, even when technically appropriate tests and evaluations have been performed and evaluated, conditions will be encountered during construction that may differ from those anticipated. All the above have an impact on the final cost of a project. Many adjustments are resolved by simply over- or underrunning a contract item. If the amount involved is great, or if it results from a changed condition, it will be negotiated and resolved through completion of a supplemental agreement to the contract. Some changes, however, are disputed. It was found during this study that the term "claim" is often misused. For purposes of this paper, "claim" refers to a request for a change in the contract price that has not been resolved through negotiation and is in dispute at the time the final estimate was prepared.

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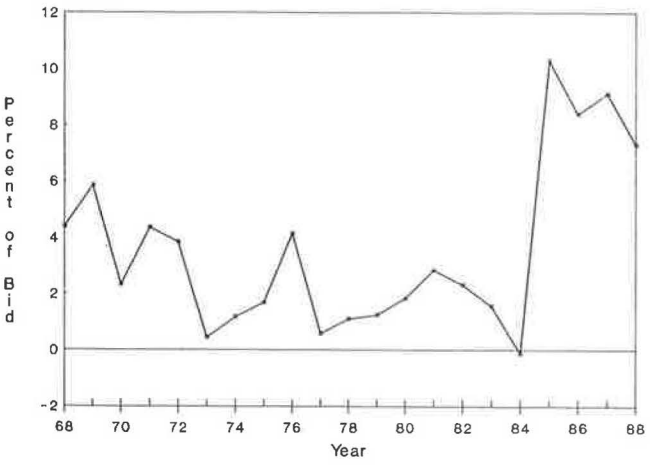

FIGURE 1 Total cost overrun rates, 1968–1988.

PATTERNS AND TRENDS IN PROJECT COST OVERRUNS

In this section, the patterns and trends in project cost overruns are assessed and the relationship between those trends and other management factors is examined. This analysis focuses on nine questions, and the findings are structured accordingly. The questions are as follows:

1. What is the pattern of aggregate project cost overruns over time?
2. What is the pattern of project-level cost overruns over time?
3. Has the amount of construction work performed under contract with UDOT changed over time?
4. Has the average size of a construction project changed over time?
5. Has the number of projects undertaken and completed changed over time?
6. Have UDOT staffing levels and patterns changed over time?
7. What is the relationship between project cost overruns, the number of projects carried out, the value of those projects, and UDOT staffing patterns?
8. What is the relationship between the type of construction project, the type of highway, and project cost overruns?
9. What are the principal causes of claims resulting in project cost increases?

After a brief discussion of the data employed in the analysis, each question is addressed.

The initial data analyzed consisted of quarterly summary reports of projects finalized for the period 1980–1988. The information provided in these reports consisted of project identification number, location, contractor, project engineer, completion date, original estimate, winning bid amount, final cost estimate, and the amount and percentage of overrun or underrun. This information was then summarized by quarter and year. A preliminary analysis was conducted to identify trends and potentially important patterns between contractors, project engineers, districts, and type of project. On the basis of this initial assessment, a sample was drawn from the 817 total projects. This sample included

- All projects with unusually large overruns ($100,000 or larger),
- All projects carried out by contractors with an unusually high percentage of contracts with large overruns,
- All projects supervised by project engineers with an unusually high percentage of projects with large overruns, and
- A 10 percent random sample of the remaining projects.

The final sample size was 106 projects, accounting for 95 percent of all overrun dollars paid between 1980 and 1988.

For the more detailed information required by the sample, UDOT project files and archives were searched and additional information was extracted on start dates, highway type, type of project, claim and adjustment amounts, reason for claims, and so forth. These data were further supplemented with project-specific information taken from the UDOT Comptroller's Construction and Payment Management System.

Some of the information collected for the sample required subjective assessments by the research team. Of particular note here are the reasons for cost adjustments. The list of potential reasons was first generated by engineers on the team and then reviewed by other team members. The data collection instrument, with the revised list of 18 potential reasons for cost adjustments, was then used to collect and categorize information about the projects and claims. In reviewing criteria used to categorize reasons for claims, it was determined that some ambiguities remained. The team reviewed each project again and revised assigned categories as needed. Three additional categories were created.

To summarize, the data used began with the quarterly summary reports provided by UDOT, supplemented by other project-specific UDOT information. In addition to using these data, a sample was drawn, and extensive primary data collection was undertaken for the sample. In combination, these data permitted the research team to address the nine questions identified. The data present a fairly striking picture of cost overruns. To fully understand this picture, each question will be addressed in turn.

