- Reduced oxidation of mixtures;
- Less CO_2 as a result of less fuel;
- Emulsion, cutback, or sulfur mixtures;
- No particulate or hydrocarbon emissions;
- Clean water by-product/water conservation; and
- Investment credits not otherwise available.

Letters patent obtained regarding this invention are USA No. 4,245,915 and No. 4,378,162, Australia

No. 519,913, Great Britain No. 8,027,237, and Canada No. 1,148,935. Other foreign patents pending.

Unified System for Contract Management in Pennsylvania

JAMES W. SLAUGHTER

ABSTRACT

Before the 1980s the Pennsylvania Department of Transportation managed the various functions that surround construction contracts by using an unwieldy combination of manual and automated procedures. One of the department's major data processing development projects during 1981-1982 resulted in the implementation of a new contract management system. That system, which is now used to administer construction contracts, enables contracts personnel to capture initial design estimates, maintain a standard items catalog, develop bid proposal packages, maintain a library of standard special provisions, tabulate and evaluate bids, certify and monitor all contractors, prepare the contract itself, track contract-contractor relationships, monitor automated pricing data on standard items, adjust active contracts via work orders, estimate and process payments to contractors, forecast cash flow requirements, monitor any litigation, and close out completed projects. The background, basic characteristics, and costs and savings of Pennsylvania's contract management system are described.

Since 1979 several steps have been taken in Pennsylvania to better manage construction activities and to fully integrate all functions associated with highway program management. Various automated systems, which take advantage of on-line computer terminals and shared data bases, now support and promote improved program planning and management. More information on the systems and the ways in which department personnel use those systems has been published in other papers (1,2).

The purpose of this paper is to describe the contract management system used by the Pennsylvania Department of Transportation to administer construction contracts.

SYSTEMS ENVIRONMENT

The management information systems for the Pennsylvania Department of Transportation are housed in the central office in Harrisburg. The computer mainframe has 32 megabytes of main memory and 70,773 megabytes of additional disk storage. The information for all the systems mentioned in this paper is stored in direct access disk devices and is manipulated by modern data base management software. The application systems themselves were designed, tested, and implemented totally within the framework of the department's formal data processing development methodology.

There are more than 1,400 cathode ray tube (CRT) terminals and printers in the department's data communications network. All 11 of the engineering district offices and nearly all central office organizations access and update data via these terminals and printers. Figure 1 shows a representation of the department's data communications network.

BACKGROUND

Construction contract activities are better understood when viewed from the perspective of the department's business groups. Of three major business groups comprising the Pennsylvania Transportation Department--Commonwealth Transportation Systems Group, Driver and Vehicle Services Group, and Municipal Grants Management Group--the "roadway business" in the Commonwealth Transportation Systems Group is predominant. Because the department owns and operates its roadway business and, thus, controls all key performance areas, integrated highway program management has been recognized as a key success factor in the department's turnaround during the last 4 years. As a result, the department has evolved toward a data processing strategy in which "integration" has become a means to an end (i.e., increased productivity and improved services).

The concept of integration is increasingly demonstrated throughout the department. For example, the highway programming process in Pennsylvania has developed into an explicit and visible process by which management allocates resources and integrates these decisions into its production process.

● DISTRICT OFFICE
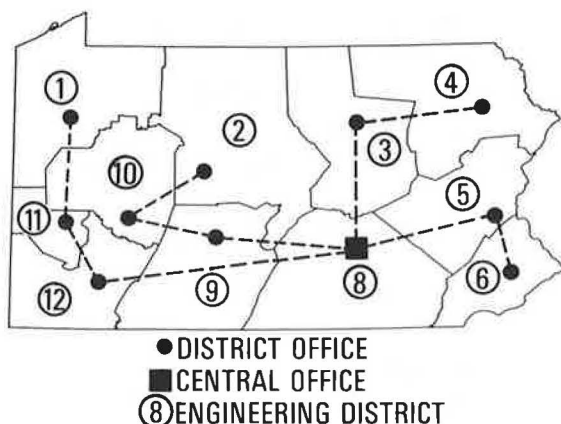■ CENTRAL OFFICE
⑧ ENGINEERING DISTRICT

FIGURE 1 Pennsylvania DOT's data communications network.

