Computerized Daily Site Reporting

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Abstract: This paper describes a computerized approach for collecting and processing site information that builds on the traditional superintendent's daily site report. System design considerations and features, lessons learned from field use, and future extensions are highlighted. Goals include improvements in the ease and accuracy with which field data can be recorded and processed to produce fast feedback on project status and problems. Benefits claimed for the approach include development of a coherent picture of the current status of a project and how it got there; faster response time in dealing with problems; integration of the site reporting, project planning, and project scheduling functions; an increased likelihood of schedule updating and speedier updating (thus leading to increased schedule credibility); help in dealing with claims; and documentation of experience in a form useful for future projects.

Introduction

A construction project is a unique, complex, custom-built response to a client's needs. It involves the execution of a large number of diverse activities by many participants, and evolves in both space and time, normally in a hostile and changing work environment. Consequently, it is very difficult, if not impossible, to "instrument" a construction project fully to:

- Record the values of various context variables (e.g., weather conditions and work-force parameters) that are helpful in explaining reasons behind the current status of a project.
- Assess the current status of activities, extra work orders, and back charges in terms of active state (e.g., postponed, started, ongoing, idle, and finished), work scope completed, and problems encountered and their immediate consequences (man-hours and/or time lost).
- Measure resource consumption rates and their allocation to ongoing activities.

Collection and analysis of the foregoing information is essential for the quick detection of time, cost, scope, and quality deviations from planned performance; explanation of the causes of these deviations; and, thus, the suggestion of appropriate corrective actions.

Currently, to instrument a project for reporting on work progress and problem sources on an ongoing basis, one must employ human sensors, i.e., seasoned construction personnel. At present, for the reasons described later, site reporting for the majority of projects is less than satisfactory. With time, bar coding (Stuckhart 1990), video (Eldin and Egger 1990), electronic weather stations, and so forth will be used more extensively to supplement human sensors, but only for specialized or narrowly focused measurement tasks.

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Much of the literature to date on project control deals with sophisticated methods for processing the information identified previously, given the assumption that it can be collected and, more often than not, at considerable levels of detail. Insufficient work has focused on what information can be readily and reliably collected (especially for early detection of problems), how best to collect it, how to forge a two-way link between the collection process and the systems used for planning and control, and how to provide feedback to site and office personnel at a much higher frequency than offered by traditional cost-accounting and schedule-updating cycles.

This paper describes one approach that addresses these issues at the overall project level for medium-sized building and civil engineering projects from the perspective of the general contractor or construction manager. For such projects, site and office management personnel must fulfill multiple functions as opposed to being dedicated to one (e.g., planning and scheduling). Application of the approach to large-scale projects would require additional features to cope with scale effects.

The approach, which seeks simplicity and practicality, starts with the superintendent's traditional daily site report so as not to increase the reporting burden. It reflects the resource limitations imposed because of competitive pressures and the skill levels of site management personnel. Instead of the report being the normal free-form document (perhaps with some preprinted headings), it is generated by the planning-and-scheduling system, with reporting being standardized around activities, responsibility, and problem-source codes. Reports can be entered directly into the computer on site or entered later from the hard-copy report completed by the superintendent or their assistant. Once entered, the data can be used to update the schedule in terms of actual start and finish dates, or projected finish dates in the case of ongoing activities. Thus, a link is forged between the planning-and-scheduling process and site reporting.

Benefits claimed for the approach include the following: development of a coherent picture of the current status of a project and how it got there; faster response time in dealing with problems because multiple views of the project can be generated right at the site; integration of the site-reporting, project-planning and project-scheduling functions, thus enhancing communications between site and office; an increased likelihood of schedule updating and speedier updating, leading to increased schedule credibility; help in dealing with claims; and documentation of experience in a form useful for future projects.

Observations on Current Practices

The paradigm for the planning-and-control process is conceptually simple:

1. Identify the primary construction strategies and technologies that will shape the project plan.
2. Scope the work in terms of activities and responsibilities, based on project definition, construction strategies and technologies selected, and past experience.
3. Sequence the work in the form of a network model.
4. Select methods for the activities, and determine their durations or production rates.
5. Compute the schedule.
6. Iterate through steps 1–5 with those involved to ensure acceptability.

