A SYSTEM FOR FORECASTING AND MONITORING CASH FLOW
Phase I: Forecasting Payments on Construction Contracts

by

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(The opinions, findings, and conclusions expressed in this report are those of the authors and not necessarily those of the sponsoring agencies.)

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SUMMARY

The research on which this paper is based was performed as part of a study to develop a system for generating a one-to-two year forecast of monthly cash flows for the Virginia Department of Highways and Transportation. It revealed that presently used cash flow forecasting methods consistently underestimate ending cash balances. In addition, it showed that the behavior of individual contracts varies widely, with the percent paid out halfway to completion ranging from zero to 93%. Furthermore, contractors' schedules, upon which current forecasts are based, are not reliable indicators of the contracts' duration, payout patterns, or final cost, and by the end of the scheduled duration (contractual time limit not allowing for shutdowns) contracts are typically less than 70% complete. Cost overruns average 7.8% of the contract amount and seasonality is a critical determinant of construction payout as is exhibited by the fact that the proportion of payouts as a percentage of annual payout can be six times as high in September as in January. A simple technique which emphasizes the effects of seasonality on payout and realistic estimates of contract duration explained more than 93% of the variation in a retrospective test on the sample data base. The accuracy of the forecasting method in actual use will depend on the variability of the weather and on the prompt entry of information on contracts let and scheduled advertisement dates into the forecasting data base.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the assistance of the following individuals who lent their time and expertise to this study. We would like to thank Director of Finance Harold Worrall for requesting the study and providing general direction, and Russell Sauvager of the Budget Division, who acted as invaluable liaison with the Division and the rest of the Department throughout the study. K. C. Tingler of the Construction Division and Wilma Treadwell of the Fiscal Division assisted us in the collection of data. We are also grateful to Mike Gale of the Florida Department of Transportation and to Richard Kane of the New York Department of Transportation for taking the time to explain their forecasting methods to us.

We are especially appreciative of the contribution to the study made by Jennifer Ward of the Research Council, who performed all of the computerized data analysis and wrote the testing programs. We would also like to thank Miles Thornton for preparing the charts and graphs, and Susan Kane and Jan Kennedy, who did a superb job of typing the draft of this report.

FINDINGS

1. Presently used cash flow forecasting techniques consistently underestimated ending cash balances by as much as 55% between April 1982 and March 1983.

2. Based on a sample of 162 completed contracts, contracts of $2,500,000 or more account for 50% of the dollar volume of construction, while contracts of less than $500,000 account for about 13%.

3. The behavior of individual construction contracts varies widely. For example, the percentage paid out at the halfway point between the contract date and the completion date ranges from zero to 93%. Therefore, it is not feasible to duplicate or predict the payout patterns of individual contracts.

4. Contractors' schedules do not appear to be reliable indicators of the contracts' duration, payout patterns, or final cost.

5. Contracts tend to fall farther behind schedule as they progress; by the end of the scheduled duration (the contractual time limit not allowing for shutdowns), they are typically less than 70% complete.

6. On the average, contracts require 82% (14.5 months) more elapsed time than the scheduled duration.

7. Cost overruns range from 2.7% to 11.6% of the contract amount, with a weighted average of 7.8%. Work orders account for only 28% of all cost overruns.

8. Seasonality is a critical determinant of construction payout, which can be six times as high in September as in January.

9. Between April 1982 and March 1983, the existing forecasting techniques tended to underestimate construction contract payout, especially during the summer and autumn construction peak.

CONCLUSIONS

1. Based on an examination of the assumptions made and the forecasting results obtained, the existing techniques for forecasting construction contract payout could be improved.

2. As compared to the presently used method, it appears that aggregate construction payout can be predicted more accurately by a simple technique that emphasizes realistic estimates of contract duration and the effects of seasonality on payout.

3. Improved forecasting is possible only if accurate information on contracts let and scheduled advertisement dates is entered into the data base in a timely manner.

RECOMMENDATIONS

1. The simplified version of the monthly factors forecasting method should be implemented on the Budget Division's IBM personal computer. The forecasts obtained from it should be evaluated for several months by comparing them to the forecasts obtained from the existing methods and to actual payout data.

2. An electronic data transfer from the central computer to the IBM personal computer should be instituted, if possible, either by direct link or via a storage medium such as floppy disk.

3. The sample data base should be expanded periodically by adding projects which have been completed. The expanded data base should be reanalyzed to update the forecasting technique, if necessary.

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INTRODUCTION

Methods for forecasting and managing cash flow are well-established in the private sector, where inadequate cash balances can mean bankruptcy and excessive balances can result in foregone business opportunities. In the public sector, until fairly recently there was less perceived need for close forecasting and monitoring of cash flow. Revenues for highway and transportation departments were quite predictable — in the main they could be depended upon to rise steadily. This and the fact that construction cost increases were moderate made the planning of a maintenance and construction program free of cash shortfalls rather straightforward.

During the past several years revenues for most such departments have become volatile and unpredictable, and construction expenditures have been subject to unprecedented rates of inflation. During such periods a public works agency such as the Department of Highways and Transportation runs a serious risk of encountering an inadequate cash balance in carrying out its construction and maintenance program. This risk can be minimized by (a) maintaining large cash balances which divert funds from current needs, or (b) developing and using reliable management tools for short-term forecasting and monitoring of cash inflows and outflows.

Over the last several years highway and transportation departments in several states have developed such management tools. Cash flow forecasting is practiced in a systematic way in Florida, Pennsylvania, New York, California, Utah, Arkansas, and Alabama. The Virginia Department of Highways and Transportation does not yet have forecasting techniques in use which are reliable enough for the management of the financial affairs directorate.

The shortcomings of the present forecasting techniques are illustrated by the comparisons made in Table 1 between the cash flows that were forecast at the beginning of April 1982 and the cash flows that actually occurred. The table shows that the forecast consistently underestimated the ending cash balances by as much as 55%. This resulted from underestimates of revenues, overestimates of outlays, or both.

Table 1

Forecasted and Actual VDH&T Cash Flows, April 1982-October 1982
(In Millions of Dollars)

	Apr. '82		June '82		Aug. '82		Oct. '82	
	Apr. '82 Forecast	Actual	Apr. '82 Forecast	Actual	Apr. '82 Forecast	Actual	Apr. '82 Forecast	Actual
Beginning Cash Balance	49.4	49.4	43.2	55.9	15.6	49.6	21.3	33.7
Income								
State Revenue	42.2	40.1	56.3	62.4	52.2	46.2	54.6	52.9
Federal Aid	12.3	18.0	16.5	15.1	21.6	9.5	25.4	22.5
Other	1.2	1.6	1.2	2.0	1.2	1.2	1.2	2.5
Total Income	55.7	59.7	74.0	79.5	75.0	56.9	79.3	77.9
Outlays								
Counties, Other Agencies, Transit, City Streets	20.9	21.4	7.0	5.9	9.0	9.0	25.1	22.7
Salaries, Wages, Fringes	15.3	14.6	15.2	14.9	15.9	16.0	15.9	15.6
Materials & Equipment	10.0	6.7	10.0	8.7	10.0	1.7	13.0	1.0
Right-of-Way	2.5	3.1	3.0	3.8	3.4	3.5	3.4	4.5
Maintenance Contracts	0.2	0.2	11.7	6.9	15.8	10.0	12.2	8.6
Construction Contracts	13.8	8.3	19.5	22.3	19.9	29.4	19.2	28.6
General Fund Loan	3.0	3.0	3.0	3.0	--	--	--	--
Total Outlays	65.7	57.8	69.4	65.5	74.0	69.6	88.8	81.0
Ending Cash Balance	39.4	51.8	47.8	69.9	16.6	36.9	13.7	30.6

The forecast for April 1982 is an example of both. Since April is the first month of the forecast, the beginning cash balance reflects the actual ending balance from the preceding month and did not have to be estimated. On the income side, state revenues were slightly overestimated, but federal-aid revenues were substantially underestimated, for a total revenue underestimate of $4.0 million. Outlays, on the other hand, were overestimated by $8.4 million of spending on construction contracts and materials and equipment. The ending cash balance was underestimated by $12.4 million.

The forecast for August 1982 illustrates the effect of offsetting errors. To begin with, the beginning cash balance was underestimated by $34.0 million, an error carried over from the previous month. Outlays were overestimated by $4.4 million, but this obscures the fact that construction contracts were substantially underestimated while maintenance contracts and materials and equipment were overestimated. Finally, revenues, particularly federal aid, were overestimated by $18.1 million. The result of these over- and underestimates is an ending cash balance that was underestimated by $20.3 million, a 55% error.

The interesting question, which cannot be answered with these data, is whether these over- and underestimates are forecasting errors per se, or whether they reflect deliberate actions taken by the Department during the course of a month to ward off potential shortfalls or take advantage of potentially large cash balances.

In any case, in part due to the unreliability of the forecasts, the potential for cash flow to play an integral role in setting the advertising schedule was not realized. Achieving this potential requires the ability to forecast reliably at least twelve months ahead. This would allow the use of forecasted cash flows to suggest changes in the advertising schedule well in advance of the advertising date.

Under the present circumstances, however, frustrating delays in the work program and last minute changes in ad dates can occur when cash inflows are inadequate to pay for ongoing as well as scheduled projects, as happened during the latter half of 1980. Alternatively, unnecessary delays and missed opportunities can occur when cash balances turn out to be larger than needed, as was the case during much of 1982.

STUDY PURPOSE AND SCOPE

The overall objective of the study is to develop, in cooperation with the Budget Division, a system for forecasting and monitoring cash flow over the short run. The eventual scope of the study will encompass forecasting techniques for generating one-to-two-year monthly forecasts of Highway Construction and Maintenance Fund Revenues, federal-aid reimbursements, wages and salaries, materials and equipment outlays, payments on maintenance contracts, and payments on current and proposed construction contracts.

The system will ultimately utilize data on fuel and franchise tax revenues, license and registration fee receipts, outstanding federal-aid reimbursements, outlays for wages and salaries and materials and equipment, and payments on maintenance contracts and current and proposed construction contracts.

This Phase I report describes the development of forecasting techniques for payments on current and proposed construction contracts. The report also identifies the information flows within the Department which the Budget Division analysts will need in order to prepare accurate monthly forecasts. Finally, the report discusses the steps which the Budget Division must take to implement the forecasting techniques.

INFORMATION GATHERING

Cash Flow Forecasting in Other State Highway Departments

Several states – including Alabama, Arkansas, Pennsylvania, New York, Florida, Iowa, California, Utah, and Idaho – have or are developing systematic cash forecasting methods. For this study, the project team reviewed in detail the methods that have been developed in Pennsylvania, New York, and Florida, and concluded that the forecasting techniques developed in New York were most applicable to conditions in Virginia. These techniques are described in the section on the monthly factors model below.

In addition to gaining a knowledge of the specific forecasting techniques, the project team gained two significant insights from the review of the systems in these states. The first is that accurate forecasting techniques, while vital to success, are not sufficient to generate good forecasts, if the information systems within the department do not provide a steady flow of up-to-date, accurate, and easily accessible information for the forecasts. The second insight is that an accurate cash forecasting system can be a useful management tool only if the forecasting function is closely integrated with the programming function, so that programming changes are promptly reflected in the forecasts and forecasted cash flow surpluses or shortfalls can be properly taken into account in programming decisions.

Data Collection

Constraints

In order to analyze construction payout patterns it was necessary to examine the complete monthly payment history of each contract in the data base, from the first to the final payment. The Fiscal Division, which maintains the records of contract payments, began keeping monthly records of payments to contractors in July 1979. This limited the data collection effort to contracts which began after July 1, 1979, and were completed by August 1982.

Sources and Procedures

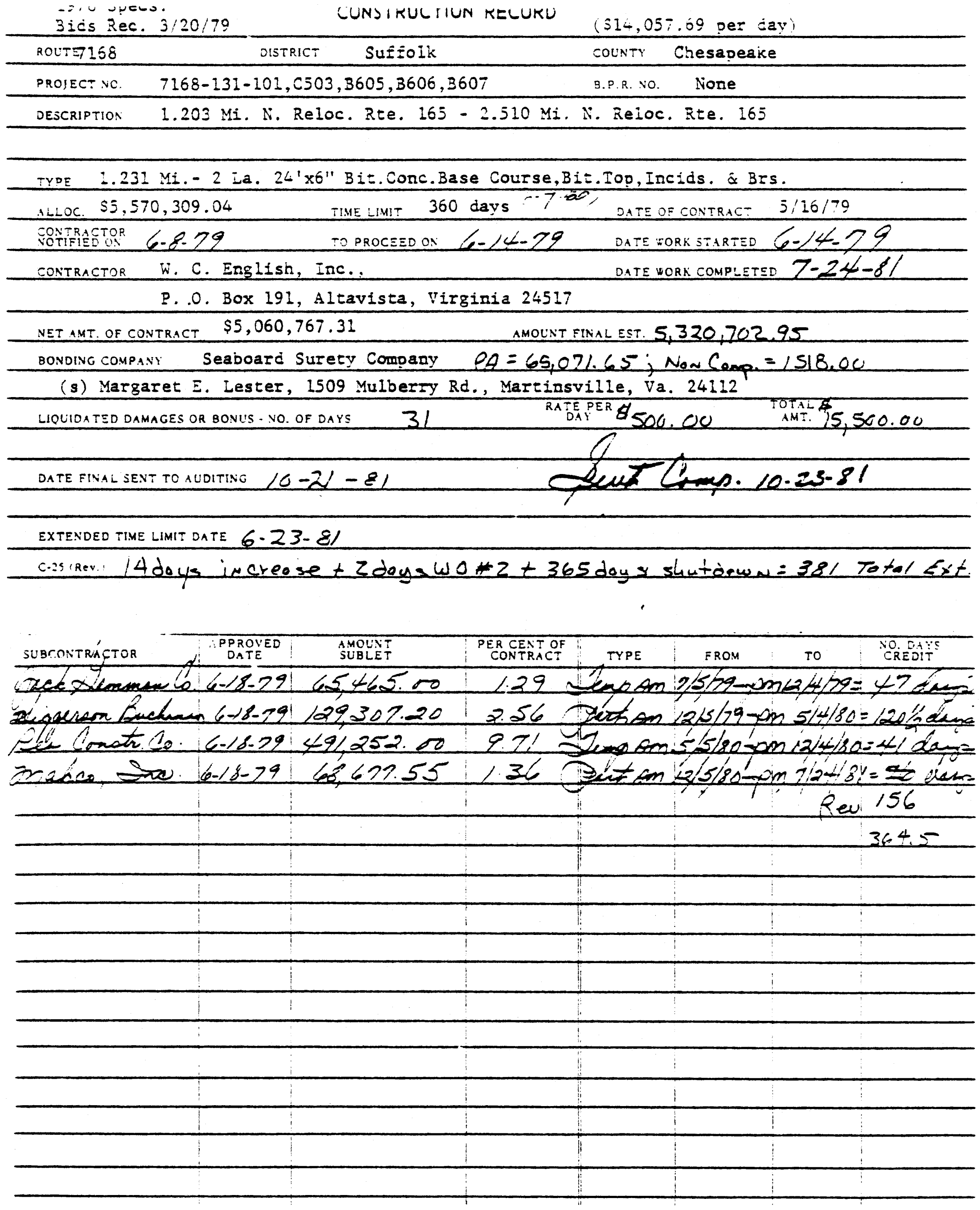
The data on each contract were collected from the Fiscal Division and the Construction Division. The card file maintained by the Construction Division provided the data on the date of the contract, the time limit, the date work was completed, the district, the road system and project type, the net contract amount, and the amount of the final estimate. A sample of a Construction Division card record is reproduced as Figure 1. The Fiscal Division records supplied the data on the contractor's progress schedule estimate, the actual monthly cash payments, work orders, and supplemental final payments. Figures 2 and 3 are an example of the Fiscal Division card records. The data were collected on coding sheets such as the one shown in Figures 4 and 5.