Noteworthy in Pennsylvania's highway programming process is the Program Management Committee (PMC). The PMC, chaired by the Secretary of Transportation and comprised of several of the department's top managers, oversees the development of the 12- and 4-year programs, as well as the 1-year obligation plan and quarterly letting schedules. Supported by the Center for Program Development and Management, the PMC monitors performance of project selection, funding, major milestone schedules, approvals, and out-of-tolerance adjustments. Similarly, performance monitoring of routine maintenance is under the direction of the district engineers who are responsible for managing that program.

It is within this framework that "integrated" information systems have proved useful. Two information management systems, project inventory and project management, are used to track all candidate, programmed, and authorized projects under PMC purview. Regardless of the nature of a project, all construction contracts--including both maintenance and improvement projects--are tracked by the contract management system.

The Deputy Secretary for Highway Administration is responsible for the successful completion of work on all construction projects. To ensure uniformity in application and consistency of standards, two central office bureaus monitor activities: the Bureau of Design monitors preconstruction, and the Bureau of Construction and Materials monitors construction. The 11 engineering districts, which also report to the Deputy Secretary for Highway Administration, are organized much like the central office for managing contract processes. Working closely with contractors, local governments, and the central office, district office personnel carry out line management functions within contract processing.

The contract management system is the data processing tool used by the department to increase productivity and improve services within construction contract activities. After a project's design phase is completed and the project is approved for letting and construction, the contract management system processes begin.

CHARACTERISTICS

In the major part of this paper the actual characteristics of the contract management system (CMS) will be described. The areas that will be covered are security and backup, information flow, and batch reports.

Security and Backup

In addition to data management software that protects the data bases, a password mechanism is used in the CMS to provide three added levels of security. Everyone who uses CMS is assigned a unique password that is stored on a special, separate data base. A password has 20 different indicators that define in detail those three security levels.

The first level of password security indicates the "office code" of the password's owner. The office code is checked by the system to assure that personnel can access only information about their organization.

A second security level concerns the 13 specific on-line screens and the types of access, if any, that are available to the password's owner. The types of access are inquiry, update, and none (no access). If a person's password indicator for a screen is blank, that screen information is not accessible. If the indicator is "I," the screen data can be seen but not changed. If the indicator is "U," the password owner can add, delete, change, or simply display information within that screen.

The third level of security deals with confidential information and "signature" authorizations. These indicators are used by the system to check whether the password's owner is allowed to approve work orders or payments to contractors. Other indicators at this security level are used to allow a person to view certain confidential data or to change the status of an overall contract.

For backup of the CMS data bases, there are nightly tape copies made of each. The data management software prevents the loss of any on-line transactions during the daily processing. These two protections form the system's backup.

Information Flow

There are four major areas involved in processing information through the CMS:

- Contract functions,
- TEXT functions,
- Construction item functions, and
- Contractor functions.

Because contract and TEXT functions are closely interwoven, those two subjects will be described under one heading. Note that the word "TEXT" is used to mean the CMS function that allows a person to manipulate lines of words from an on-line terminal. The word "text" is used for the subject matter (lines of words) that is stored in the CMS Document data base.

Two data processing terms need to be explained. The word "on-line" refers to direct interactive teleprocessing between CRT terminals and printers and the mainframe computer. This means that changes entered via CRTs are made to the data bases immediately. On-line processing enables a person at one terminal to update information and, an instant later, someone at any other terminal location can display that revised data or use it in an urgently needed report.

The word "batch" refers to the computer processing that is not done in the interactive teleprocessing environment. Because of the higher costs of teleprocessing, most recurring reporting and system maintenance functions are batch processed. High-volume and time-consuming processes are carried out in batch mode. For example, information purges of history files and monthly statewide reports are done by batch processing.

Any batch and on-line processes that could possibly try to update the same data should not run simultaneously. Most of the on-line processing occurs during normal working hours; so, batch work is usually processed in the late evening after the on-line work has stopped.