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7. Communicate and implement the plan.
8. Monitor progress and problems.
9. Incorporate actual performance, including scope changes in the plan, recompute the schedule, then revise the plan and schedule, incorporating corrective action(s) as required.
10. Document and resolve claims.
11. Document the experience gained in a form useful for future projects.

Although simple in concept, there are difficulties for virtually every step in this process, given current practices. Our focus here is on step 8—specifically field reporting from the viewpoint of the general contractor. Improvements to steps 9–11 are a by-product of the proposed approach.

From direct observation of several projects, the eighth step tends to be very poorly done. The only report that must be done with certainty and as much accuracy as possible, is the daily time sheet. Even then, while all hours worked by the general contractor's personnel and heavy equipment must be accounted for, their allocation to individual cost codes and/or activities, if done at all, is approximate at best and highly unreliable at worst.

If progress and problems are reported by the superintendent or their assistant in the traditional daily site report, it is done using descriptors that most likely do not correspond to activities in the schedule and that change from day to day for the same work item. (In some cases, especially on larger projects, we have observed that some site personnel with reporting responsibilities have no familiarity with the project schedule; they perform task planning and reporting without reference to it.) Yet this is the only report that attempts to describe ongoing work and problems on a daily basis.

Few standards exist that describe how field reporting should be done. Also, it is almost always done manually, precluding computerized analysis. Consequently, its use is limited to claims situations, at which time the inadequacy of the reporting is realized. Without automated processing, it is almost impossible to isolate trends or causes of problems quickly enough to ameliorate problems while they still exist.

Impediments to effective execution of step 8 are severalfold.

1. It is difficult to identify the state of each activity on a daily basis—sites can be very extended, not all work is readily visible, crews may be assigned to more than one activity simultaneously, and so forth.
2. Those observing site activities in most cases receive little training in formal recording, and tend not to think in terms of cause-and-effect chains when describing problems. Thus, for example, if an activity starts late because mechanical work was not completed on time, which in turn started late because of errors in drawings, the problem recorded is invariably a late start by the mechanical subtrade. Additionally, the qualifications of site staff are highly variable, ranging from tradesperson to professional engineer. Literacy capabilities vary widely and can create embarrassing situations.
3. The daily site report is not integrated with the schedule—it is treated as a completely separate document, blank in its initial state except for prespecified headings. Thus, no advantage is derived by field personnel in having the overall work plan translated into day-by-day reporting formats for field use. We contend that this is an important missing link in the development of integrated planning-and-control systems.
4. Those responsibile for observing and recording data on a daily basis

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tend to be action-oriented and shun paper work. This propensity to avoid comprehensive documentation of a day's events is heightened because of the very substantial pressure these individuals are under to maintain momentum of the project and respond to problems, the perennial understaffing of field management positions because of intense competitive pressures, and the perception that these reports may be used against them. Seemingly, as long as the project is proceeding in a satisfactory way, senior management is forgiving of inadequate reporting. If the daily report could be turned into something useful for site personnel as well as serve the company's information needs, the likelihood of it being properly completed would be increased.

5. It is difficult to make a compelling case to senior management to justify increased expenditures for reporting and analysis for achieving time and/or cost savings. It is not that they don't exist; they are just hard to measure and cannot be pinpointed a priori. The argument used most successfully to date deals with improved success with claims, leading to attainment of other day-to-day benefits.

The challenge becomes how to build on existing reporting structures, because of their longstanding general acceptance, to improve the processes of planning and control. Attempts to introduce additional reporting layers will fail as field management personnel are already overburdened. In fact, for a system to succeed, it must integrate present reporting requirements in a way that reduces the current burden while improving the quality of the data obtained. Thus, the approach described here builds on the superintendent's traditional daily site report.

Features Required

To rectify current deficiencies, attention needs to be directed to both technical and human/organizational issues, which are in fact interrelated (e.g., ease of use becomes, in part, a user interface design issue). Technical issues include such topics as the specific item to be measured, ways to measure it, methods to classify information, development and use of standards, appropriate data structures, relationships amongst data items, exchange of information among functions, and user interface design. Human/organizational issues deal with items such as motivation of personnel to comply with reporting requirements, training, implementation strategies, sharing of information, and the way information is used. The focus of this paper is on technical issues. However, the writer's experience suggests that a technical fix alone is insufficient as the human/organizational side is the largest impediment to improved planning and control. (One could contend that a less-than-perfect system implemented and complied with effectively is far superior to a very good system poorly implemented.) In this regard, training programs must receive high priority. As part of a complete implementation strategy, they are crucial to the success of the approach described in this paper.