Profile of Sample and Preliminary Analysis

Data were collected on 173 contracts. The payment data were plotted by computer against elapsed time for each contract. By comparing these plots visually, it was possible to identify contracts, such as the one shown in Figure 6, which exhibited unusual payout patterns. These atypical contracts are called outliers. They were considered to be so unrepresentative of normal contracts that they were excluded from the sample.

After exclusion of the outliers the sample consisted of 162 contracts. These contracts represent 19.5% of the total construction activity during FY80, 27.4% for FY81, and 9% for FY82. The distribution of contracts by contract amount and duration in Table 2 shows that half of the sample were contracts of $500,000 or less and 12 months or less in duration, while 9.0% – 14 contracts – were greater than $2,500,000 and longer than 1 year. Contracts from $500,000 to $2,500,000 and from 1 to 2 years made up 23.0% of the sample – 37 contracts. This mix of large and small, short and long contracts is representative of the total work program.

The distribution of the dollar volume of construction activity by size of contract is shown in Table 3. The 14 largest contracts accounted for over 50% of the dollar volume of construction activity for the sample, while the 92 smallest contracts made up about 13%. The average contract duration, from contract date to completion, weighted by the dollar volumes was 18.4 months.



[illegible]70 Specs.
Bids Rec. 3/20/79

CONSTRUCTION RECORD

($14,057.69 per day)

ROUTE 7168 DISTRICT Suffolk COUNTY Chesapeake

PROJECT NO. 7168-131-101,C503,B605,B606,B607 B.P.R. NO. None

DESCRIPTION 1.203 Mi. N. Reloc. Rte. 165 - 2.510 Mi. N. Reloc. Rte. 165

TYPE 1.231 Mi.- 2 La. 24'x6" Bit.Conc.Base Course,Bit.Top,Incids. & Brs.

ALLOC. $5,570,309.04 TIME LIMIT 360 days 7-7-80 DATE OF CONTRACT 5/16/79

CONTRACTOR NOTIFIED ON 6-8-79 TO PROCEED ON 6-14-79 DATE WORK STARTED 6-14-79

CONTRACTOR W. C. English, Inc., DATE WORK COMPLETED 7-24-81

P. .O. Box 191, Altavista, Virginia 24517

NET AMT. OF CONTRACT $5,060,767.31 AMOUNT FINAL EST. 5,320,702.95

BONDING COMPANY Seaboard Surety Company PA = 65,071.65 ; Non Comp. = 1518.00

(s) Margaret E. Lester, 1509 Mulberry Rd., Martinsville, Va. 24112

LIQUIDATED DAMAGES OR BONUS - NO. OF DAYS 31 RATE PER DAY $500.00 TOTAL AMT. $15,500.00

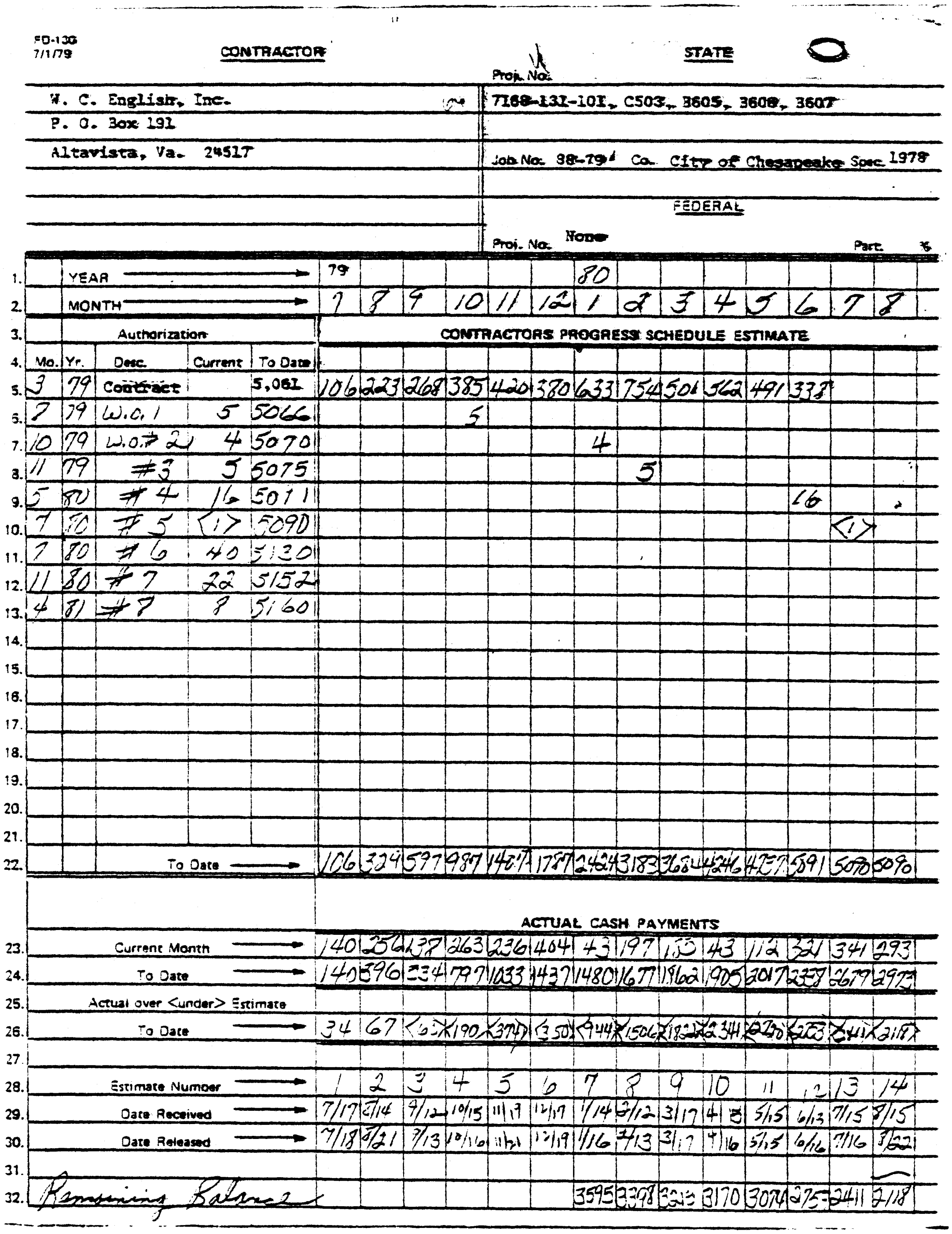
DATE FINAL SENT TO AUDITING 10-21-81 Sent Comp. 10-23-81

EXTENDED TIME LIMIT DATE 6-23-81

C-25 (Rev.) 14 days increase + 2 days WO #2 + 365 days shutdown = 381 Total Ext.

SUBCONTRACTOR	APPROVED DATE	AMOUNT SUBLET	PER CENT OF CONTRACT	TYPE	FROM	TO	NO. DAYS CREDIT
Jack Hammer Co.	6-18-79	65,465.00	1.29	Temp am	7/5/79	pm 12/4/79	= 47 days
Higgerson Buchanan	6-18-79	129,307.20	2.56	Perm am	12/5/79	pm 5/4/80	= 120½ days
Lee Constr. Co.	6-18-79	491,252.00	9.71	Temp am	5/5/80	pm 12/4/80	= 41 days
Mabco, Inc.	6-18-79	68,677.55	1.36	Dist am	12/5/80	pm 7/24/81	= ~~[illegible]~~ days
						Rev	156
							364.5

Figure 1. Construction Division contract record.



FD-13G
7/1/79

CONTRACTOR

W. C. English, Inc.
P. O. Box 191
Altavista, Va. 24517

STATE

Proj. No. 7168-131-101, C503, B605, B608, B607

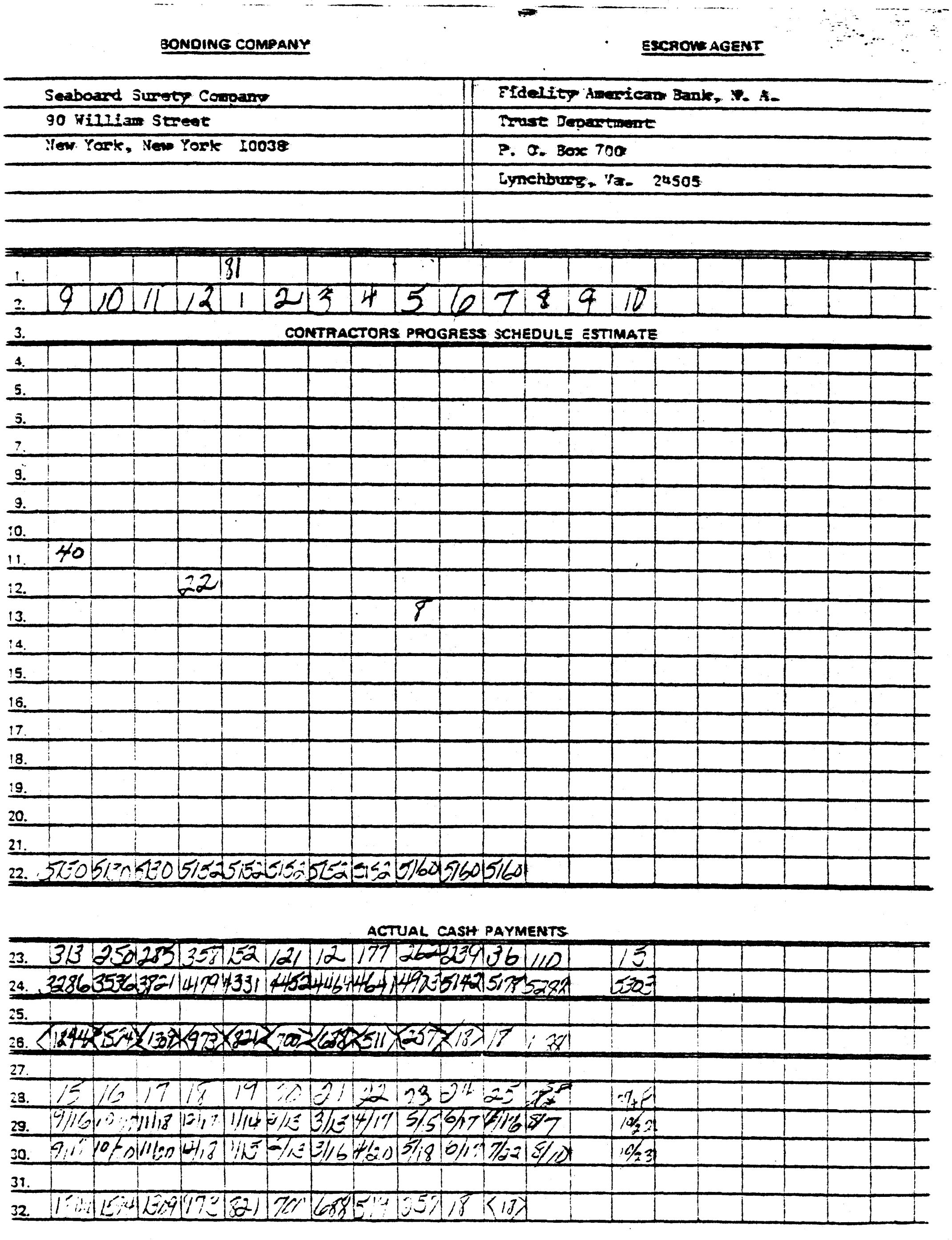
Job No. 38-79 Co. City of Chesapeake Spec. 1978

FEDERAL

Proj. No. None Part. %

1.		YEAR →				79						80								
2.		MONTH →				7	8	9	10	11	12	1	2	3	4	5	6	7	8	
3.		Authorization				CONTRACTORS PROGRESS SCHEDULE ESTIMATE														
4.	Mo.	Yr.	Desc.	Current	To Date															
5.	3	79	Contract		5,061	106	223	268	385	420	380	633	754	501	562	491	338			
6.	7	79	W.O. 1	5	5066				5											
7.	10	79	W.O.# 2	4	5070							4								
8.	11	79	#3	5	5075								5							
9.	5	80	# 4	16	5091												16			
10.	7	80	# 5	<1>	5090													<1>		
11.	7	80	# 6	40	5130															
12.	11	80	# 7	22	5152															
13.	4	81	# 8	8	5160															
14.																				
15.																				
16.																				
17.																				
18.																				
19.																				
20.																				
21.																				
22.			To Date →			106	329	597	987	1407	1787	2424	3183	3684	4246	4737	5091	5090	5090	
						ACTUAL CASH PAYMENTS														
23.			Current Month →			140	256	138	263	236	404	43	197	185	43	112	321	341	293	
24.			To Date →			140	396	534	797	1033	1437	1480	1677	1862	1905	2017	2338	2679	2972	
25.			Actual over <under> Estimate																	
26.			To Date →			34	67	<63>	<190>	<374>	<350>	<944>	<1506>	<1822>	<2341>	<2720>	<2753>	<2411>	<2118>	
27.																				
28.			Estimate Number →			1	2	3	4	5	6	7	8	9	10	11	12	13	14	
29.			Date Received →			7/17	8/14	9/12	10/15	11/19	12/17	1/14	2/12	3/17	4/8	5/15	6/13	7/15	8/15	
30.			Date Released →			7/18	8/21	9/13	10/16	11/21	12/19	1/16	2/13	3/17	4/16	5/15	6/16	7/16	8/22	
31.																				
32.	Remaining Balance											3595	3398	3228	3170	3074	2753	2411	2118	

Figure 2. Fiscal Division construction record — side 1.