Contract and TEXT Processing

CMS processing begins when district office personnel enter five types of information. These data are vital to the accurate tracking of a project through CMS. Development of the bid proposal package, letting information, and several other contract processes depend on the data entered from the design package. The five kinds of information to be input from terminals by district personnel are

1. Basic contract information, which includes overall items of interest such as contract number, project location, important dates, and contract status;
2. Funding data, such as federal, state, and local shares, accounting codes, and work type breakdowns;
3. Design item information, such as item numbers, funding sources, units of measure, design estimate prices and quantities, item descriptions, and operation codes;
4. Schedule data, such as number of calendar days by operation code, month, and year; and
5. Text information for the bid proposal package, including the project description, general provisions, and special provisions.

A "status" field in the basic contract information is used to indicate a contract's stage of development. The six stages through which a contract passes are design, letting, award, current, semifinal, and final. As the contract progresses and the status is changed from one stage to another, the system automatically "locks out" some data from further updating. Some status changes cause batch activities to occur that night. For example, when the status on a contract is changed from "award" to "current," the contract award and execution dates (along with other fields) are "locked," and the bid prices from the designated three low bidders are used that night to automatically recalculate certain statistics in the (standard) Items data base.

First, each district office assigns a unique contract number to a project. The contract number is a six-digit number of which the first two digits are the district's numeric code and the last four digits are a sequence number. This contract framework avoids any contract numbering confusion among the district offices.

After a contract number is assigned, the basic contract data, schedule, funding, and design items can be entered. Using the on-line terminals, district personnel enter that information into CMS. Entered for items are item number, quantity, funding source, and unit price. For nonstandard items, three more fields of information must be given: unit of measure, operation code, and item description. CMS calculates the price extensions and total design estimate amount and stores all information on the CMS Contract data base. Figure 2 shows the Design/Contract Item screen.

The design estimate data are easily accessible by the on-line functions of CMS. Information can be added, changed, and deleted according to a district's needs. In addition, an on-line Design Item report, which summarizes item estimate data, can be printed at any (on-line) printer in the district or central offices.

Contract No.   Contract Status

Design Total $
- - - - - - - - - - - -
Item #   Funding   Operation

Unit Measure   Description

Original Qty

Desn. Unit   Awrd Unit
Price   Price

Qty Added   Qty Ded   Qty Used

FIGURE 2 Design/contract items screen.

The schedule information, taken from a bar chart developed during the project's design phase, is also entered from terminals. The calendar day breakdown for the project's schedule is important for the development of Cash Flow Reports that will be described later.

At the same time some district terminals are being used to enter estimate data, other district terminals can be used with CMS TEXT functions to develop the bid proposal package for a contract.

TEXT functions offer some of the most powerful capabilities in the CMS. Available from any CRT, the CMS TEXT screens provide all the usual text-handling features--create, change, delete, copy, print entire documents and move, add, copy, revise the lines of words (text) within documents. There are other CMS TEXT functions, however, that are designed especially for contract processes and are proving to be substantial labor savers.

For example, at two different times during CMS contract processing, information is acquired programmatically from nontext data and rearranged into specific department document formats; then, the actual, formal department documents are created on the CMS Document data base. All these actions occur without a single manhour expended.

The types of documents maintained by CMS TEXT functions are further examples of customized features. The three types of documents are standard, simple, and package.

Standard documents are those that contain the text that is most commonly used to prepare bid proposal packages. A specialized variation on standard documents is the capability in CMS to "merge" certain lines from one document to another. This allows the standard document to serve as a "form letter" with only a few lines that need to be filled in (e.g., dates, names, locations), while another document need only contain the few lines that are to be completed in the "form letter." Standard documents are protected and can only be changed or deleted by a central office password. These documents can, however, be used by every district office.

Simple, or stand-alone, documents can also be created. These documents are stored in the CMS Document data base and can be updated and printed in the same manner as all other CMS text. For example, this paper is stored in the CMS Document data base; it was developed and printed without having to relate to the non-TEXT (contract, contractor, or items) functions within CMS.

The last type of document, a "package," is used

to list all the separate documents that are to form a particular bid proposal package. When the various necessary documents have been established, the bid proposal package is actually assembled by creating a "package" document. This package document contains the exact names for each document needed for the bid proposal package. When CMS prints this package, it prints all the documents in order as listed in the package document.