Identified here are several of the more important features required of an automated site-reporting system. The first two—dealing with computerized integration of site reporting with a planning and control system and with development of a standard classification of problem sources—are central to the approach devised. For effective transfer of experience to new projects, additional standards relating to activity descriptions, and subcontractor coding should be treated.

System Integration

Essential to a streamlining of the reporting functions of site personnel, while achieving more complete and accurate data and more effective control, is the integration of the daily site system with other project management functions. These include planning and scheduling, procurement, cost accounting, change-order management and extra work orders, back-charging, and document control. The goal is to be able to trace the implications of a site problem in terms of immediate consequences, actions taken to mitigate it, and the final outcome. Practically, this means that the daily site system must be able to extract information from the project management data base in standard formats for data collection purposes as well as to provide selected information required for the other management functions mentioned previously. The tactic adopted to achieve this for the system described here is to embed the daily site system directly within a planning-and-scheduling system. An alternative would be to have separate application programs with translators to facilitate the exchange of project data.

In computerizing the daily site report, consideration should be given to what information can be provided to site personnel both to help them in their management tasks and to ease their reporting burden. For example, by integrating daily site reporting with planning and scheduling, it is possible to identify what subtrades should be present on any given day as well as which activities should be worked on. Additionally, if manpower requirements for each activity were available (information that is very difficult to obtain from subtrades in building construction), then the number of tradespeople per subtrade expected each day could also be output, which could then be compared to actual subtrade staffing levels. Effectively, integration allows day-to-day customization of the daily site report, putting more useful information in the hands of site personnel.

Problem-Source Classification

To facilitate automated analysis to spot trends, suggest corrective actions, and assign responsibility for problems, it would be helpful if consensus could be achieved on a universal list of problem sources encountered in on-site and off-site construction processes and elements of this list standardized in terms of terminology and groupings. The term *problem source* is used here to indicate presence of a condition that may point to time, cost, quality, scope, or safety problems. The existence of a source (i.e., its recording in the field) does not necessarily mean that one or more problems will result. For example, heavy precipitation may cause a delay in an excavation activity. However, some allowance for inclement weather undoubtedly will have been included in the original estimates of activity duration and cost. So, for this case, analysis of daily site records permits an estimate of the cumulative time lost to date because of inclement weather, which can then be assessed against any allowance made in the original estimate.

One way of approaching compilation of a universal list is to develop a list of problem-source classes (e.g., weather, site conditions, and owner/consultants), and a list of relevant problem sources for each class (e.g., excessive precipitation, congestion, and design change). For the first implementation of the system, problem-source classes and sources were developed in consultation with project management staff of a general build-

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ing contractor who specializes in high-rise residential construction and who sponsored some of the earlier work on the system. This breakdown was hard-coded into the software. While it worked reasonably well (it was used for more than two years on numerous projects, during which time contractor personnel did not request changes), it is not extensive enough to encompass a broad range of project types. Later use on a major civil engineering project demonstrated the need for flexibility in allowing the user to edit and augment the problem classification, depending on the nature of the project. For example, for heavy civil work, access and geotechnical problems may need to be broken out in considerable detail.

Field experience coupled with an examination of the claims and productivity literature (Bramble and Callahan 1987; Smith 1987; Thomas and Yiakoumis 1987) has resulted in an extensive list of soft-coded problem sources.

- Weather:
  - Temperature too high
  - Temperature too low
  - Wind too high
  - Too much precipitation
  - Humidity excessive
  - Freeze-thaw cycles present
- Site conditions:
  - Storage space insufficient
  - External access inadequate
  - Internal access inadequate
  - Congestion present
  - Site not prepared/ready
  - Ground conditions poor
  - Ground conditions unexpected
  - Work space not cleaned
- Owner/consultants:
  - Decision(s) required
  - Changes requested
  - Interference/stop work orders present
  - Extra work requested
  - Inspection/tests awaited
  - Quality demanded excessive
- Design/drawings:
  - Drawings insufficient/incomplete
  - Errors in drawing
  - Design changes/additions made
  - Information conflicts
  - Design coordination poor
- Work force:
  - Undermanning
  - Overmanning
  - Trade stacking
  - Low skill level
  - Excessive turnover
  - Low motivation/morale
  - Inadequate instructions