Aggregate Project Cost Overruns over Time

Using the summary data provided by UDOT, it was possible to compute total overruns for the period 1968–88. Figure 1 shows the overrun trend for this 21-year period, calculated by taking the difference between the final estimate and the original winning bid amount, expressed as a percentage of the bid amount. Thus, an overrun of 10 percent indicates that the final cost of the project exceeded the winning bid amount by 10 percent.

It will be noted that, as was previously recognized by UDOT, overruns as a percentage of bid amount were relatively stable (between 0 and 6 percent) until 1985. Since 1985, however, overruns have totaled 8 to more than 10 percent of bid amounts. Although the trend line suggests that overruns have been reduced since 1986, the level of overruns as a percentage of

original bid amount remains relatively high compared with earlier years. This suggests that the situation has not returned to "normal," and further investigation is needed. One immediate question is whether these aggregate trends also hold at the individual project level.

Project-Level Cost Overruns over Time

Again using the quarterly summary data, the overrun as a percentage of winning bid for each project was plotted by year. Substantial overruns and underruns on individual projects have occurred with some regularity through the period considered. This is not surprising because any given project may encounter unforeseen problems, or may be expanded or cut back in response to engineering, fiscal, political, or other concerns. Traditionally, UDOT has been comfortable with this wide variance in project overruns as long as the total overruns for a given year did not exceed about 3 to 4 percent of total bid amounts. It is also the case, however, that since 1985, more projects have had overruns in excess of 15 percent than was common earlier. Indeed, the average overrun has increased significantly since 1984. Thus, the pattern of increased overruns observed in the aggregate seems to be present at the individual project level as well.

Amount of Construction Work Performed Under Contract with UDOT

To address the issue of amount of construction work performed, it is necessary to adjust the quarterly summary information for changes in construction costs over time. This adjustment was made using the Federal Highway Administration's published highway construction cost index for the relevant years. The constant dollar (1986 dollars) value of work completed is shown in Figure 2. From 1968 through 1979, the value of work finalized declined sharply from a high of more than $180 million to less than $60 million.

This pattern reversed in 1979 and the value of work performed began to increase again, and by 1987 equaled or exceeded levels observed in the late 1960s. It seems likely that this dramatic fourfold shift in construction activity would tax any organization, but to understand fully the kind of effect such a change had on UDOT, it is necessary to address two related questions regarding the size of projects and the number of projects undertaken.

Average Size of Construction Projects

The final estimate and original bid amounts for each project completed between 1980 and 1988 were converted to constant 1986 dollars using the same Federal Highway Administration highway construction cost index. Figure 3 shows the trend in constant dollar average original bid amount. The figure suggests that although projects completed in 1983 on average were quite a bit larger and those completed in 1985 were somewhat smaller, the average size of projects completed between 1986 and 1988 was not substantially different from the average project size in the early 1980s. Figure 3 also shows a similar trend in the constant dollar average final cost of projects completed. With the exception of 1983 and 1985, the average size of projects appears quite similar. This suggests that with the total value of work increasing during this period but the average size roughly stable, one would expect increases in the number of projects undertaken.

Number of Projects Undertaken and Completed by UDOT

Figure 4 shows a plot of the number of projects completed each year between 1980 and 1988. Note that the count for 1980 is not complete, because one quarter's data were missing. The trend shown is nonetheless quite striking. The number of projects completed each year before 1984 ranged between 60 and 70. In 1984 this number began a steady, marked increase.

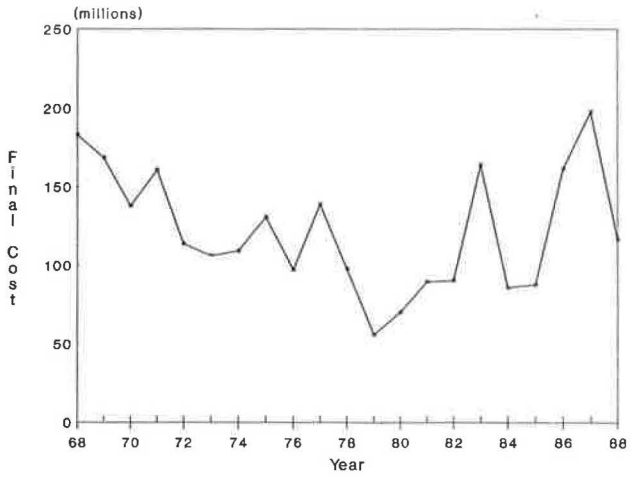

FIGURE 2 Value of work completed, constant 1986 dollars, 1968–1988.