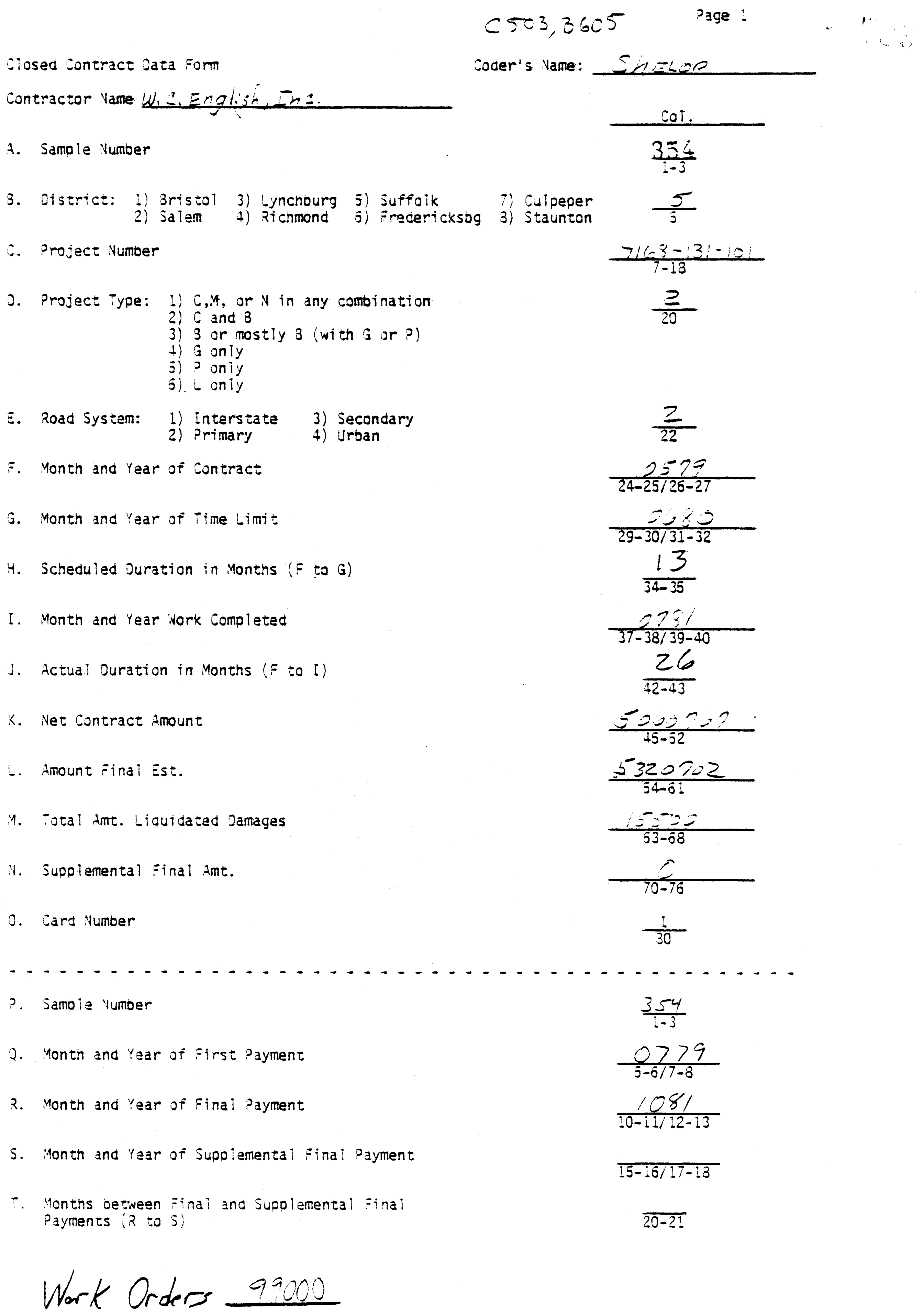
BONDING COMPANY	ESCROW AGENT
Seaboard Surety Company	Fidelity American Bank, N. A.
90 William Street	Trust Department
New York, New York 10038	P. O. Box 700
	Lynchburg, Va. 24505

1.					81															
2.	9	10	11	12	1	2	3	4	5	6	7	8	9	10						
3.	CONTRACTORS PROGRESS SCHEDULE ESTIMATE																			
4.																				
5.																				
6.																				
7.																				
8.																				
9.																				
10.																				
11.	40																			
12.				22																
13.									8											
14.																				
15.																				
16.																				
17.																				
18.																				
19.																				
20.																				
21.																				
22.	5130	5130	5130	5152	5152	5152	5152	5152	5160	5160	5160									

ACTUAL CASH PAYMENTS

23.	313	250	285	358	152	121	12	177	262	239	36	110		15						
24.	3286	3536	3821	4179	4331	4452	4464	4641	4923	5142	5178	5288		5303						
25.																				
26.	<1844>	<1574>	<1309>	<973>	<821>	<700>	<688>	<511>	<257>	<18>	18	38								
27.																				
28.	15	16	17	18	19	20	21	22	23	24	25	26		27						
29.	9/16	10/[illegible]	11/18	12/17	1/14	2/13	3/15	4/17	5/15	6/17	7/16	8/7		10/22						
30.	9/17	10/20	11/20	12/18	1/15	2/13	3/16	4/20	5/18	6/17	7/22	8/10		10/23						
31.																				
32.	1844	1574	1309	1172	821	700	688	514	357	18	<18>									

Figure 3. Fiscal Division construction record - side 2.



C503, 3605 Page 1

Closed Contract Data Form Coder's Name: Shelor

Contractor Name W. C. English, Inc.

		Col.
A. Sample Number	354	1-3
B. District: 1) Bristol 3) Lynchburg 5) Suffolk 7) Culpeper 2) Salem 4) Richmond 6) Fredericksbg 8) Staunton	5	5
C. Project Number	7163-131-101	7-18
D. Project Type: 1) C,M, or N in any combination 2) C and B 3) B or mostly B (with G or P) 4) G only 5) P only 6) L only	2	20
E. Road System: 1) Interstate 3) Secondary 2) Primary 4) Urban	2	22
F. Month and Year of Contract	0579	24-25/26-27
G. Month and Year of Time Limit	0680	29-30/31-32
H. Scheduled Duration in Months (F to G)	13	34-35
I. Month and Year Work Completed	0781	37-38/39-40
J. Actual Duration in Months (F to I)	26	42-43
K. Net Contract Amount	5063707	45-52
L. Amount Final Est.	5320702	54-61
M. Total Amt. Liquidated Damages	15500	63-68
N. Supplemental Final Amt.	0	70-76
O. Card Number	1	80

- -

P. Sample Number	354	1-3
Q. Month and Year of First Payment	0779	5-6/7-8
R. Month and Year of Final Payment	1081	10-11/12-13
S. Month and Year of Supplemental Final Payment		15-16/17-18
T. Months between Final and Supplemental Final Payments (R to S)		20-21

Work Orders 99000

Figure 4. Sample coding sheet – side 1.

U. Record of Monthly Payments

1 140 23-29
2 256 31-37
3 138 39-45
4 263 47-53
5 236 55-61
6 404 63-69
7 43 71-77
Card Number 2 80

* * *

Sample No. 354 1-3
8 197 5-11
9 185 13-19
#10 43 21-27
#11 112 29-35
#12 321 37-43
#13 341 45-51
#14 293 53-59
#15 313 61-67
#16 250 69-75
Card Number 3 80

* * *

Sample No. 354 1-3
#17 285 5-11
#18 358 13-19
#19 152 21-27
#20 121 29-35
#21 12 37-43
#22 177 45-51
#23 262 53-59
#24 239 61-67
#25 36 69-75
Card Number 4 80

* * *

Sample No. 354 1-3
#26 110 5-11
#27 0 13-19
#28 15 21-27
#29 29-35
#30 37-43
#31 45-51
#32 53-59
#33 61-67
#34 69-75
Card Number 5 80

* * *

V. Contractor's Progress Schedule

Sample No. 354 1-3
#35 106 5-11
#36 223 13-19
#37 268 21-27
#38 385 29-35
#39 420 37-43
#40 380 45-51
#41 633 53-59
#42 754 61-67
#43 501 69-75
Card Number 6 80

* * *

Sample No. 354 1-3
#44 562 5-11
#45 491 13-19
#46 338 21-27
#47 29-35
#48 37-43
#49 45-51
#50 53-59
#51 61-67
#52 69-75
Card Number 7 80

Figure 5. Sample coding sheet — side 2.

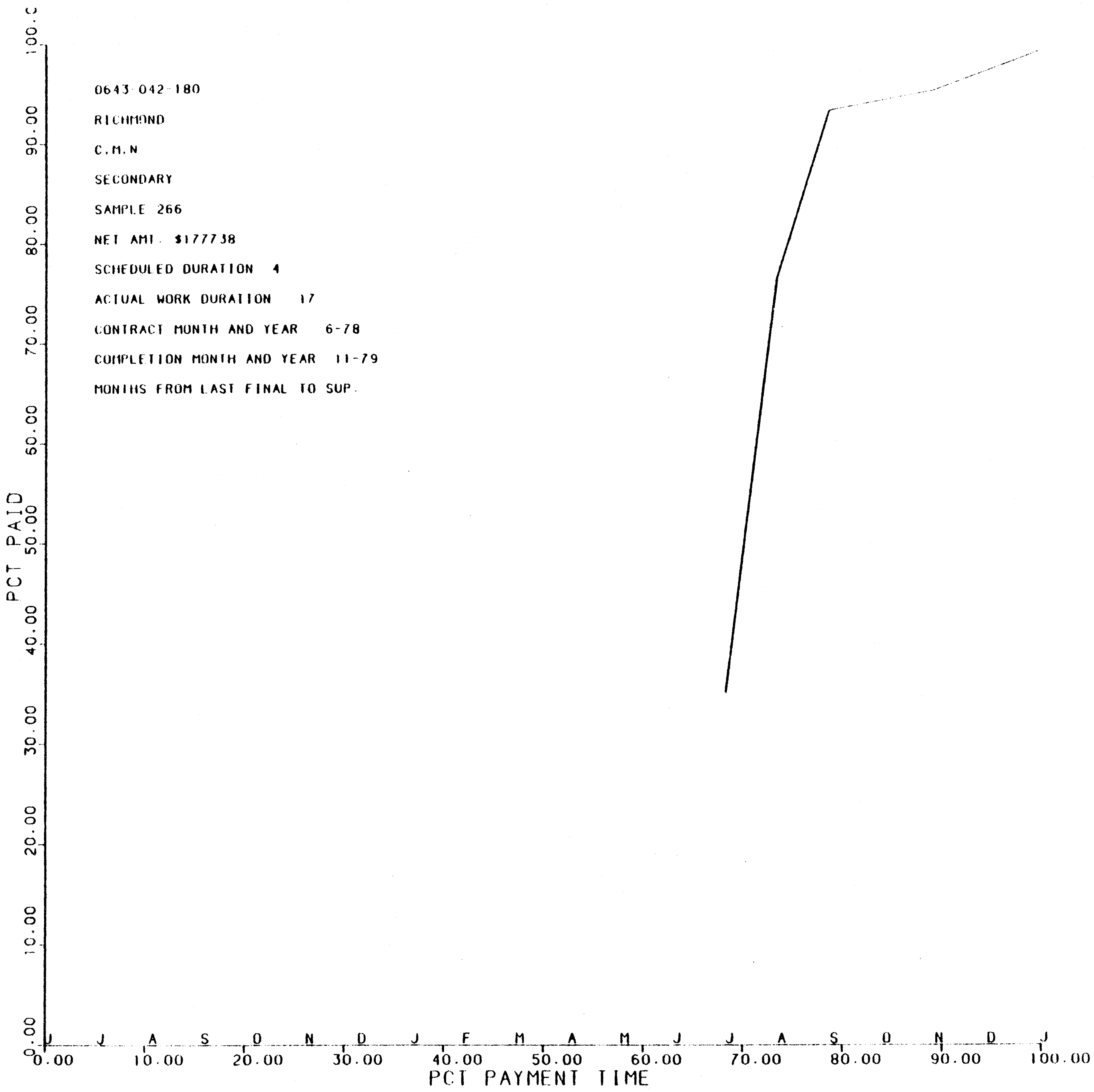


Figure 6. Example of an atypical contract.

Table 2

Distribution of Sample by Duration And Contract Amount

Contract Amount ($)	Actual Duration from Contract to Completion						
	0-3	4-6	7-12	13-17	18-24	25-36	Total
< 250,000	11	18	15	1	0	0	45
250,001-500,000	1	3	33	9	1	0	47
500,001-1,000,000	0	1	15	15	2	0	33
1,000,001-2,500,000	0	1	1	12	8	1	23
2,500,001-6,000,000	0	0	0	2	1	5	8
> 6,000,000	0	0	0	0	5	1	6
Total	12	23	64	39	17	7	162

Table 3

Distribution of Construction Dollar Volume
By Size of Contract

Contract Amount($)	Number of Contracts	Percent of Dollar Volume	Cumulative Percent
< 250,000	45	3.3	3.3
250,001 - 500,000	47	9.9	13.2
500,001 - 1,000,000	33	13.2	26.5
1,000,001 - 2,500,000	23	23.4	49.8
2,500,001 - 6,000,000	8	18.6	68.5
> 6,000,000	6	31.5	100.0

Eighty percent of the sample contracts were for combination construction or combination plus bridge construction. The distribution of contracts by road system and project type given in Table 4 shows that 146 of the 162 contracts were on the primary and secondary systems. Of those, all but 6 involved combination and/or bridge construction. Of the 13 interstate contracts, 9 were for combination and/or bridge construction. The sample included only 3 urban projects.