    - Unsafe practices/accidents
    - Poor trade coordination
- Work:
    - Rework (design changes)
    - Rework (workmanship)
    - Rework (damage)
    - Rework (errors)
    - Estimating errors
    - Construction error
    - Layout error
    - Poor workmanship
- Supplies/equipment:
    - Insufficient materials
    - Insufficient equipment
    - Late delivery of materials
    - Late delivery of equipment
    - Tools/equipment breakdown
    - Fabrication errors
    - Poor materials handling
- Schedule:
    - Delay of activity predecessor
    - Improper activity sequencing
    - Out-of-sequence work
    - Delay of off-site procurement
    - Duration estimate inadequate
    - Damaged deliveries
- Utilities/city:
    - Awaiting permits
    - Awaiting connections
    - Awaiting inspections/tests
    - Interference with utilities
    - Damage to existing utilities
    - Unanticipated utilities
- Miscellaneous:
    - Theft
    - Strikes
    - Vandalism
    - Shutdown from workers' compensation board
    - Contract award delay
    - High noise levels
    - Natural disaster

The list continues to evolve as it is applied to more and more projects. Interestingly, the small number of contractors using the system seem to adopt the breakdown given and add little in the way of new insights as to the groupings of problem sources or individual sources within a grouping.

The subject of problem sources and their classification is deserving of considerably more work because of its central importance to the analysis of daily site records. Ideally, problem sources should be defined in a way that each is independent of the other, avoiding cause-effect relationships amongst them. This is important for automated interpretation of problem sources for purposes of suggesting corrective actions because relatively simplified reasoning processes can then be employed. Nevertheless, other work (Diekmann and Al-Tabtabai 1992) that makes use of causal models indicates such independence may not be possible to achieve.

Measurement

The design of an automated system must give recognition to the difficulty of recording data in the field. The recording task has to be made as simple and foolproof as possible and reflect the considerable time pressures personnel work under. Preformatted responses should be available for checking or circling to minimize writing and errors. To assist in the latter, use of hand-held, pen-based computers that could be used directly in the field (Carr 1991) are deserving of consideration when the technology is more reliable. Their use would help avoid dependence on site personnel memories at the end of the day when much of the paperwork is normally done.

Most important to address is what data should be collected on a daily basis to provide a useful image of the current status of the overall project and how it came about. At least two types of data are required: overall project context information; and data on ongoing work tasks as described in terms of activities (both scheduled and unscheduled), extra work orders, and back charges.

The first data group provides important context or backdrop information that can be used to help explain performance at the individual task level. Data elements include site environment conditions (e.g., weather, access, and ground conditions), work-force parameters (e.g., trades present, numbers of workers and supervisory personnel, and skill levels), and flows of goods and services onto and off of the site (e.g., inspections and deliveries). Many of these data items appear in preprinted daily-site-report formats typically found within construction firms. We have sought to refine their descriptions to make the data gathered more useful for analyzing activity performance.

The second data group deals with the activities, extra work orders, and back charges scheduled for a given day. Data of importance include: status of a work task (postponed, started, ongoing, idle, or finished); description of the work performed that day; problem sources encountered; what project participant, if any, is responsible for the problem source; an extended description of the problem source and its consequences for the work task at hand; field quantification, if possible, of man-hours and/or time lost; and suggestion or identification of actions to deal with the problem source.

Ideally, all data sought should be quantifiable in numerical form using objective and reproducible measurement techniques. This is seldom the case, except for selected weather data and subtrade manpower counts. Instead, one is faced with making subjective assessments expressed in linguistic as opposed to numerical variables. For example, ground conditions may be expressed as good, fair, or poor, with additional commentary to describe specific features.