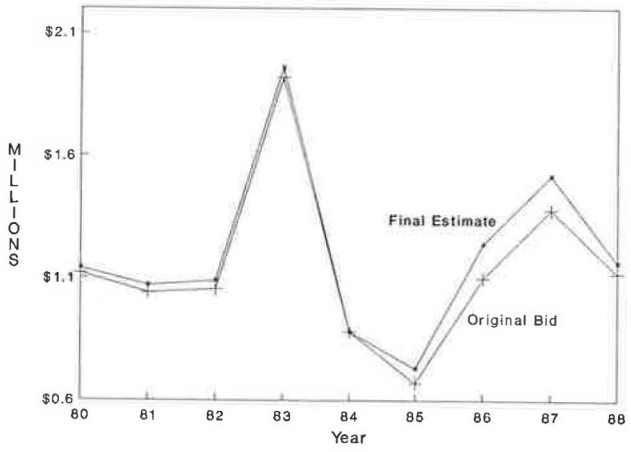

FIGURE 3 Average project original bid and final estimate by year of project completion using constant 1986 dollars.

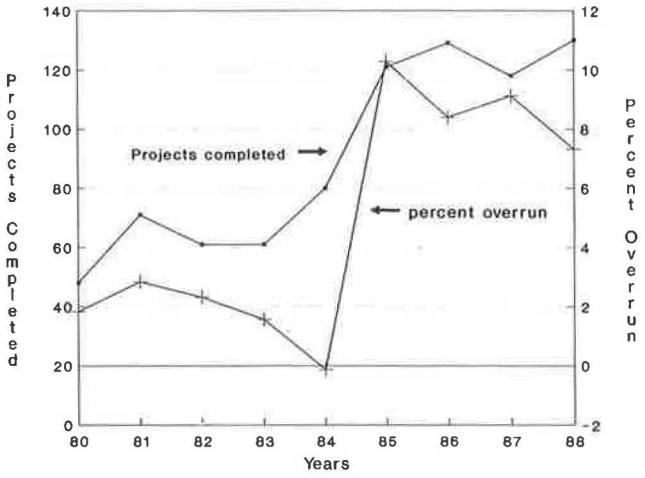

FIGURE 4 Number of projects completed and total cost overrun rate, 1980–1988.

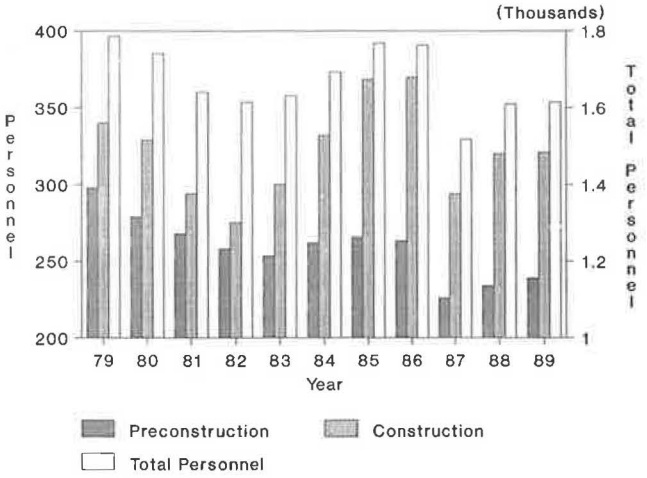

FIGURE 5 UDOT preconstruction, construction, and total personnel by year.

By 1986 the figure had more than doubled. Since 1985 UDOT has completed 120 to 130 projects each year.

Figure 4 also juxtaposes this trend with the pattern of increased overruns. Note that the level of overruns tracks fairly closely with the number of projects completed. This suggests that as the number of projects to be completed has increased, the level of overruns has increased as well. To understand this phenomenon, it is important to consider both UDOT staffing patterns for this period and the nature of the work being done.

UDOT Staffing Levels and Patterns Over Time

Actual full-time equivalent (FTE) personnel counts were obtained as of the end of December for the years 1979 through 1988. In addition, an estimate of the 1989 level was developed. The trends are summarized in Figure 5.

The preconstruction FTE pattern shows consistent reductions in staff from 1979 through 1983, slight increases followed by general stability from 1983 to 1986, then a dramatic drop in staffing levels due largely to the early retirement "window" provided to all state employees in 1987. Since 1987 some effort has been made to rebuild the preconstruction staff, but clearly the new personnel are younger and less experienced than those they replace. This was, after all, the intention of the early retirement program.

The construction division FTE pattern shows a decline through 1982, then a marked buildup in response to increased work loads through 1986. Again, a dramatic drop occurred in 1987 due to early retirements, followed by some rebuilding since then. Total staffing levels also show a similar trend for the same period.