A document is printed in several ways. Two different types of on-line prints are available. First, a work print, which shows a document exactly as it appears on the CRT (including the line numbers), can be done. Second, a full print, which has no line numbers and which "expands" the printout to look like a finished product, can be made. Both on-line TEXT prints will be created immediately on any on-line printer.

A significant feature of CMS on-line printing is the capability to designate any on-line printer as the destination where hard copy is to be printed. This "electronic mail" feature is proving to be more useful and efficient than other forms of interoffice correspondence.

Batch is the other mode in which documents are printed. This style of printing is done at night on the system laser printer. When a CMS user enters a request on a CRT for a document to be batch printed, a message is logged on the CMS Activities data base. Later that night the activity message will trigger a batch document print process. Batch printing is preferable when the document to be printed is voluminous or is not needed until the next day.

After basic contract information, the design estimate, and the bid proposal package are entered into CMS and reviewed by the appropriate district personnel, the contract status is changed from "design" to "letting." This triggers a message on the Activities data base, and during the nightly batch processing, CMS automatically builds the Bid Schedule of Prices text for the proposed contract. That text is programmatically created and placed on the Document data base under a predefined naming convention and is available that same night to be printed as part of a bid proposal package. The next morning that Bid Schedule of Prices document is also accessible via the on-line CMS TEXT screens.

CMS is also designed to speed the bid tabulation and bid evaluation process of a letting. After the bids are opened and read, information for each bid is entered into CMS via the CRTs. CMS displays a screen format on the terminal showing the item number, quantity, and unit of measure from the design estimate information. The basic bid information (contractor number, letting date, and total bid price) from each bidder is filled in on the screen. Figure 3 shows the Bid Letting screen; X marks entry fields. The item information that needs to be entered on this screen is the contractor's unit and extended prices of the items listed. CMS then computes the extended amounts from the unit prices and quantities shown. CMS also calculates a total bid amount from the data entered on the bid. The computed totals are maintained on the Contract data base and are displayed during an inquiry or update of that contractor's bid information.

When a contractor's bid has been entered, the next bid for the contract is entered in the same manner. Several different contractors' bid prices can be entered simultaneously into CMS from different terminals. This process continues until all the bids for a proposed contract are completed.

After all the bids for a proposed contract have been entered, an evaluation request is made of the CRT. An on-line evaluation process is performed on each bid. The computed amounts are compared with the contractor's entered amounts and any discrepancies are flagged. Because CMS has access to both the Items and Contractor data bases, a bidder can be evaluated in terms of his ability to do at least 50 percent of the work. An on-line Bid Evaluation report that shows all the contractor's bid information is produced. For each bidder, there is a list of item numbers, quantities, contractor's extended amounts, computed extended amounts, and flags if the amounts do not agree. For each contractor, a percentage of the work that the contractor is qualified to do is calculated and printed on the evaluation report. These combined features provide easy comparison of bids.

All information entered for a proposed contract, whether design estimate or bid data, is easily accessible from CMS terminals. The bid information entered can be viewed again and corrections made. After all corrections have been made, the evaluation process may be performed again and the Bid Evaluation reports produced. This process is repeated as many times as necessary to complete the evaluation.

When the final bid order is established, the same bid information on-line screen is used for marking the "bid status" (order) of each individual bid (Figure 3). When the bid status has been completed for the low three bids, CMS logs a message on the Activities data base. This message triggers a batch Bid Tabulation report to be run that night. The Bid Tabulation report is described later.

To advance from proposal and bid processing toward contract execution, the award date is entered and the contract's status is changed to "award" by using the basic contract information on-line screen. This status change causes the nightly batch process to build the Contract Schedule of Prices on the CMS Document data base using the designated low bidder's information. The remainder of the contract text is developed by using the on-line TEXT functions of CMS.

After a contract is awarded, the prime contractor and subcontractor information for all contractors working on a contract can be added, displayed, or updated by using the on-line functions of CMS. Each contractor's certification number, whether prime or sub, his percentage of the work, and the contract dollar amount for which he is responsible are maintained for each contract.