Our observation is that construction personnel are comfortable making subjective assessments of inanimate items and do so reasonably effectively. (Their years of experience provide them with a mental image of what is more or less typical or average. This image becomes the benchmark against which they gauge the situation at hand.) They seldom, however, record explanatory or supplementary notes. Furthermore, when faced with making assessments of personnel-related issues, whether dealing with their own

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work crews or the assessment of subtrade performance, they are reluctant to do so. Fear of the assessments becoming public knowledge and thus creating friction in working relationships or being used to impute less-than-satisfactory performance in the execution of their own management duties seems to form the basis for the reluctance. As an example of this, we explored the concept of a leading indicator of activity performance on a civil engineering project. The idea was to have site staff rank daily activity performance as to above, equal to, or below expectations. Theoretically, this would permit the detection of trends early on—for example, allowing initiation of corrective actions as speedily as possible for cases of continuing substandard performance, or possibly reallocating resources in the case of better-than-anticipated performance. However, personnel were not prepared to share the judgment even though it is often made, fearing this type of scenario: You constantly ranked performance above average, yet there is now time and cost overruns. Why? The idea of a leading indicator is worthy of more investigation, but at present, it has not been implemented.

Interface

As many defaults as possible must be used to minimize the amount of information that has to be recorded by field personnel on a daily basis. As stated in part previously, date information, activities, and change orders scheduled for work and their expected state (e.g., start, in progress, or finish), subtrades responsible for the day's activities, and scheduled deliveries can be automatically output on the form, given integration of the system with other project management functions. The facility to treat unscheduled work, extra work orders, and back-charging also has to be included.

Consistency checks should be included to provide immediate feedback about data anomalies. Examples of such anomalies are situations where an activity is flagged as being completed but given an ongoing status the next day, or where a subtrade is recorded as having no manpower on site yet subtrade activities are reported as ongoing.

Routines are required to filter out redundant data (site conditions, shared manpower, and equipment resources) when area superintendent reports are merged. Typically, large projects are broken into a number of subprojects and/or work areas, whereas site conditions and resource use (including manpower and equipment) cross these organizational boundaries, leading to redundancy in reporting. To develop a coherent view of the total project, individual site reports have to be merged and overlaps reconciled.

A rich reporting environment is required so that performance by activity and/or trade can be accessed; problem sources analyzed; correlations between activity/trade performance, work environment, and site conditions studied; and so forth. Tabular and graphic representation capabilities as well as rudimentary statistical analysis techniques are required. They can be fulfilled either by building these features directly into the system or by permitting export of the files to other software tools.

System Features and Lessons to Date

Selected aspects of the current version of the daily site system are described here. It has been developed within the framework of an integrated construction management software system called Representing Construction (REPCON) (Russell 1990). The phases of development of the system (i.e.,

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research prototype used by researchers; first system version for use by others; and finally the current system, which is still evolving) reflect an incremental learning process that took place over several years. Generous access to the projects and personnel of two firms—one a general building contractor, the other a heavy civil engineering contractor—has been instrumental in this learning process and in making the system responsive to many of the realities of construction.

A brief profile of the kinds of projects that shaped development of the system is helpful. We focus on the two firms most closely associated with development and use of the system, although it has been used by others on high-rise building projects.

The general building contractor's specialty is multiunit housing projects, with the occasional foray into hotel, retail, and commercial construction. The majority of the projects are built within a 25-km (15-mi) radius of the head office. The housing projects range from single building projects of seven to 35 stories to multibuilding projects (the largest to date is a 14-building project consisting of townhouse complexes and apartment buildings). Project value ranges between $4 million and $25 million, and project duration is between 10 and 18 months. Projects are executed under either a lump-sum or construction management contract. Site staffing typically consists of a seasoned project superintendent, a project engineer and a foreman if the project is large enough, and a safety officer. At the head office, a project manager is in charge of the project and obtains backup from office staff. Daily-site-report formats are generated at the office in duplicate, sent to the field for completion, and returned to the head office for data entry and schedule updating.

The locations of projects pursued by the heavy civil engineering contractor are generally far from head office. The construction site may range from less than 1 km long to more than 5 km long. Project size ($30 million–$300 million) and/or spatial distribution of a project requires several area or specialist superintendents along with substantial site staff who function largely independently of the head office on a day-to-day basis. Each project may involve a number of subprojects and last from 1.5 to five years. Contractual arrangements are based on lump-sum and/or unit price contracts. Projects are capital-intensive in terms of formwork technology, cranage, and other equipment, including specialized fabrication facilities. They usually involve a significant number of design and site condition changes which often lead to claims. The projects also involve significant risks because of their technical complexity, long duration, unanticipated site conditions, and exposure to the elements. They may involve joint-venture partners. Finally, the client is invariably an arm of government, involved directly or indirectly through consultants with the project.