The payout data showed that the payout pattern of individual contracts was highly variable. For example, the ratio of actual duration to scheduled duration varied from less than one to six. The number of months between the contract and the first payment was anywhere from zero to 13 months. The final estimate varied from 84% to 165% of the contract amount. This variability is illustrated in Figure 7, which shows the minimum, maximum, and mean payout by contract size group at 50% of time elapsed from contract to completion. Interestingly, the largest contracts (greater than $6 million) were the least variable, with the halfway payout ranging from 47% to 75%. However, the next to largest category ($2.5 to $6 million) was among the most variable, ranging from 14% to 93%. For the three smallest contract size groups, the minimum payout at 50% elapsed time was zero, while the maximum reached 91%.

In spite of the variability of individual contracts, certain predictable patterns occurred. The pattern illustrated by Figure 8 is that longer duration contracts were farther along, in terms of percent already paid out, at any point in the life of the contract than shorter duration contracts. For example, at 50% of time elapsed, a 7-to-12-month contract was 29% paid out, on the average. A 25-to-36-month contract was 60% paid out. In general, the percent paid out was likely to be closer to the percent of time elapsed on long duration contracts than on short contracts. The data also show that large contracts had smaller cost overruns, in percentage terms, than smaller contracts. Large contracts also tended to stay closer to schedule than smaller contracts, as discussed later.

Table 4

Distribution of Sample By Road System and Project Type

Project Type	Road System				
	Interstate	Primary	Secondary	Urban	TOTAL
Combination or Minimal Plan	2	46	41	2	91
Combination with Bridge	3	19	15	1	38
Bridge	4	5	14	0	23
Grading	0	2	0	0	2
Paving	1	3	0	0	4
Landscaping	1	1	0	0	2
Signals	2	0	0	0	2
Total	13	76	70	3	162

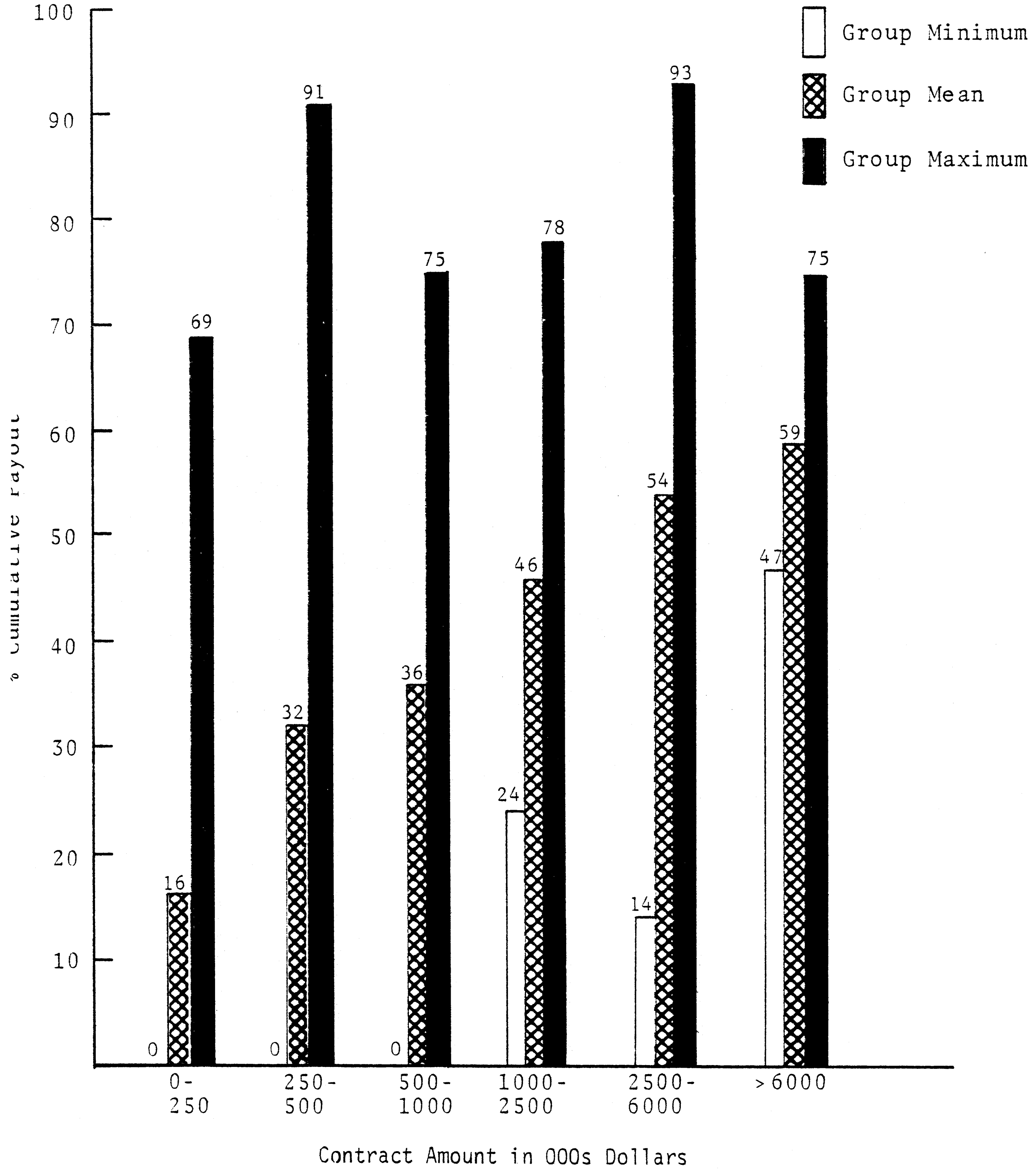


Figure 7. Percent paid out at 50% time elapsed, by contract size.

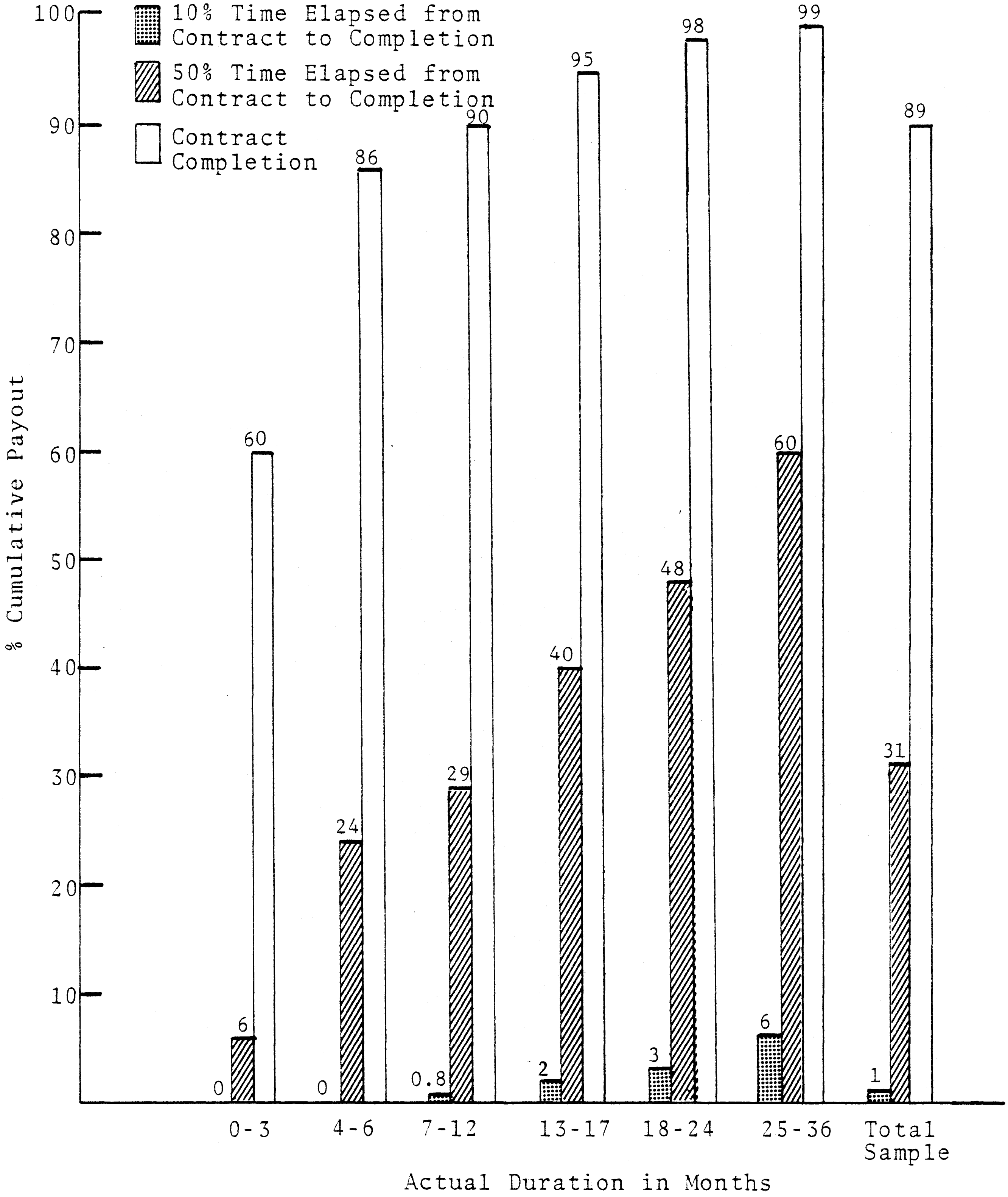


Figure 8. Mean payouts at three points in contract, by contract duration.

CURRENT FORECASTING TECHNIQUES

Current Contracts

The techniques currently used by the Department to forecast construction contract payout have certain identifiable limitations. In the case of current contracts, the forecast is based upon the contractor's progress schedule estimate. If the cumulative payout is not equal to the scheduled payout, the difference is simply distributed equally over the months remaining on the progress schedule. If the project is not completed on time, the balance remaining in the contract is paid out in the following month if less than $100,000, or over the following 6 months if greater than $100,000.

The difficulty with this forecasting technique is that the data show that the contractors' progress schedules were not reliable indicators of the contracts' actual duration, final cost, or payout patterns. The contractors' schedules typically did not allow for any delays in construction, particularly for seasonal slowdowns and shutdowns. Table 5 demonstrates the extent to which schedules were exceeded on contracts of various sizes. The number of additional months needed ranged from 5 to 25, with a dollar-volume-weighted average of 14.5 months, or 82% of scheduled duration. This finding is further illustrated by Figure 9, which shows the ratio of actual to scheduled payout throughout the scheduled time period for contracts of various sizes.

As a general rule, contracts fell farther and farther behind as they approached the end of the scheduled time limit. For example, contracts from $1.0 to $2.5 million in size were nearly on schedule at the 25% time elapsed point. By the 75% time elapsed point, however, they had fallen to 72% of the scheduled estimate. At the scheduled completion date, only 64% of the work had been done. The largest projects (over $6 million) generally stayed closer to schedule than smaller projects, but they also fell behind as time elapsed, until they were only 87% completed when the scheduled time limit was reached.

Table 5

Schedule Overruns, by Contract Size

Contract Size ($)	Actual Duration ÷ Scheduled Duration	Additional Months Needed
< 250,000	1.83	5.0
250,001 - 500,000	1.88	8.8
500,001 - 1,000,000	1.88	10.9
1,000,001 - 2,500,000	2.10	18.0
2,500,001 - 6,000,000	2.08	25.0
> 6,000,000	1.44	10.0
Weighted Average	1.82	14.5

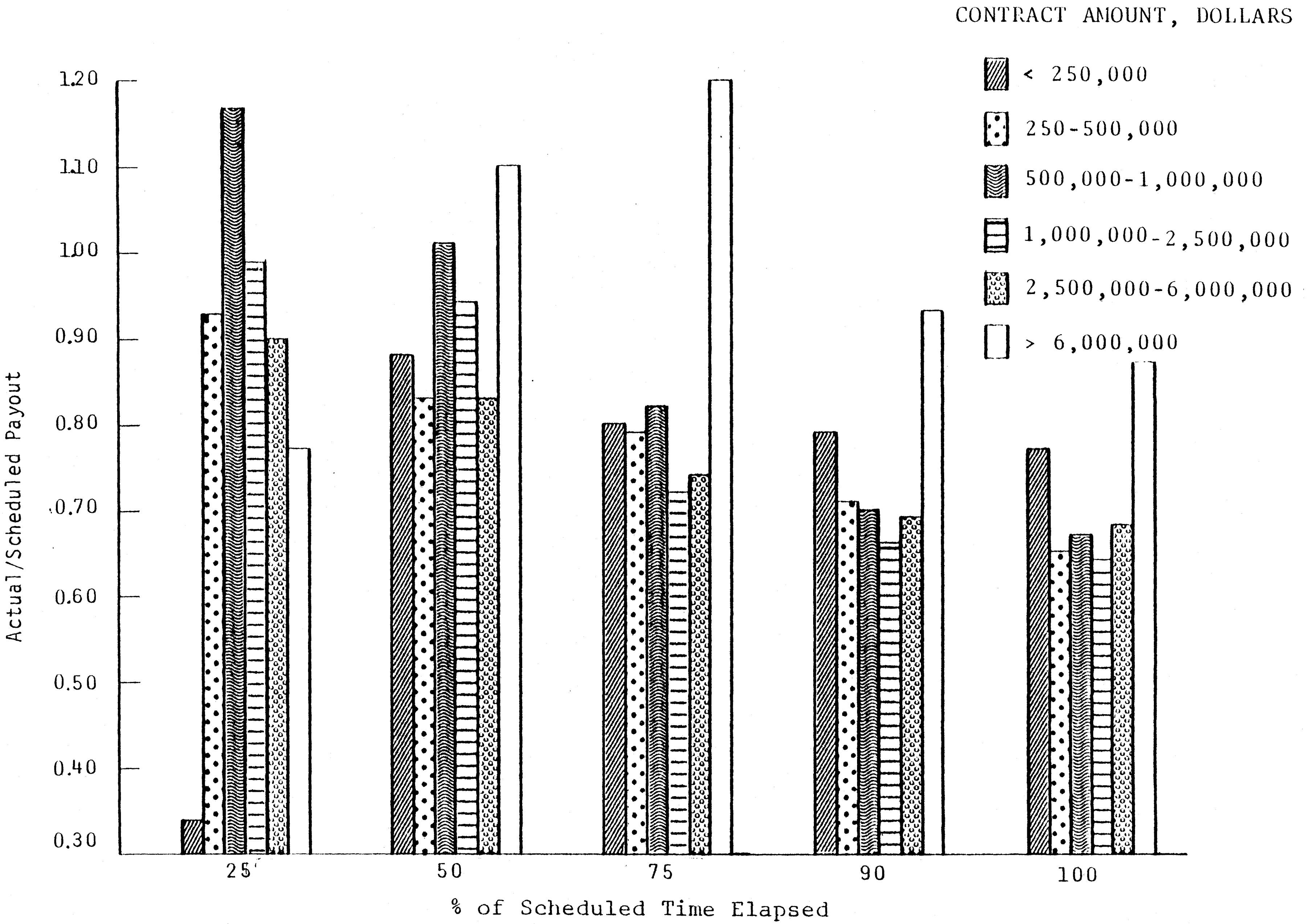


Figure 9. Actual/scheduled payout vs. time elapsed on contractors' schedules.