In addition to these overall trends in staffing levels, UDOT experienced some internal realignment of staff. Table 1 shows

TABLE 1 UDOT STAFFING LEVELS AND PATTERNS BY YEAR

	Staffing Levels			Percent		Headquarters Preconstruction
Year	Const	Preconst	Total	Const	Preconst	% of All Preconst
79	340	298	1786	19.0	16.7	73.8
80	329	279	1741	18.9	16.0	72.4
81	294	268	1641	17.9	16.3	70.1
82	275	258	1615	17.0	16.0	70.5
83	300	253.50	1631	18.4	15.5	68.8
84	332	262	1693	19.6	15.5	67.9
85	368	265.75	1768	20.8	15.0	68.0
86	370	263.25	1763	21.0	14.9	68.5
87	294	226	1518	19.4	14.9	68.1
88	320	234	1610	19.9	14.5	65.8
89	321	239	1615	19.9	14.8	66.9

total UDOT staffing levels in preconstruction, construction, and overall. In addition, the table shows preconstruction and construction staff as a percentage of total staff, and the percentage of preconstruction staff in the UDOT central office. It appears from these data that preconstruction staff have declined in both absolute size and size relative to the rest of the department. In addition, a smaller percentage of preconstruction staff is located in the central office now than 10 years ago. Investigations regarding reasons for these reductions and realignments are outside the scope of this study. The interest here is to note the changing patterns and attempt to relate the observed changes to cost overruns.

Relationships Between Cost Overruns, Number of Projects, and Staffing Levels

Relating these data to cost overruns is somewhat difficult. The project data discussed so far are for projects completed in each year. Clearly, the preconstruction staffing levels of interest are those in place when the projects were conceived and designed, not those existing when the projects were completed. Construction personnel are involved in projects during the entire construction phase, which may last for several years. In an effort to understand the relationships between staffing levels, work loads, and cost overruns, the construction initiation year was identified for as many projects as possible. With the help of UDOT personnel, these data were obtained for 499 projects. Based upon the size and type of these projects, the duration and starting years for the remaining projects were estimated.

The projects being considered here were finalized between January 1980 and March 1989. Projects completed in 1980 include projects begun and finished during 1980, and larger projects begun in earlier years but finalized in 1980.

Thus, for the years before 1980, virtually all projects considered were fairly large. For example, our data include 12 projects begun in 1978. Clearly other projects started in 1978, but they had been completed before 1980. Likewise, at the end of the period considered, only smaller projects appear in the data. Large multiyear projects started in 1987 and 1988 are still in progress and not included.

Despite the inherent limitations created by this censoring, several insights are obtained by relating staffing levels to these data. Figure 6 shows a plot of the number of projects and aggregate overrun rates by year of construction initiation. Focusing on the years 1980 through 1985, the association between number of projects started and the eventual overruns on those projects appears quite strong. The lines in Figure 6 are dotted after 1985 to reflect the substantial censoring in these years, because large projects initiated during this period were not yet completed by the end of 1988. Overall, the correlation between project cost overruns and the number of preconstruction engineers working for UDOT in the year prior to construction initiation was $-.62$. Thus, the pattern suggests that cost overruns tend to increase as the size of the design staff decreases.

It should be noted that because of the delay between the design phase and actual project completion, the full effects of the early retirement may not yet have been felt in terms of project cost overruns. Many of the projects designed since

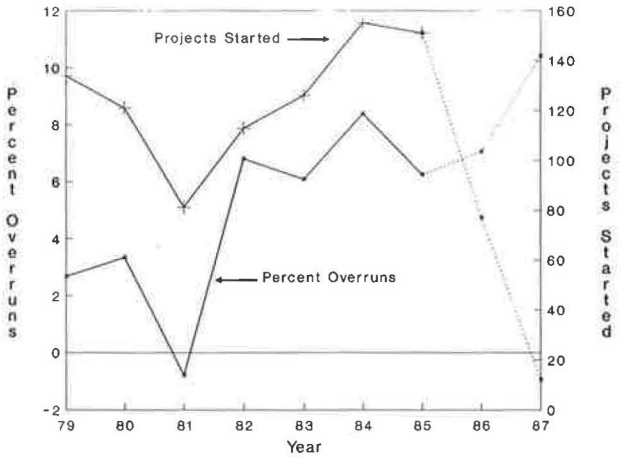

FIGURE 6 Number of projects and total cost overrun rate by year of construction initiation. See text for explanation of dotted lines.

1987 are just now being completed. If the above pattern holds, higher project overruns can be expected.