When the contract has been executed and the work has begun, any changes in the contract item quantities or prices may only be made through a work order. The on-line functions of CMS are used to develop work order worksheets. The information needed by CMS for a work order is the item number, operation code, quantity, unit of measure, and unit price. CMS calculates the additions, deductions, and total work order cost. CMS produces an on-line printed Work Order report that contains all the necessary totals.

The work order information is accessible by CMS through the CRT. Additions, deletions, and correc-

Contract No. (X)   Bid Status

Work %

Contractor No. (X) Total Bid $ (X)

Item #	Qty	Unit Price	Bid Total
		(X)	(X)

FIGURE 3 Bid letting screen.

tions can be made at any time during the review and approval process. After the work order has been approved, however, no changes can be made to the approved work order. The Work Order report, which lists items and totals, can be produced at any time during the remainder of the contract.

CMS is also used as an aid in the work order approval process. Because CMS can access all standard items, people approving the work orders can inquire against the (standard) Items data base to check on average weighted unit prices by locale for any questionable work order item.

When the work order is ready for approval, the needed approval data are added to the on-line screen that was previously used in preparing the work order. At this time the status of the work order is changed from "review" to "approved." A work order can only be approved by certain people in the user community and, in addition, the on-line edits precisely follow the department policy on who can and cannot approve work orders. After a work order has been approved, the work order information is locked and then used to automatically adjust item quantities for further payments.

When a payment estimate is completed by a field inspector, the estimate information must be submitted to CMS via a CRT in the district office. Required data are item number, funding code, quantity, and days of contract time completed. When the payment data have been entered and marked for review, a message is automatically logged on the Activities data base. During the nightly batch processing, a report that lists all the payments ready for approval is produced in the central office. That report is then routed to the Bureau of Construction and Materials.

When a payment estimate is ready for approval, a Payment Estimate worksheet is requested from a terminal by approval personnel. An on-line printer nearby immediately produces the desired hard copy. This estimate worksheet lists items, descriptions, quantities, funding, units of measure, and prices. A totals sheet is also created and shows the breakdown by funding source of the total dollar amount to be paid.

All payment information in CMS is accessible through CRTs. Payment data can be added, updated, or deleted at any point in the approval process. The Payment Estimate worksheet can be produced from an on-line printer at any time.

When a payment has been approved, no further changes to that payment can be made. A Payment Estimate worksheet is triggered again, signed by an authorized individual, and sent to the Comptroller. This sheet contains all the data necessary for the generation of the contractor's payment.

If a contract involves litigation (i.e., one or more claims are filed against the contract), the claim court docket information is entered via terminals and is stored in the Contract data base. Docket data can be added, altered, or deleted at any time during the life of the claim.

After all claims have been cleared against a contract and the contract is in final form, the contract and its associated data remain in the on-line data bases for approximately 6 months. After that time, the final contract is moved to a history file that can be accessed if needed.

Construction Item Processing

A standard item is a construction item that is defined by department specifications. These standard item numbers, current cost figures for each standard economic area (locale), and a "weighted average unit price" covering cost figures for a 2.5-year period are maintained on the CMS (standard) Items data base.

After the three low bidders have been determined for a proposed contract and the contract itself has been awarded and signed, the status of the contract in CMS is moved to "current." This causes a message to be added to the Activities data base. During the nightly batch processing, the standard item information from the designated three low bidders is used to update the construction item current cost figures and to recalculate the average weighted unit prices.

The information contained in the (standard) Items data base is also accessible to the on-line functions of CMS. Figure 4 shows the main fields on the Item Catalog screen. This standard item information is easily brought up by any terminal user with the proper inquiry authority. However, updates to this data are carefully controlled: this information can be changed only by a few people.

Item No.		Unit Measure		
Operation		Prequal Codes		
Item Description				
Last/Avg Unit Price	Last/Total Quantity	Date Last Price	High/ Low Price	No of Bids

(Entries for five locales)

FIGURE 4 Construction item catalog screen.