The final cost of a project was generally much closer to the original contract than was the duration. Table 6 shows that the cost overruns ranged from 2.7% to 11.6%, with contracts exceeding $6 million having the smallest percentage overruns. The weighted average for the sample was 7.8%.

Table 6

Cost Overruns as Percentage of Contract Amount by Contract Size

Contract Size ($)	Cost Overrun
< 250,000	9.0
250,001 - 500,000	7.8
500,001 - 1,000,000	11.6
1,000,001 - 2,500,000	9.4
2,500,001 - 6,000,000	11.5
> 6,000,000	2.7

The current forecasting technique takes account of only a small portion of these overruns. Work orders received on a contract through the date of the forecast are added to the original contract amount for a revised contract total. Future payments are projected until the sum of payments is equal to the revised contract total. When this point is reached in the forecast, no further payments are projected. This method makes no attempt to forecast work orders not yet received at the time of the forecast. Furthermore, work orders account for only 28%, on the average, of cost overruns. The remaining 72% consists of quantity overruns which do not require work orders.

For example, on the contract shown in Figures 2 and 3, work orders received by July 1980 amounted to $29,000, for a revised contract total of $5,090,000. A forecast made in that month, therefore, would have projected payments totalling $5,090,000. However, work orders totalling another $70,000 were subsequently received for a revised contract total of $5,160,000. In addition, the final sum of payments actually made came to $5,303,000. The total cost overrun was actually $242,000, of which $99,000 was accounted for by work orders.

To summarize the limitations of the forecast techniques in use for current contracts, they are –

1. over-reliance on the contractors' progress schedule estimates, which are not good indicators of actual payments made and which tend to ignore the seasonality of construction;

2. failure to make reasonable estimates of the duration of contracts, which exceed their schedules by 14.5 months, on the average; and

3. failure to anticipate probable cost overruns, which range from 2.7% to 11.6% of the contract amount.

Proposed Contracts

The technique used for forecasting payouts on proposed contracts also has certain shortcomings. A 23-month payout period is assumed for all proposed contracts. When this 23-month schedule, shown in Table 7, is plotted, it becomes a smooth curve as shown in Figure 10. The schedule is fairly close to the dollar-volume-weighted payout period for the sample, which is 21.4 months. The shape of the curve is also fairly representative, although many of the payout curves in the sample are more concave (exponential) or S-shaped.

Table 7

Twenty-three-Month Payout Schedule for Proposed Contracts

Month	Monthly Payout Percent	Cumulative Payout Percent
1	0.6	0.6
2	3.7	4.3
3	7.0	11.3
4	9.2	20.5
5	6.9	27.4
6	6.9	34.3
7	7.0	41.3
8	6.7	48.0
9	7.2	55.2
10	7.8	63.0
11	5.6	68.6
12	7.0	75.6
13	4.0	79.6
14	4.2	83.8
15	3.7	87.5
16	1.6	89.1
17	2.8	91.9
18	1.6	93.5
19	2.2	95.7
20	1.0	96.7
21	1.1	97.8
22	1.5	99.3
23	0.7	100.0

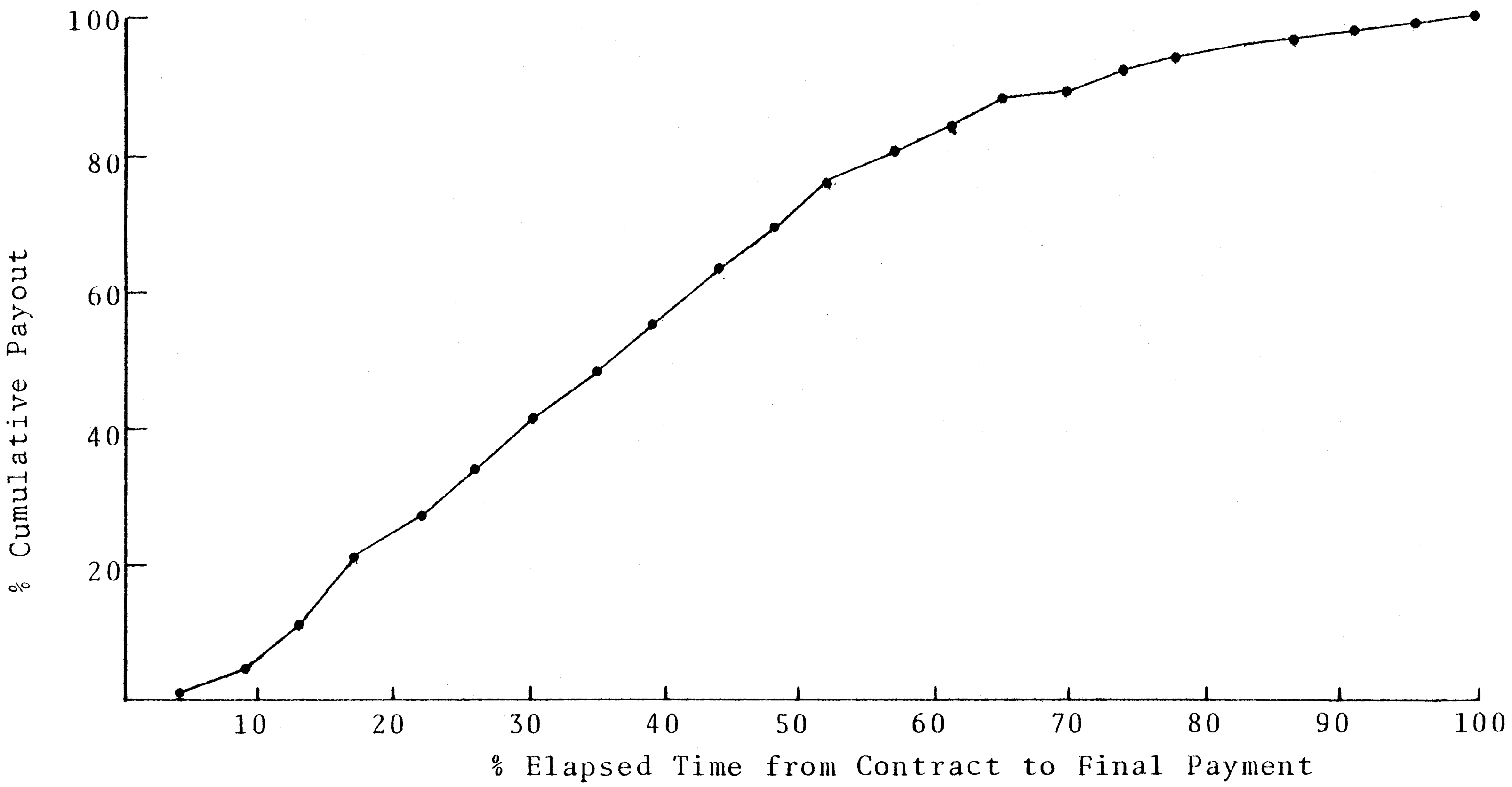


Figure 10. Twenty-three-month payout curve used for proposed contracts.

The principal weakness of this forecasting technique, aside from the failure to anticipate cost overruns, is that it does not allow for the seasonality of construction work. The importance of seasonality is demonstrated by Figure 11, which shows the monthly construction payout during FY82 as a percentage of the total for the year. As may be expected, the peak period for construction activity was the summer and autumn, and the slow season was the middle of winter (January and February). The monthly percentage for the peak month of September was more than six times the percentage for the slowest month of January. The effect of seasonality naturally varies from year to year. This variability, as well as the role of seasonality in forecasting, will be discussed in greater detail later in this report.

Forecasting Results

The final result of these limitations on the forecasting techniques which have been discussed is an unsatisfactory forecast. This is illustrated by the comparison in Figure 12 of actual construction payouts from April 1982 to March 1983 with a forecast made by the Budget Division in April 1982 using the techniques described above. The most striking feature of this comparison is that the forecast seriously underestimated the summer and autumn construction peak. This was probably a result of the failure to account for seasonality in the forecasting techniques. The forecast underestimated payout more than three times as often as it overestimated payout. While no forecasting technique is totally accurate, a good test is that a forecast overestimates about as often as it underestimates, thus indicating that it is not biased in one direction.

Another factor which may have affected the forecasting results obtained by the Budget Division is the difficulty of predicting the advertisement dates of proposed projects. Until recently, these ad dates were so uncertain that neither the information in the PDMS nor the 2-year advertising schedule was reliable. This situation has apparently improved greatly, although there will always be some projects which are delayed, moved up, added, or dropped from the schedule.

The Programming and Scheduling Division recently completed an analysis of the advertising schedule which was released in October 1982. Of the 179 projects which were scheduled for advertising through March 1983, 159 were actually advertised. Of these, 127 were advertised in the month scheduled and another 28 were advertised within the same quarter. In addition, 14 projects were advertised that had been advanced or added to the schedule, while 6 projects were dropped from the schedule. This much variability in ad dates is probably a normal part of Department operations, and will prevent any forecasting technique from being totally accurate. The inaccuracy can be minimized by updating the forecasting data base promptly whenever Programming and Scheduling announces changes in ad dates.

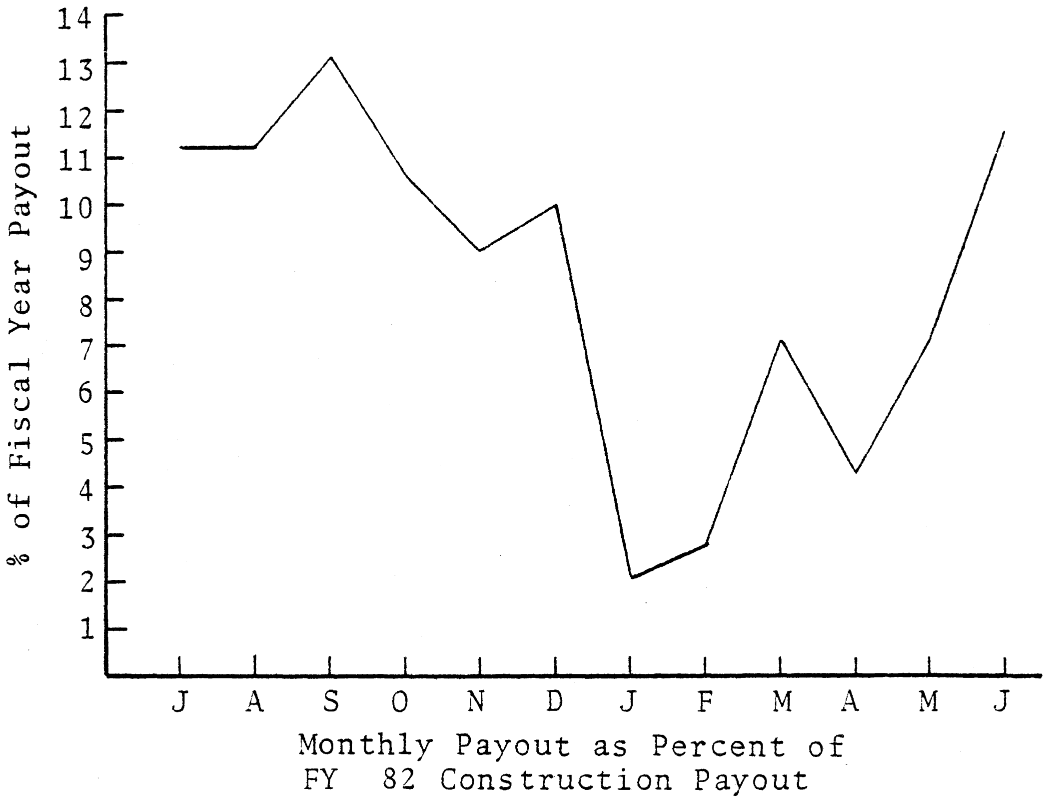


Figure 11. Seasonality of construction payout.