Relationship Between Type of Construction Project, Type of Highway, and Project Cost Overruns

Table 2 is computed from data on project authorizations from 1979 through 1988, and shows the percentage of project authorizations by type of project each year. Thus, in the top row of Table 2, Interstate projects (Type I) accounted for 19.9 percent of all authorizations in 1979. By 1988 this figure had fallen to 8.8 percent (second to the last column). Overall, Interstate projects accounted for 14.5 percent of all authorizations between 1979 and 1988 (last column of the table). Several trends in Table 2 are worth noting. First, as mentioned above, the emphasis on building the Interstate system has declined as that system has neared completion. While Interstate projects accounted for 19 to 20 percent of authorizations in the 1979–1981 period, the level fell to 9 to 10 percent in the last three years.

At the same time, Interstate rehabilitation projects (Type IR) have increased sharply. These projects accounted for less than 3 percent of all authorizations prior to 1981. In 1984, Interstate rehabilitation projects were increased to 15.5 percent of all authorizations. By 1987, the figure had grown to roughly one-fourth of all authorizations. This timing coincides with the increases in cost overruns, given that projects first authorized in one year will likely be finalized in subsequent years.

Other trends worth noting include the decline in state-funded Interstate projects (Type NI). In recent years, such projects have virtually disappeared. Note also the increase in emergency projects (Type ER) from 1983 to 1987. This may reflect the creation of a new category, or, as seems more likely, it may result from repairing flood damage from extensive flooding that occurred in 1983.

In an effort to ascertain the effect of this changed project environment, in which Interstate construction is being replaced by Interstate rehabilitation, the sample of 105 projects was

TABLE 2 AUTHORIZATIONS BY TYPE OF PROJECT

Type of Project	Percent of All Authorizations										
	79	80	81	82	83	84	85	86	87	88	Total
I	19.9	19.2	19.0	10.0	21.3	8.2	13.5	9.0	11.3	8.8	14.5
NF	12.9	1.4	3.4	15.0	18.1	14.5	13.5	12.4	4.8	17.5	12.0
IR	1.8	2.7	6.9	10.0	9.6	15.5	18.3	12.4	22.6	29.8	11.6
R	8.8	9.6	1.7	8.8	9.6	11.8	8.7	7.9	8.1	8.8	8.7
F	7.0	9.6	6.9	3.8	4.3	8.2	3.8	7.9	6.5	1.8	6.1
M	5.8	8.2	3.4	6.3	3.2	2.7	4.8	9.0	12.9	8.8	6.1
NM	9.4	0	5.2	6.3	6.4	7.3	3.8	3.4	4.8	5.3	5.7
BROS	0.6	4.1	15.5	7.5	6.4	5.5	3.8	4.5	4.8	0	4.7
S	5.8	11.0	6.9	2.5	4.3	5.5	1.0	0	6.5	3.5	4.6
NI	7.0	9.6	6.9	6.3	4.3	1.8	1.9	2.2	1.6	0	4.3
NS	2.3	0	0	2.5	1.1	2.7	4.8	9.0	1.6	3.5	2.9
ER	0	0	0	0	2.1	3.6	9.6	4.5	3.2	0	2.5
HES	1.8	2.7	5.2	3.8	1.1	1.8	2.9	2.2	0	1.8	2.2
OTHER	17.0	21.9	19.0	17.5	8.5	10.9	9.6	15.7	11.3	10.5	14.1
Total	100	100	100	100	100	100	100	100	100	100	100

Key:

Project	Designation Description
I	Interstate 1956 and subsequent act construction
NF	State funded highway project on Federal-aid Primary System
IR	Interstate (4R)
RS & RRS	Rural Secondary & Railroad Crossing
F	Federal-aid Primary project
M	Urban system attributable
NM	Non Participating Urban System
BROS	Bridge replacement off system
S	Federal-aid Secondary, Construction
NI	State funded highway project on Interstate System
NS	State funded project on Federal-aid Secondary System
ER	Emergency Repair
HES	Hazard elimination

used to determine reasons for cost adjustments by type of project. Table 3 summarizes these findings. In the table, all projects sampled have been grouped into either Interstate rehabilitation or "all other." The table shows the percentage of projects sampled that had cost adjustments for each of our predetermined reasons. Using a Chi-square test, field design changes were found to be significantly more common in Interstate rehabilitation projects than in other types of projects.

Table 4 shows the average number and size of contract adjustments per year for the sample projects. The most striking finding in the table is that the average contract adjustments for contracts initiated between 1982 and 1984 were substantially higher than for other years.