Contractor Information Processing

All contractors who work on state highway construction contracts must be prequalified by the state. To gain this eligibility, a contractor must send into the Bureau of Construction and Materials a prequalification package. This package contains three statements that are used to determine the various contractor qualification ratings. The contractor's affirmative action statement is used to determine the contractor's equal opportunity posture. The contractor's organization and experience statement is used to determine the types of work a contractor is qualified to do for the department. The contractor's financial statement is used to determine the quantity of work that a contractor can undertake along with his current obligations. The prequalification package must be completed and submitted by the contractor in order to achieve state qualification. When a contractor has once been qualified by the state, a prequalification package must be sent in yearly in order to maintain state qualification.

The Bureau of Construction and Materials evaluates the prequalification package and, if the package is approved, issues a certificate making the contractor eligible to submit bids. Contractor qualification information is entered into CMS using the CRT, and the data are stored on the CMS Contractor data base. During the course of the evaluation process, contractor information is added, changed, or deleted. Figure 5 shows the Prequalified Contractor screen; the Y or N after each type of work indicates whether the contractor can (Y) or cannot (N) carry out that type of work.

Maintaining the contractor data is the responsi-

Contractor No.		Status
Name	Minority Type	Expiration Dates
Address		
IRS No.	Capacity ($)	Ability Factors

A: N	B: N	C: Y ...
(42 Types of Work)		

FIGURE 5 Contractor screen.

bility of the Bureau of Construction and Materials. Only a few people can add, revise, or delete this information. Most of the contractor data can be displayed at a terminal by anyone in the CMS community. There are data, however, that are confidential and can only be seen by the Prequalification Officer and other selected personnel.

Batch Reports

Batch reports are preprogrammed and are available to run at night on request or on a preset recurring basis. Unlike the six different types of CMS on-line reports mentioned earlier, the batch reports are printed only on the laser printer in the central office.

It should be noted that the department also uses proprietary report generator software packages that are available through CRTs and can access various CMS data. These packages round out the CMS reporting capabilities by providing powerful, yet flexible, tools for the CMS user community.

During the nightly batch processing, an extract process is performed against each of the CMS data bases. A series of sequential files is produced from the extract process. From these sequential files, any or all of the reports listed hereafter can be created. The first four reports are briefly described; several other report titles are simply listed to illustrate the variety of production reports in CMS.

- The Bid Tabulation report is created on the night when the order of bids for a contract has been established. Shown are the contractor information (name, address, certification number) and each of the three low bidders' unit price and extended amount for each item bid. The report also shows total bid amount for each of the other bidders. Rejected bidders, if any, are named without displaying price information.
- The Construction Contracts report shows by district the current contract expenditures. On the report are contract number, location, contract status, and amounts such as expenditures, retainage, liquidation, tendered, and contract total.
- The Contractor/Contract Cross Reference lists for each contractor the contracts in which he is participating. Shown are percentage of work, work amount, current contract amount, and the code for whether the contractor is a prime contractor or a subcontractor for that particular contract.

- The Cash Flow Forecast for a Single Contract breaks down the contract amount into the months of the year during which the work is to be performed. The report shows, for each future month, the amount of work scheduled to be performed and, for past months, the payments tendered.

Other reports that can be generated are

- Status of Contracts by Federal Project Number,
- Contracts Finalized in a Given Period,
- Status of Contractor Claims,
- Qualified Contractors List,
- Disqualified Contractors List,
- Confidential Qualified Contractors List,
- Prequalified Contractors Average Factors,
- Minority Contractors List,
- Qualification Expiration List,
- Line of Credit Expiration List,
- Contractors Qualified for Type XX Construction, and
- Construction Cost Catalogue.

COSTS AND SAVINGS

CMS development costs, annual operating costs, and estimated annual savings are given in Table 1. All personnel costs include overhead, such as benefits. The development period for CMS was from November 1980 through December 1982. The annual operating costs include on-going CMS enhancements by in-house systems personnel. The savings estimate is entirely from the standpoint of efficiencies and personnel productivity. The user community claims that, with CMS, it would require 40 fewer people than it did in the pre-CMS era to administer the same number of contracts. However, with a substantial increase in construction contracts, this means that, with CMS, the department can administer more contracts with the same number of people. One area of large savings is the development of bid proposal packages. It is estimated that 40 to 70 percent savings are being realized by using CMS TEXT functions to prepare bid proposals and related material.