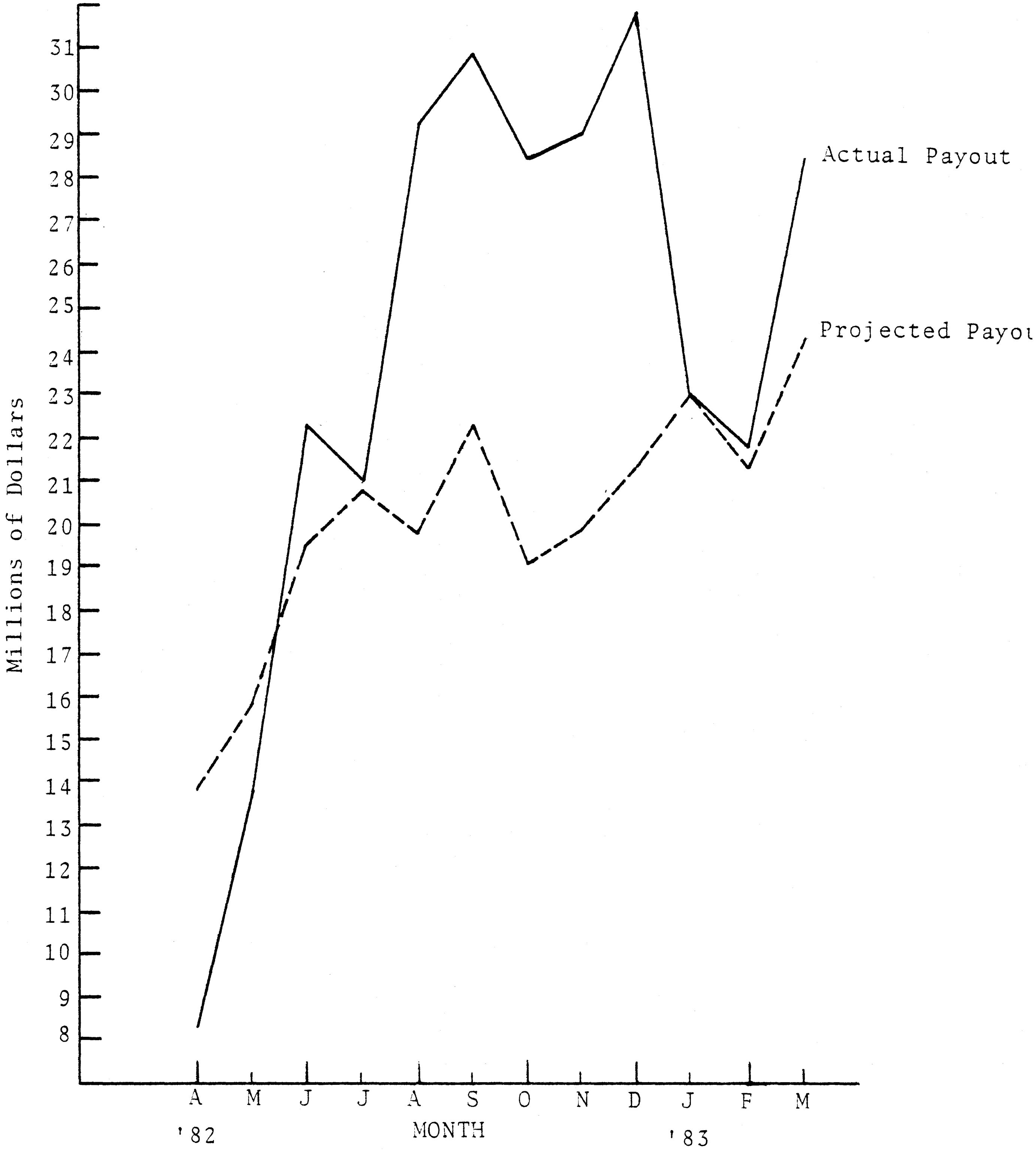


Figure 12. Comparison of construction payout with Budget Division forecast.

DEVELOPMENT OF NEW FORECASTING TECHNIQUES

The problem of forecasting payouts on construction contracts incorporates several distinct questions. Addressing these questions separately will result in both greater understanding of payout patterns and a more accurate forecasting technique than is currently the case. This section will describe the analysis performed and the forecasting techniques developed for (1) contract duration, (2) the amount of the final estimate, (3) payout patterns, and (4) ad dates for proposed contracts.

Contract Duration

Contract duration is defined, for the purposes of this study, as the elapsed time in months from the month in which the first payment is made to the month in which work is completed. Intuitively, contract size would be expected to be the single most powerful determinant of duration. An analysis of the data shows this to be correct, although, as shown by Figure 13, the relationship was not proportional. Other factors which may influence contract duration are project type, road system, and the month in which the contract is signed.

A regression analysis that was performed using all of these factors showed that 69% of the variation in duration was explained by contract size, but that the increases in duration were less than proportional to the increases in size, especially for the largest contracts. The results also showed that contracts on the secondary system took less time to complete than did contracts on the other systems, and less time to complete if the contract was signed in January, February, March, April, July, or December. Contracts for combination construction projects involving bridges and those for signal projects tended to be longer than most others. An equation which includes all of these variables can explain 76% of the variation in contract duration. This equation is

$$\text{ACTDUR} = 38.78 + 3.84 \ln \text{NETAMT} - 3.28\ \text{MNCN} - 0.49\ \text{RDSYS} + 1.53\ \text{PRTYPE},$$

where

ACTDUR = actual duration in months from month of first payment to month of completion;

NETAMT = original contract amount;

MNCN = month in which contract is signed (1 if January, February, March, April, July, or December, otherwise 0);

RDSYS = road system (1 if secondary, otherwise 0); and

PRTYPE = project type (1 if project is type C with a bridge (type B) also involved, otherwise 0).

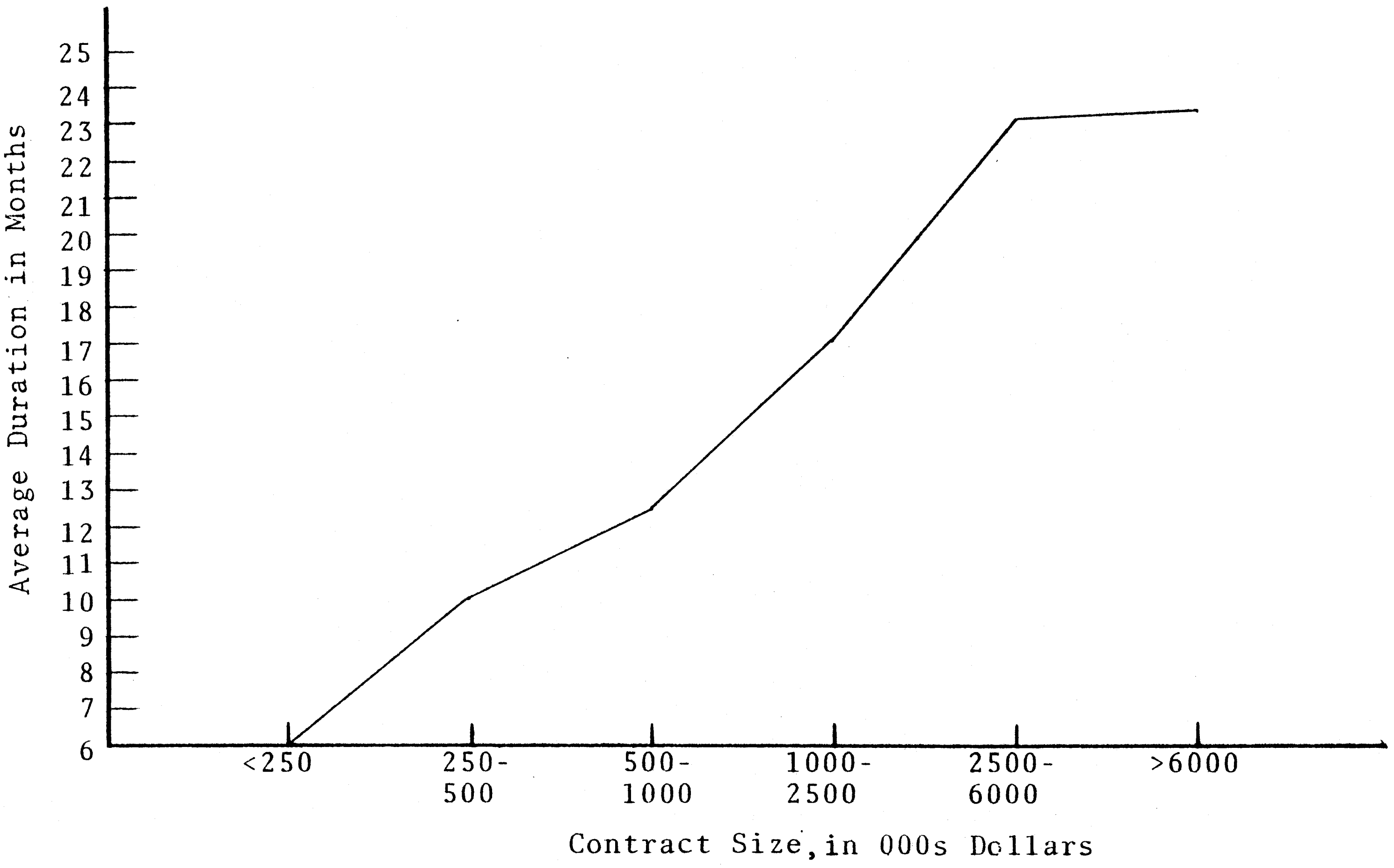


Figure 13. Relationship of contract size to duration.

Table 8 shows the durations calculated for contracts of various sizes and categories using the equation above. For a given contract size, the contracts with the longest estimated durations were combination construction plus bridge or signal contracts on the interstate, primary, or urban systems which were signed in May, June, or August through November. Contracts with the shortest estimated durations were those other than combination plus bridge or signal projects on the secondary system which were signed in January through April, July, or December. The difference between the shortest and longest duration estimated for contracts of a given size was 5.5 months.

The Construction Division recently estimated the average construction time for various contract size groups. Their estimates for contracts of less than $1 million are comparable to those from the regression equation. However, for larger contracts, the Construction Division estimates are as much as 3.5 to 5 months longer than the regression estimates.

Amount of Final Estimate

As discussed in an earlier section, the final estimates ranged from 102.7% to 111.6% of the original contract amount (see Table 6). For forecasting purposes, the mean percentage cost overrun for each contract size group was used to predict the size of the final estimate for each contract, as shown below.

Final Estimate = Cost Overrun Factor x Contract Amount,

where

Cost Overrun Factor = 1.090 for contracts < $250,000
= 1.078 for contracts $250,001-$500,000
= 1.116 for contracts $500,001-$1,000,000
= 1.094 for contracts $1,000,001-$2,500,000
= 1.115 for contracts $2,500,001-$6,000,000
= 1.027 for contracts > $6,000,000.

Payout Patterns

The timing, number, and size of the monthly payments on a construction contract constitute the payout pattern. The payout patterns of the sample contracts were analyzed by two methods. The first method was conventional regression analysis, the second was the method of monthly factors analysis, which emphasizes seasonality.

Table 8

Contract Durations Calculated by Regression Equation, Months

	Secondary				Interstate, Primary & Urban			
	Month Contract Signed				Month Contract Signed			
	1-4,7,12		5,6,8-11		1-4,7,12		5,6,8-11	
	Project Type		Project Type		Project Type		Project Type	
Contract Amount	C&B or S*	Other	C&B or S	Other	C&B or S	Other	C&B or S	Other
$ 125,000	5.5	4.1	8.8	7.4	6.3	4.9	9.6	8.2
375,000	9.5	8.1	12.8	11.4	10.3	8.9	13.6	12.2
750,000	12.1	10.7	15.4	14.0	12.9	11.5	16.2	14.8
1,500,000	14.6	13.2	17.9	16.5	15.4	14.0	18.7	17.3
3,000,000	17.1	15.7	20.4	19.0	17.9	16.5	21.2	19.8
6,000,000	19.6	18.2	22.9	21.5	20.4	19.0	23.7	22.3
12,000,000	23.1	21.7	26.4	25.0	23.9	22.5	27.2	25.8

*Combination plus bridge or signal

Regression Analysis

The regression analysis was performed separately for each contract size group. The cumulative percent paid out in each month of each contract was analyzed as a function of the percentage of time elapsed from the first payment to the completion date, the month in which the payment was made, and the cumulative percent already paid out. The regression equation is

$$PCTP = a + b\,(PCTT) + c(PCTT^2) + d(PCTT^3) + e(PCTPL) + f(PMTMON),$$

where

PCTP = the cumulative percent of the final estimate paid out by the end of this month;

PCTT = the percentage of time elapsed from the first payment through the month of completion;

PCTPL = the cumulative percent paid out at the end of the previous month; and

PMTMON = the month in which the payment is being made (1 if the month is January, February, March, or April, and 0 if the month is May, June, July, August, September, October, November, December).

The equation includes the square and the cube of the percent time elapsed (PCTT) because this allows for changes in the slope of the payout curve. The variable PMTMON allows for the fact that construction activity is much lower in winter and early spring than in the rest of the year.

The results of the regression analysis were quite good. The R^2s, which represent the percentage of variation explained by the equation, are given below for each contract size group.

Contract Size ($)	R^2
< 250,000	.87
250,001 - 500,000	.94
500,001 - 1,000,000	.96
1,000,001 - 2,500,000	.98
2,500,001 - 6,000,000	.99
> 6,000,000	.99

The results of a forecasting test of these equations will be presented in a later section.

Monthly Factors Analysis

A forecasting technique based on individual contract duration and the seasonality of the total work program has been in use by the New York DOT for several years. The basic equation is

$$\mathrm{ESTPMT}_t = \mathrm{AMTREM}_{t-1} \times \frac{\mathrm{MONFACT}_t}{\Sigma_t^n \mathrm{MONFACT}},$$

where

ESTPMT_t = the estimated monthly payment for the month t;

AMTREM_{t-1} = the amount remaining in the contract after the payment made in month t-1;

$\mathrm{MONFACT}_t$ = the monthly seasonality factor for month t; and

$\Sigma_t^n \mathrm{MONFACT}$ = the sum of monthly seasonality factors for the months remaining in the contract's duration from month t to the month of final payment.

The monthly seaonsality factors are computed from historical data by dividing the total construction contract payout for each month (for all contracts) by the total payout for the year. The result gives an estimate of the percentage of annual payout which typically occurs in each month. Then, the monthly seasonality factors used for forecasting may be averaged over several years to smooth out year-to-year variations. The first step in adapting the monthly factors method to Virginia was to calculate the monthly seasonality factors for the Virginia Department of Highways and Transportation's construction program. In order to determine the variability of these factors, they were calculated using four different data bases: (1) monthly payouts for the total construction program for FY 1980-81, (2) monthly payouts for total construction program for FY 1981-82, (3) FY 1980-81 payout for the sample data base described earlier, and (4) total payout for the combined 3-year sample data base. The results are shown in the bar chart in Figure 14.