If the combination of more field design changes, greater difficulty with traffic control, and problems with obtaining appropriate construction materials are combined, the vision that emerges is that Interstate rehabilitation projects appear to present UDOT with design difficulties not found in other types of projects. The final question to be addressed here then is whether such reasons are related to project overruns.

Principal Causes of Claims Resulting in Project Cost Increases

To address this question, the sample of projects was divided into two groups: those with overruns greater than or equal to 10 percent of the original bid amount and all other projects. Because of the nature of our sample, a high percentage of the projects fell into the "10 percent or more" group. The percentage of projects sampled that had cost adjustments for each of our predetermined reasons was computed for each group. The findings are summarized in Table 5.

Reasons found to be significantly different (Chi-square test, $p > .05$) in the two project groups are underlined in the table. With the exception of subsoil problems, all the significant differences correspond to problems found to occur more frequently in Interstate rehabilitation projects. This suggests that the design difficulties associated with rehabilitating the Interstate system are directly related to high project cost overruns.

Our findings suggest that significant changes have occurred in the highway construction and management environment in

TABLE 3 REASON FOR ADJUSTMENT BY TYPE OF PROJECT

Reason for Adjustment	Percent of Projects by Project Type IR	All Other
1. Quantity estimate error	30.8	36.7
2. Technical design error	65.4	63.3
3. Time estimate error	15.4	12.0
4. Unclear specification	11.5	11.4
5. Archaeological	0.0	1.3
6. Environmental problems	0.0	6.3
7. Field design change	92.3	72.2
8. Groundwater	11.5	25.3
9. Labor violation/dispute	3.9	6.3
10. Subsoil	11.5	19.0
11. Traffic control problem	34.6	27.9
12. Traffic damage	3.9	3.8
13. Weather	26.9	17.7
14. Construction materials	11.5	6.3
15. Utility relocation	3.8	12.7
16. Zoning change approval	0.0	0.0
17. Other	9.2	11.4
18. Other	3.8	3.8
19. Traffic safety improvements	3.9	13.9
20. Design concept change	0.0	1.3
21. Surface water	0.0	3.8
Total N	26	79

TABLE 4 AVERAGE SIZE AND NUMBER OF ADJUSTMENTS PER PROJECT BY YEAR

Project Start Year	Average Number Adjusts.	Average Amount Adjust.	Total Number of Adjusts.	Total Amt Adjusts.
80	12.0	298,207	12	298,207
81	11.5	-13,059	46	-52,237
82	9.4	311,344	94	3,113,437
83	13.9	323,732	111	2,589,859
84	9.5	371,050	218	8,534,139
85	7.6	138,414	189	3,460,342
86	7.5	188,070	82	2,068,768
87	3.9	42,480	55	594,715
88	2.0	22,879	4	45,758

the past 10 years. As the Interstate system has neared completion and as the Interstate has aged, emphasis has shifted to rehabilitation projects. These projects appear to present a somewhat different set of design and construction issues. Coupled with this shift has been a substantial increase in the number of projects undertaken by UDOT and a marked reduction in preconstruction staff. The result seems to be that fewer people are being required to do more and different design work than previously. Not surprisingly, the result is an increase in the number of field design changes and resulting project cost overruns.

This analysis has been based upon an examination of historical data stretching back as much as 20 years and has focused on general patterns and trends. While this effort has proven very fruitful in understanding the nature and sources of past cost overruns, it is also important to consider the current environment and conditions affecting construction, design, and management. The following sections detail the research efforts and findings regarding current conditions and perceptions in UDOT and in various organizations with which UDOT interacts in the construction process.

PERSPECTIVES OF UDOT PERSONNEL AND OTHER INVOLVED PARTIES

A series of interviews was held with 17 UDOT personnel, including preconstruction and construction engineers on both the state central office and district office level. Interviews were also held with representatives of eight construction companies, representatives from the Attorney General's Office, and attorneys representing the contracting community. The central theme of these interviews was to discover reasons for cost overruns on construction projects.

Eight Utah highway construction contractors who do substantial UDOT contract work were interviewed. They were selected with the aid of the Utah Association of General Contractors, who helped arrange interviews based on two criteria. First, the goal was to talk with enough contractors to get a fair idea of the views of various small, medium, and large contractors in Utah. Second, all contractors not in the first group who wanted a chance to have input to the study were given an opportunity to meet. Meetings with high level representatives of the eight contractors lasted for approximately one hour each.