TABLE 1 CMS Costs and Savings

	Development Costs ($) (11/80-12/82)	Annual Operating Costs ($)	Estimated Annual Savings ($)
Consultant systems personnel	327,100		
In-house systems personnel	243,800	100,000	
In-house user personnel	136,000	2,600,000	900,000
	(40 manmonths)	(115 people)	(40 people)
Machine (computer)	50,000	100,000	
Total	756,900	2,800,000	700,000[a]

[a]$900,000 minus annual operating costs of in-house systems personnel and machine.

In Table 1 the total annual savings is calculated by subtracting both the annual operating costs for machine and the in-house systems personnel costs from the estimated annual savings for user personnel.

PLANS FOR THE FUTURE

The CMS is evolving with the department in its systems strategy. Currently, there is a major data processing development effort under way to implement a completely new set of "foundation information systems." These integrated systems are to provide the

automated processes that are most essential to running the department's three business groups. Included are systems for financial management, budgeting, project accounting, federal aid billing and tracking, accounts payable, human resources management, and accounts receivable. These systems are to replace the department's existing accounting system. The CMS will interface with at least two of the foundation systems.

In another important venture, the department is actively gathering and analyzing bid and bidder information to detect bid collusion and rigging patterns. With solid data provided from such systems as CMS, the potential advantages for the department are enormous. One single such case in 1983 resulted in the department gaining a $1.5 million settlement. More competitive prices are now anticipated because such bid collusion cases are publicized in the news media.

Data processing systems for general maintenance and department resources are also being revamped. A new system is being developed to improve and integrate department processes dealing with maintenance management, automated inventory management, and equipment management. There may be a need to integrate some functions from CMS and the new maintenance management system.

There are other improvements to be made to CMS. Processes such as monitoring percentage goals by contract for minority business enterprises are to become more automated and integrated for CMS and other systems. The CMS user community regularly submits ideas for improving the system. Improvements will probably continue as long as system changes bring about further increases in productivity or improvement in services.

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Adjusted Pay Schedules: New Concepts and Provisions

RICHARD M. WEED

ABSTRACT

Shortly after the AASHTO Road Test had furnished a wealth of statistical data on pavement construction and performance, highway agencies began to use this data to develop end-result specifications based on statistical concepts. These specifications usually included adjusted pay schedules, the development of which was sometimes quite arbitrary. More recently, attempts have been made to improve both the accuracy with which pay schedules are established and the fairness with which they are administered. The rationale underlying several recent advances in the state-of-the-art is discussed. Included are the use of the principle of liquidated damages to relate pay reductions to the anticipated monetary loss resulting from substandard work, the development of the crediting concept to overcome a basic inequity of many existing pay schedules, and the establishment of bonus provisions that provide additional incentive by awarding payment slightly in excess of the contract price for superior quality work.

The AASHTO Road Test generated a wealth of data relating pavement quality to performance. Shortly

thereafter highway agencies began to use this data to develop end-result specifications based on statistical concepts. It was found that various statistical measures effectively described the characteristics that were desired and that, by performing tests on random samples taken at the job site, it was possible to determine the extent to which the desired results had been achieved. Then, depending on the degree of compliance, adjusted pay schedules were used to award an appropriate level of payment. A recent report (1) traces the evolution of specifications of this type.

Although not all highway agencies embraced this new approach with equal enthusiasm, it was difficult to deny the many advantages that statistical end-result specifications offered over the earlier "method" specifications. A major advantage is the practical mean end-result specifications provide for dealing with marginal quality. A construction item that falls just short of the specified quality level does not warrant rejection but neither does it deserve 100 percent payment. Adjusted pay schedules provide a logical and convenient way to accept work that is only slightly deficient. Another desirable characteristic is the proper division of responsibility. By defining the control of the construction process as the contractor's responsibility and the acceptance of the work (end result) as the highway agency's responsibility, a much firmer legal basis is established for those situations in which truly