The fiscal year 80-81 sample shows the greatest difference between the peak month and the lowest month of the year — the July factor of .16 is more than 8 times the March factor of .019. On the other hand, the seasonality is less extreme for the combined 3-year sample: The proportion of total annual payout for the peak month of July is 0.12, about 3 times the proportion paid out for the lowest month, March, which is .036. The fiscal year totals for 1980-81 and 1981-82 exhibit intermediate levels of seasonality with the most highly variable months being January, which ranges from .021 to .069, and March, which ranges from .019 to .071. The peak months of July and August are moderately variable. In contrast, the months of September and October are quite stable. This means that year-to-year variations in monthly seasonality could produce forecasting errors of several millions of dollars, particularly in January and March and in the

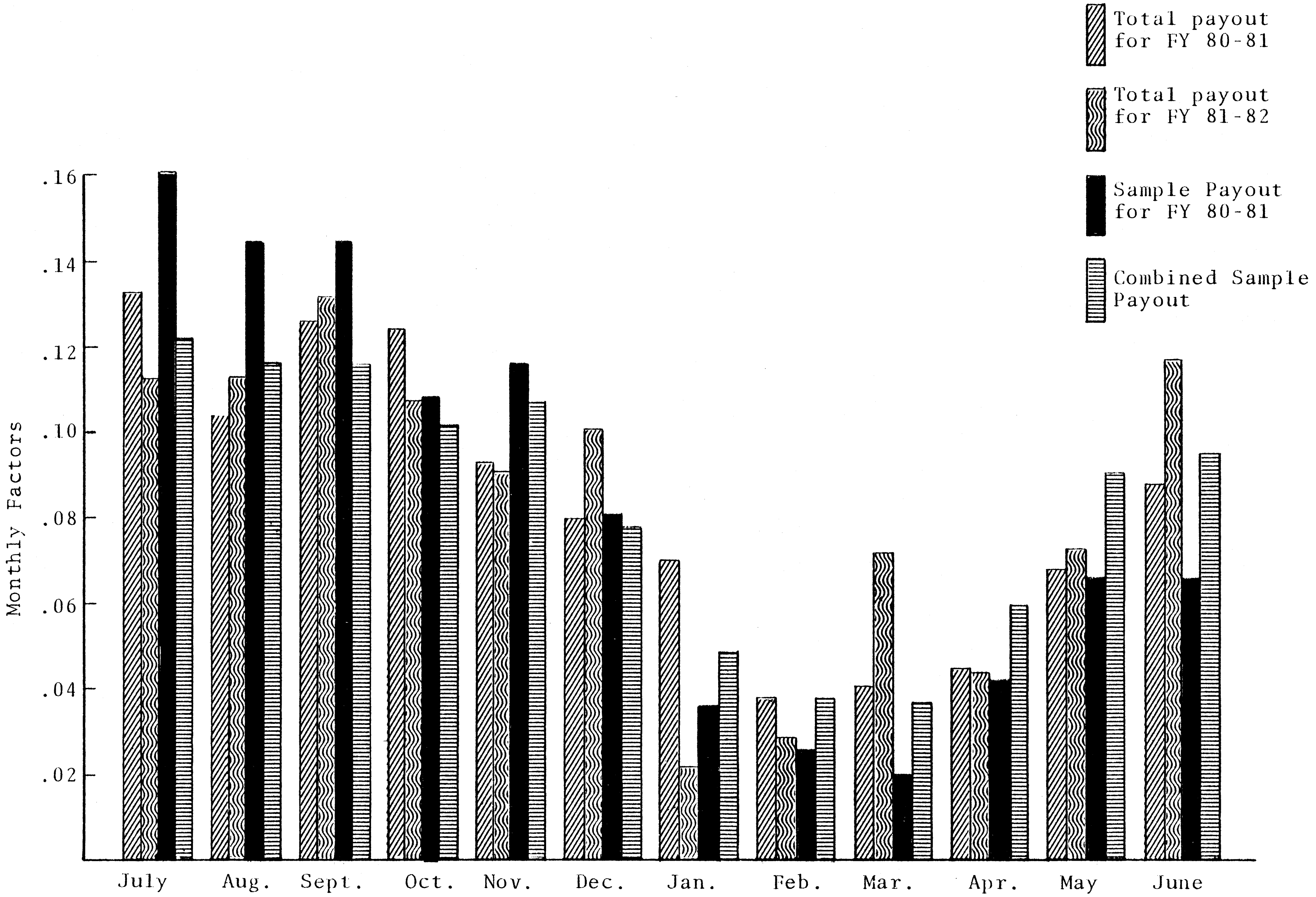


Figure 14. Variations in monthly factors from sample and aggregate payouts.

peak months. Forecasting tests were conducted on the sample using monthly factors from the combined three-year sample and from the fiscal 1980-81 sample. The results of these tests will be presented in the next section.

A number of trial calculations with the monthly factors equation indicated that it performs better empirically if certain assumptions are made about the timing and size of the first two payments as well as the final payment. Based on the data in the sample, the first payment is assumed to occur one month after the contract month if the estimated duration is less than three months and two months after the contract month if the estimated duration is three months or longer. Using the sample data base, the sizes of the first, the second, and the final payment are specified as a percentage of the Final Estimate, depending on the contract size group. These percentages are shown in Table 9. Next, the percentage of the contract which is paid out by the completion month was calculated from the sample by size of contract: this is shown in Table 10. In addition, the payout pattern was constrained such that the payment percentage made in the month following completion equals [1-(% paid by completion month + % last payment)], the next payment always equals zero, and the last payment is made three months after completion.

Table 9

1st, 2nd and Final Payments as Percentage of Final Estimate

Contract Size ($)	First Payment	Second Payment	Final Payment
< 250,000	14.5%	23.8%	6.5%
250,001 - 500,000	8.2%	12.0%	3.7%
500,001 - 1,000,000	5.5%	10.4%	2.6%
1,000,001 - 2,500,000	5.0%	6.1%	1.0%
2,500,001 - 6,000,000	4.7%	5.6%	0.5%
> 6,000,000	2.6%	3.1%	0.001%

Table 10

Percent Paid Out by Completion Month

Contract Size ($)	Percent Paid Out
< 250,000	86.9
250,001 - 500,000	88.6
500,001 - 1,000,000	93.9
1,000,001 - 2,500,000	96.5
2,500,001 - 6,000,000	97.3
> 6,000,000	100.0

The following example illustrates how duration, final estimate, and monthly payments are calculated using the methods described above.

Project No.:	0641-016-150
Project Type:	C
Road System:	Secondary
Contract Amount:	$79,771
Contract Month:	June

Duration = -38.78 + 3.84 (ln NETAMT) - 3.28 (MNCN) - 0.49 (RDSYS) + 1.53 (PRTYPE)

NETAMT = 79771

MNCN = 0 for June

RDSYS = 1 for Secondary

PRTYPE = 0 for combination construction

Duration = -38.78 + 3.84 (ln 79771) - 3.28 (0.0) - 0.49 (1) + 1.53 (0.0)

= 4.07 rounded to 4 months from first payment to the month of completion.

Final Estimate = $79,771 x 1.090 = $86,950.

Monthly Factors

= JAN	0.048	JULY	0.114
= FEB	0.037	AUG	0.118
= MAR	0.035	SEPT	0.117
= APR	0.060	OCT	0.104
= MAY	0.094	NOV	0.106
= JUN	0.091	DEC	0.076

Using the monthly factors shown above, the following estimate of payout can be made.

Month	Payment	Calculation
June	0	Recall, the model is constrained so that no payments are made in first two months after contract date.
July	0	
Aug.	12655	86950 x .145 (total payment times 1st payment proportion for contracts less than $250,000)
Sept.	20721	86950 x .238 (total payment times 2nd payment proportion for contracts less than $250,000)
Oct.	20891	[.104/(.104+.106)][(86950x.869)-(12655+20721)]
Nov.*	21293	[.106/.106][(86950x.869)-(12655+20721+20891)]
Dec.	5747	[86950-(12655+20721+20891+21293)] -[86950x.0649]
Jan.	0	Recall, next to last payment always = 0
Feb.	5643	86950x.0649 (i.e., total payout times last payment %)

*Estimated completion month.

The calculation for the month of October is shown in greater detail below.

$$\text{October Monthly Payment} = \frac{\text{October Monthly Factor}}{\text{Sum of factors for months remaining from October to completion month}} \times \text{Amount remaining to be paid out by completion month}$$

Monthly Factor = .104 for October

Sum of Remaining Factors to Completion Month = .104 for October
.106 for November
.210

Total amount to be paid out by completion = $86,950 x .869 = $75,560

Amount Already Paid Out = $12,655 + $20,721 = $33,376

Amount remaining to be paid out by completion = $75,560 - $33,376 = $42,184

$$\text{Monthly Payment} = \frac{.104}{.210} \times \$42{,}184 = \$20{,}891$$

The payout forecasts generated by the monthly factors method can be plotted as payout curves comparable to the standard curve in Figure 10. Such a curve is shown for a 25-month contract from the sample in Figure 15. The differences between this curve and the standard 23-month payout curve in Figure 10 are shown in Table 11.

Table 11

Comparison of Monthly Factors Curve and Standard Curve

Percent of Time Elapsed	Percent Cumulative Payout	
	Standard Curve	Monthly Factors Curve
25	32	27
50	72	50
75	92	88
90	98	98
100	100	100

Generally, the payout in the monthly factors curve is less accelerated than in the standard curve, until near the end of the curve. The monthly factors curve is also less smooth than the standard curve, with dips and bulges which show the effects of seasonality. For example, from November to March the slope of the curve is less than it is from June to October, indicating a slower rate of payout. Of course, no forecasting technique or payout curve can possibly duplicate the highly variable behavior of individual contracts. Nevertheless, the forecasting tests described in the next section indicate that the monthly factors method can do a better job than the standard payout curve of duplicating the payout pattern of all contracts taken together.

Advertisement Dates for Proposed Contracts

The difficulty of predicting ad dates for proposed contracts was discussed in an earlier section. The most authoritative source of information is the 2-year advertising schedule prepared approximately every 6 months. The same information is supposed to be contained in the PDMS data base on the central computer. Changes in ad dates may occur at any time, however. These changes are announced immediately in the form of memorandums from the Programming and Scheduling Division. These changes are also supposed to be entered into the PDMS data base at least weekly.

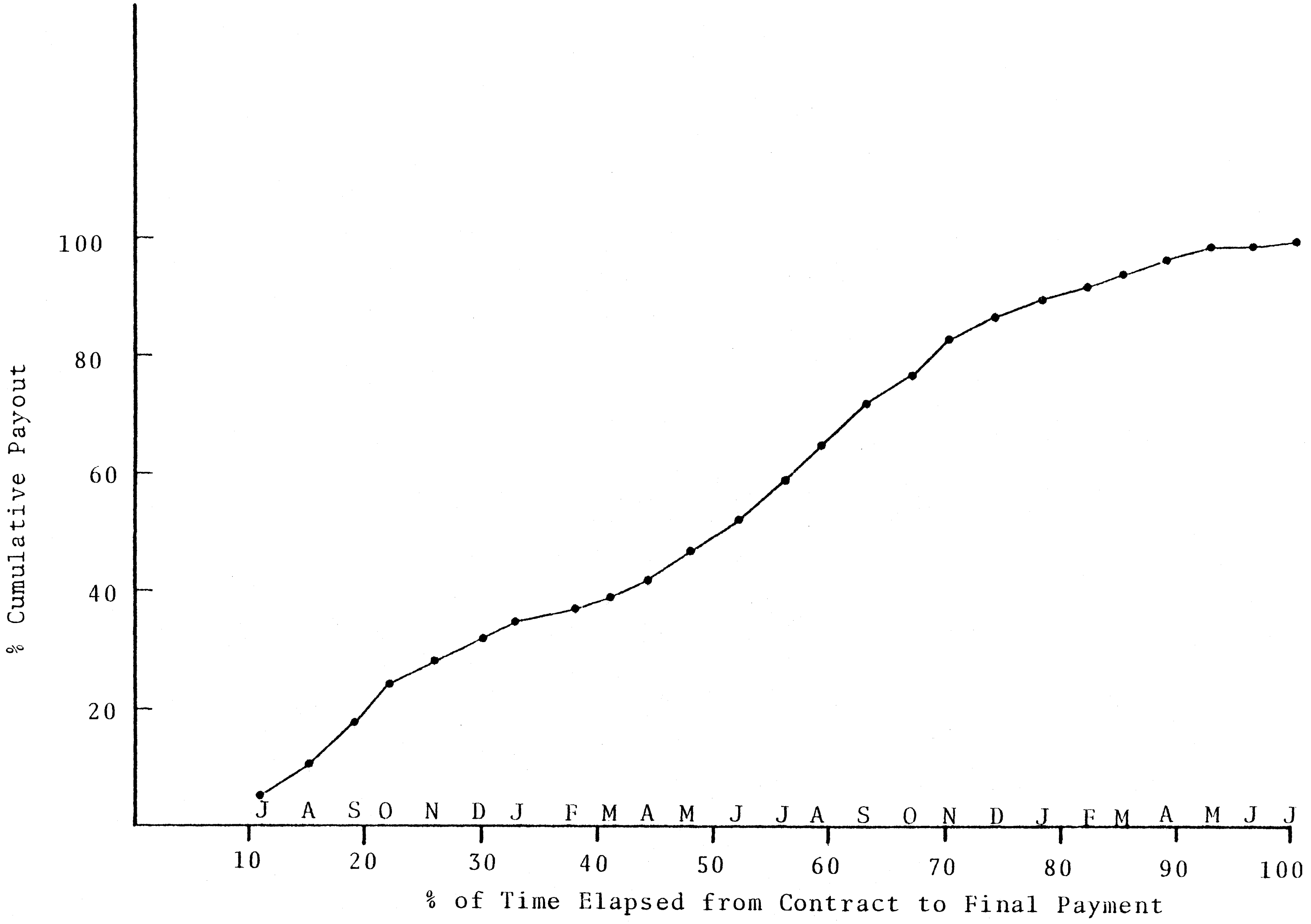


Figure 15. Sample payout curve from monthly factors method.