Principals in two Utah law firms experienced in handling litigation of construction claims against UDOT were recommended by UDOT as respected opponents in the claims litigation process and interviewed. Both attorneys were cooperative, aided in the attempt to understand reasons for cost increases in highway construction contracts, and were willing to suggest ways to reduce or eliminate them. They were particularly able at asking questions that helped identify variables to test in the empirical analysis of cases, such as, the effect of rushing jobs, the relationship between the dollar volume of work let and the incidence of underbidding, and changes in the profile and operating procedures of project engineers, effect of size of contracts, etc.

These interviews were done independently of the collection and analysis of data from the records of construction projects

TABLE 5 REASON FOR ADJUSTMENT BY SIZE OF OVERRUN

Reason for Adjustment		Percent of Projects by Size of Overrun	
		Less than 10%	10% or more
1.	Quantity estimate error	35.0	35.4
2.	Technical design error	57.5	67.7
3.	Time estimate error	10.0	15.4
4.	Unclear specification	15.0	9.2
5.	Archaeological	2.5	0.0
6.	Environmental	0.0	7.7
7.	Field design change	62.5	86.2 *
8.	Groundwater	15.0	26.2
9.	Labor violation/dispute	7.5	4.6
10.	Subsoil	5.0	24.6 *
11.	Traffic control problem	20.0	35.4 *
12.	Traffic damage	5.0	3.1
13.	Weather	10.0	26.2 *
14.	Construction materials	7.5	7.7
15.	Utility relocation	15.0	4.8
16.	Zoning change approval	0.0	0.0
17.	Other	10.0	15.4
18.	Other	5.0	3.1
19.	Traffic safety improvements	7.5	13.9
20.	Design concept change	0.0	1.5
21.	Surface water	0.0	4.6
TOTAL N		40	65

* difference is statistically significant at .05 level

described previously. To ensure as much independence and objectivity as possible, these two simultaneous research activities were conducted by different members of the research team. The focus in the data analysis reported in the previous section was to let analysis of the record lead researchers to appropriate observations and conclusions. The intention of the interviews was to gain the perception of the various parties involved in the process about factors contributing to the changed overrun picture. Results of the interviews showed considerable agreement with those conclusions reached through analysis of the project data as summarized above.

It should be noted, however, that the data analyzed reflect what was happening largely in the 1980–1988 period. The information gleaned from the interviews reflects attitudes and feelings of the persons involved at the time of the interview (1989) and their reflections on what was happening in prior years. The two are not necessarily the same, and this fact should be kept in mind as the results of the data analysis and the interview process are compared.

The groups interviewed agreed that the contractors were bidding more tightly because of increasing competition in the industry and the Utah economy. UDOT employees said companies were bidding too low and this caused them to seek additional profits through supplemental agreements or claims. Contractors believed that the low bids prohibited them from accommodating the state by performing additional work or changes for little or no additional cost, and stated that the past practice was to try to help the state by doing the work for minimal increased costs. This was no longer feasible because of low profit margins in the bids submitted.

A second point of agreement between these groups was that a major cause of cost overruns is due to design problems and the inability of project engineers to make timely corrections. They agreed that a need for design changes has always existed and indeed may be a normal part of the industry. However, from the viewpoint of those interviewed, problems in design and specifications on highway projects in Utah seem to have increased in recent years.

The design and specification problems are exacerbated by an increasing inability on the part of UDOT project engineers to take corrective action in a timely way. All groups stated that it is easier and less expensive to make corrections as quickly as possible and on the lowest organizational level possible. Contractors said that doing this is increasingly a problem and the length of time needed to make corrections and "get on with the work" has increased. Contractors also stated that this has led to larger overruns and created a great deal of "ill will."

An important observation made by all UDOT personnel interviewed is that an increasing work load has not been compensated for by an increased staffing level. This is illustrated in Figure 5.

Many of the observations made by UDOT staff illustrated the impact of the staffing/work load problem discussed above. UDOT preconstruction engineers are under pressure to increase productivity by producing a greater number of plans and specifications during a shorter time because of an increasing work load, in general, and opportunities on occasion to receive additional federal funding. This spurs the department to get projects into the field quickly so that funds will not be lost.

According to those interviewed, many of the problems that result in cost overruns arise from design errors and omissions, inadequate materials investigations, and inadequate standard specifications and special provisions. Interviews with contractors corroborated this view. Many supplemental agreements and claims deal with problems or inadequacies in these areas.

Partially in response to the early retirement offered to state employees, the state has begun to use consultants to compensate for declining staff levels and promote privatization. Two potential problems were noted with respect to consultant performance: the learning curve and their lack of ownership in the project.