RETROSPECTIVE TESTS OF THE FORECASTING TECHNIQUES

The forecasting techniques described in the previous section were tested retrospectively to determine if they could duplicate the payout patterns of the sample. This was not a true forecasting test, however, for the following reasons: (1) a true forecasting test should be on contracts that were not in the sample used to develop the forecasting technique, (2) the retrospective tests did not involve predicting the ad dates for proposed contracts, and (3) the retrospective tests utilized monthly seasonality factors based on the actual sample data, whereas in actual forecasting one will always be trying to predict the next year's payout using monthly factors from the previous year or years.

Tests of the Monthly Factors Method

A streamlined version of the monthly factors method was tested using two sets of monthly factors. The streamlined version of this method is designed to be simple to implement because it does not require updating each month based upon the payments which have occurred. Once a contract is added to the data base, no further information will be required, unless it is a proposed contract whose estimated cost or ad date is changed.

The retrospective test using monthly factors from the combined 3-year sample was extremely successful. As Figure 16 shows, the forecast tracked the highs and lows of construction activity very closely. Statistically, the monthly factors method explained more than 93% of the variation in construction payout in this test. On the other hand, the method underestimated the construction peak in June through September of 1980 by several million dollars. This implies the possibility that weather conditions were exceptionally good that summer, allowing the summer peak to be even higher than usual.

Another retrospective test was performed using monthly factors from only the FY81 portion of the sample to see if more specific monthly factors would improve the forecast. As Figure 17 shows, the estimates of the summer peak were much closer, but the rest of the forecast was not as good. Overall, the percent of variation explained in this test was about 92%. This result indicates that it is very difficult to improve one segment of the forecast by tailoring the monthly factors to it without adversely affecting the rest.

A more elaborate version of the monthly factors method was also tested. In this version, the data base was continually updated so that the amount remaining in each contract each month was calculated using the payments made up to that point. Surprisingly, the results of this test were not as good as those of the streamlined version. A possible explanation of this is that such a technique imposes a set of monthly payout factors on the contracts which are not representative of average payout patterns.

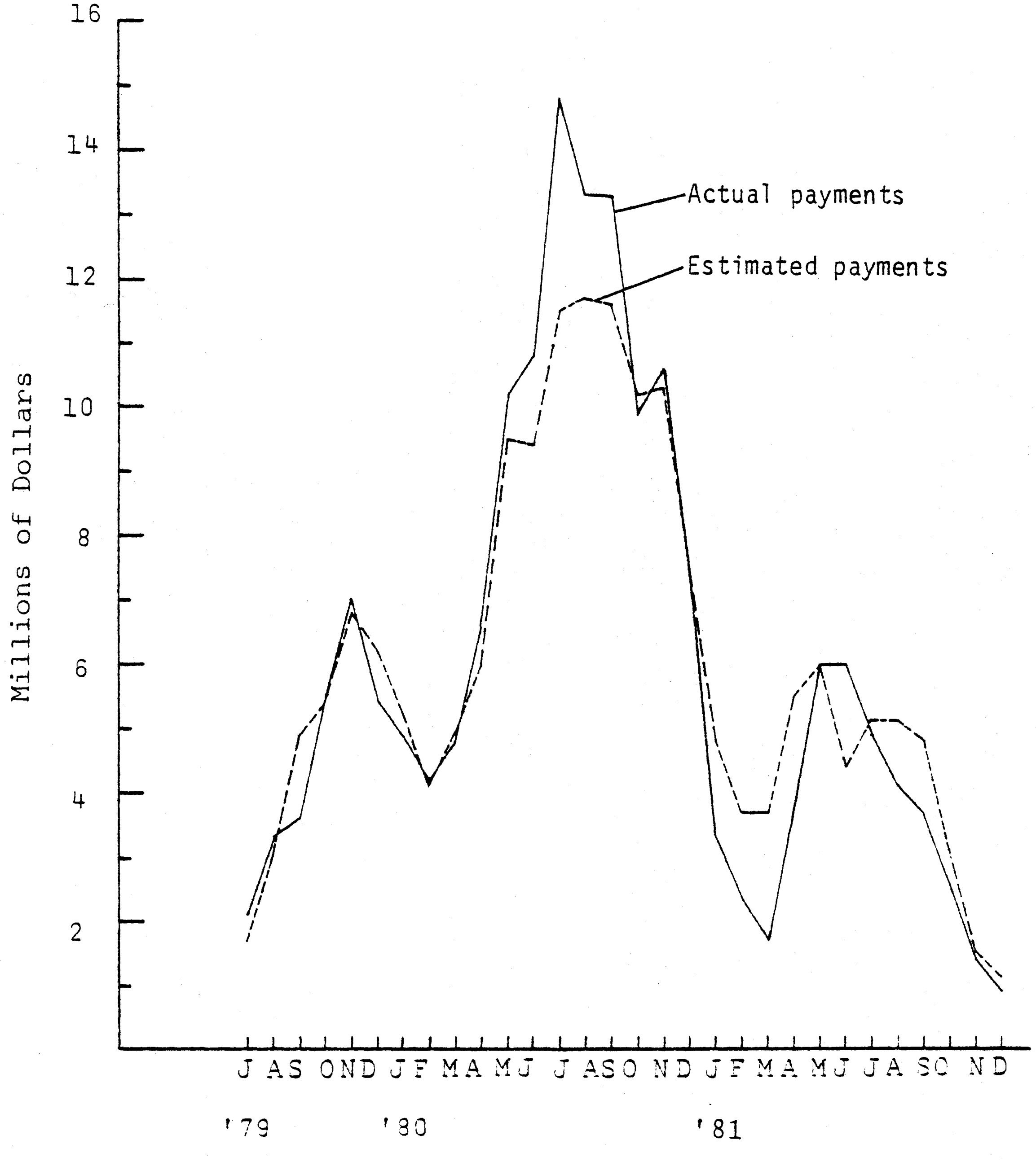


Figure 16. Test of streamlined monthly factors method using factors from combined sample.

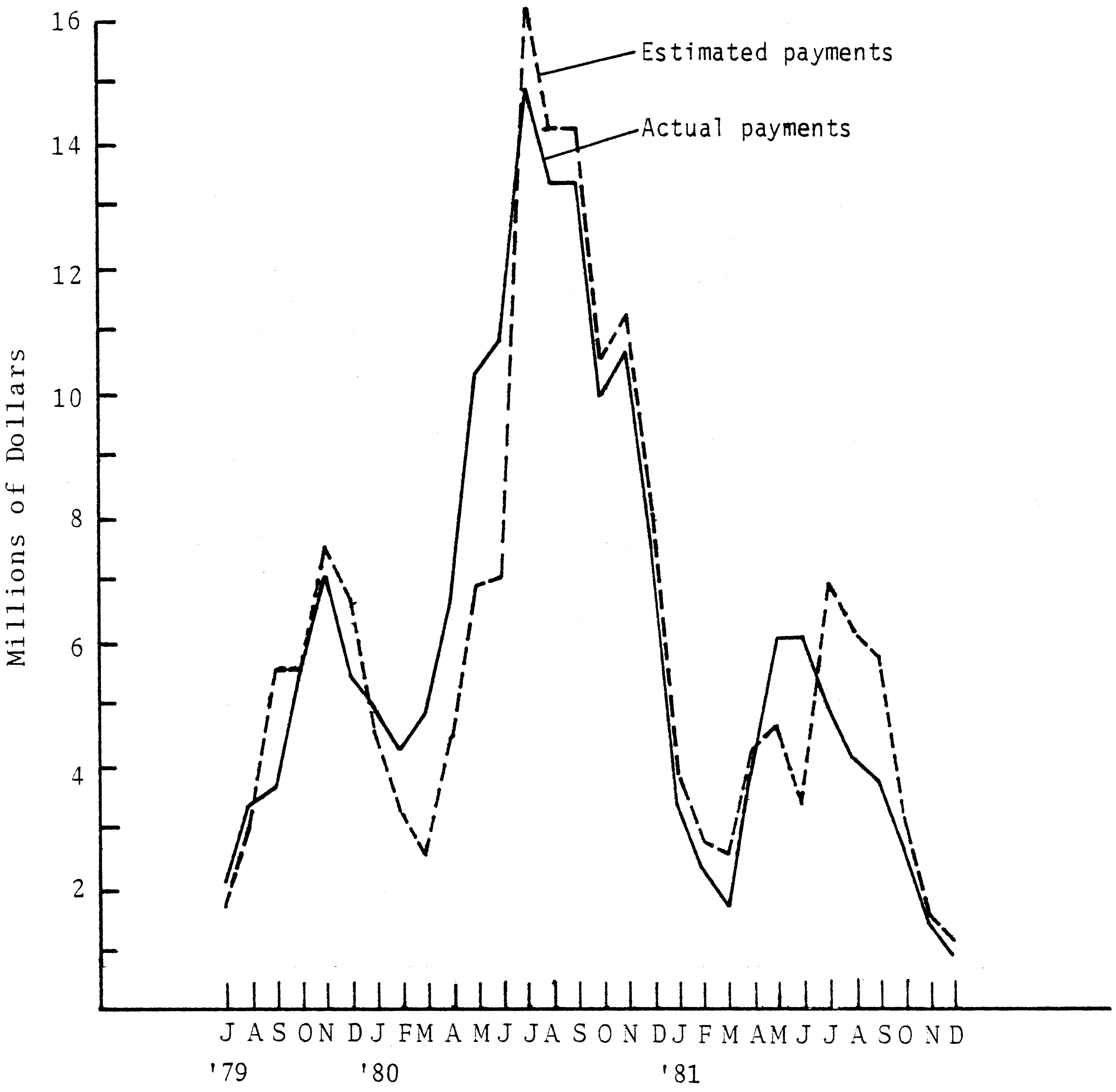


Figure 17. Test of streamlined monthly factors method using factors from FY81 sample.

The regression method described earlier was also tested in both a streamlined and an elaborate version. The results of both of these tests were significantly worse than those of the monthly factors method. The reason may be that the regression method does not capture the effects of seasonality as well as the monthly factors method does.

The following section discusses the requirements for implementation of the streamlined monthly factors method.

IMPLEMENTATION REQUIREMENTS

The information and procedures required for implementation of the streamlined version of the monthly factors method are relatively simple. This forecasting method requires less new information each month than does the method now used for current contracts. Nevertheless, effective implementation will involve cooperation among the Budget Division, the Information Systems Division, the Fiscal Division, the Construction Division, Programming and Scheduling, and Location and Design. Data interfaces and information flows may need to be significantly improved for accurate forecasting. It is also understood that the Research Council will actively participate in the implementation process by assisting with the adaptation of computer programs written at the Council, by monitoring the performance of the forecasting method, and by suggesting modifications if a need is indicated.

Data Inputs Needed

For each contract, whether existing or proposed, six items of data are needed on —

1. project number,
2. project type,
3. road system,
4. federal share (optional)
5. contract amount or construction cost estimate, and
6. contract date or ad date plus 2 months.

In the sample data base, project type, and road system were coded manually as follows:

Project Type: 1) C, M, or N in any combination with others
2) C plus B
3) B or mostly B (with G or P)
4) G only
5) P only
6) L only
7) S only

Road System: 1) Interstate
2) Primary
3) Secondary
4) Urban

However, the computer program could be modified to do this coding automatically based on the project number.

The federal share is needed for each project if the Budget Division intends to calculate federal-aid reimbursements on the basis of specific projects. If they intend to use averages, these data are not needed. The problem of forecasting federal-aid reimbursements will be examined in depth in Phase II of this study.

Table 12 displays the data sources which have been identified thus far for the forecasting inputs needed. Implementation of the forecasting method will initially require a data base consisting of all projects which have been awarded, advertised, or scheduled for advertisements. After that, monthly updates will be required on –

1. new contracts which have been awarded, and
2. any changes in ad dates or construction estimates for projects on the advertising schedule.

Ideally, this information could be transferred directly from the central computer to the Budget Division's microcomputer by an electronic interface. Alternatively, the central computer files could be transferred to floppy disks which are readable by the microcomputer. If neither of these methods of data transfer is feasible, the Budget Division may want to consider implementing the forecasting method on the central computer to facilitate data updating. The alternative is to enter all data from hard copy manually into the microcomputer. Of course, any data which are not available in the central computer's files will have to be entered manually from hard copy. It is possible that this method could result in more prompt updates than waiting for the central computer's files to be updated. This decision will be influenced by hardware and software availability and compatibility, and by personnel availability in the Budget Division.

Table 12

Sources for Forecasting Inputs

	HARD COPY DATA SOURCES					COMPUTER SOURCE
Phase of Contract	Project Type	Road System	Federal Share	Contract Amount or Construction Estimate	Contract or AD Date	ALL DATA
Contract Awarded	C.D. or F.D.	C.D. or F.D.	F.D. or	C.D. or F.D.	C.D. or F.D.	Contract Obligations File
Advertised But Not Awarded	P&S	P&S	P&S	C.D.	P&S	PDMS
Scheduled For Advertisement	P&S	P&S	P&S	L&D	P&S	PDMS

Implementing the Computer Program

The computer program written at the Council was designed solely to test the forecasting methods on the sample data base. Modifications will be required to make the program compatible with the computer hardware, with the arrangement of the data files, and with the rest of the Budget Division's cash flow forecasting system. The Budget Division may also wish to revise the format of the tables produced by the program to provide more information. The computer support staff of the Council will work closely with the Budget Division and the Information Systems Division in making these modifications.

Updating the Forecasting Method

The sample data base of 173 completed contracts used to develop the forecasting method should be expanded to include all additional projects which have been completed. These data should be reanalyzed to ensure that the equations for duration and final estimate and the monthly factors are representative of recent construction activity. This process of data collection and reanalysis should be repeated periodically.

The results of the forecasting method should be evaluated frequently and compared to the results of the existing forecasting methods over the next few months so that modifications can be made if a need is indicated.