It takes time for any new employee to become acquainted with and understand UDOT procedures as well as the technical aspects of the job. Consultants are no exception, and in fact may face greater problems because of the temporary nature of many of their assignments. Illustrations were given both of consultants being transferred to other jobs in midstream and of consultants undertaking only one project for the state. For most engineering firms in the state, doing UDOT design and construction work represents a new activity.

In preconstruction, consultants lack a sense of ownership in the project. Once the design is completed, generally few provisions are made for further involvement of the design engineers; they have no further responsibilities and any problems must be resolved by UDOT staff. Attempts have been made to address both these issues in consultant contracts; however, the provisions have not completely solved the problem.

Another effect of increasing work load has been to bypass the preconstruction review process, or at least to give inadequate attention to the review process. Many interviewees stated that the project engineer to be assigned to the project should be present at the plan-in-hand review, or even while the project is being "scoped." In addition, many instances were cited in which some steps in the review process were overlooked. UDOT is currently implementing a new "scoping" procedure that, if followed, should resolve this issue.

Another problem related to problems of design, as observed by UDOT personnel, has been a lack of construction experience on the part of design engineers. Many believed that a design engineer should have three to six years experience in construction before beginning work in design. There was general agreement that this would improve the quality of plans being produced. Conversely, few project engineers have any preconstruction design experience, and thus have little appreciation for the difficulties involved in producing complete, error-free designs and specifications.

There is also an attitude held by both UDOT personnel and contractors that the reduction in personnel and increasing work load, in conjunction with early retirement, has led to a decreased experience level of construction project engineers. This in turn has led to a reduced ability to make independent decisions in the field. Having decisions and actions made at the lowest level is the best policy from both the state's and contractor's viewpoint. Project engineers who lack experience tend to elevate decisions to the district or the headquarters level. This lengthens decision-making time, which in many cases increases the amount of the individual cost overrun and certainly contributes to the frustration level of contractors.

Most state employees interviewed stated that the use of consultants for inspection required greater supervision on the part of UDOT to ensure the maintenance of state standards. The use of consultants presents some problems in that UDOT supervisory requirements are higher. This seems to be less of a problem when consultants are used in materials investigations rather than design or construction.

The natural processes of wear and aging are creating an increasing need to do rehabilitation to the Interstate system. Many of those interviewed said that rehabilitation projects involving the Interstate system created many new problems of design, traffic control, and technology. UDOT is thus involved in unfamiliar activities involving a developing technology. These projects are difficult to design and carry through to construction. In addition, rehabilitation projects have had delay and design problems caused by utility concerns, railroad rights-of-way, and the problems of traffic using the Interstate while rehabilitation projects are underway. Traffic control is a particularly difficult problem on these projects because rehabilitation work must be done in the face of heavy traffic. UDOT has had little experience with this kind of traffic control and has difficulty with the traffic control portions of the specifications.

SUMMARY OF FINDINGS AND RECOMMENDATIONS

The quantity and complexity of work performed by UDOT personnel have increased over the past 10 years. The changing complexity includes regulations, new technology, and different types of design and construction problems encountered. UDOT has experienced a fundamental change in the nature of work carried out as construction has been replaced by reconstruction and rehabilitation, both of which were found to be more subject to cost overruns than were other types of projects.

Staffing levels have at the same time declined, especially in preconstruction. The data suggest that staffing levels have a direct effect on later cost overruns. This relationship is further complicated by the increased work load and complexity mentioned. The staffing problem led to bypassing quality assurance reviews in the preconstruction phase which, in turn, were correlated with field design changes during construction.

The declining staffing and experience level led to a centralization of decision making during the construction phase. This created delays in resolving design changes and subsequently to increased claims by construction firms. It also contributed to a deteriorating relationship between contractors and UDOT.

The increasingly competitive economic environment in the construction industry has resulted in tighter bidding and a decreased willingness on the part of contractors to "cooperate" with UDOT. Very low profit margins led to pressures to protect or enhance profits through change requests or claims. The interaction of these factors contributed significantly to the pattern of increased cost overruns.

UDOT should adhere to the preconstruction review process in place and sufficient preconstruction staff should be available to make certain that procedures are followed. UDOT should provide training, strengthen the project engineers, and decentralize the decision-making process, so that design changes can be made in a timely manner. The claims process should be improved to be less costly for both UDOT and construction firms in terms of time, energy, and money. Finally, an organizational development effort should be undertaken to improve communication and decrease the sense of division between various units.

The cost overrun problems experienced by UDOT in the recent past are not atypical. Many state departments of transportation face aging Interstate systems, retiring staff, changing technologies, external pressures to privatize significant portions of their activities, and increased competition among contractors. While a number of issues raised in this study bear further exploration, the findings and recommendations are likely relevant for many states.

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