Because of space limitations, features of the system are displayed through the use of screens as opposed to printed formats. An overview of the system by way of the daily-site-system menu is shown in Fig. 1. Integration of the daily site system with other aspects of the planning-and-control system is reflected, in part, on this menu. For example, the Enter Extra Work Orders menu item ties in with change-orders management. Not shown is the integration with the update function under Planning and Scheduling, which provides the option of interpreting daily site data to generate actual dates for use in schedule updating.

As indicated in Fig. 1, time sheets were also automated, including the ability to preprint tradesperson names and active cost codes. This helped

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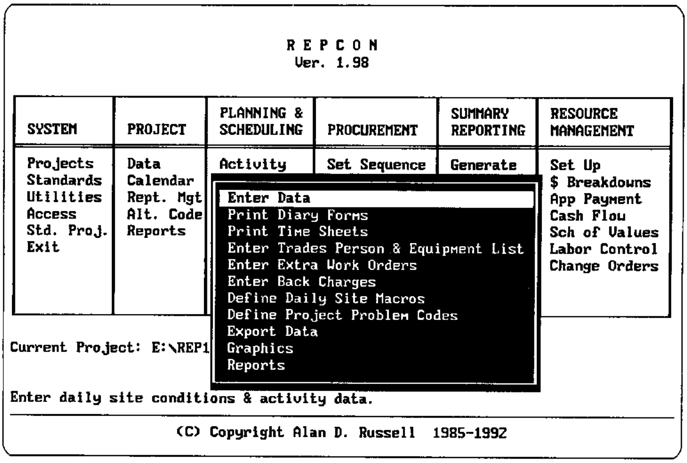

FIG. 1. Daily Site System Menu

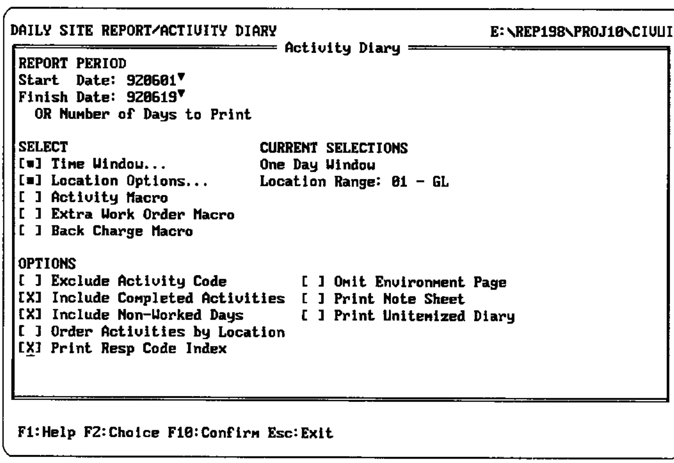

FIG. 2. Customizing Daily Diary Report

achieve acceptance of more rigorous daily site reporting for the general building contractor. For each day, the site superintendent receives, in duplicate, a computer-generated daily site report plus a time sheet, with company policy being that both must be completed and submitted. Having both forms partially filled in makes the task of completing them more appealing to site staff.

Fig. 2 depicts the specification of printed daily diary forms for field use. Reports can be generated for several days at a time. The user can select a one-, three-, or five-day window. For example, a five-day window means that all activities and subtrades that are scheduled to be active "today" or up to two days before or after "today" will be listed on the daily diary. Use of a wider window is helpful when schedule performance cannot be determined precisely or updating is not done frequently. Also shown is the ability

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to customize the report in terms of the work locations, activities, extra work orders, and back charges that are to appear. This feature is important for larger projects where several daily site reports are being completed each day. Other options exist to suppress or include information. (The flexibility to tailor the diary format and its elements was a recurring theme in dealing with site personnel, especially for the civil engineering contractor.) Given confirmation of the various options, the system searches across the data base for all activities, subtrades, extra work orders, and back charges that are scheduled to be active for the days and options selected; it then outputs the daily diaries. Each diary contains a list of problem-source codes and descriptions plus responsibility codes (optional) for easy coding in the field.

The facility exists to create a standard classification and set of problem sources under Standards at the system level (see Fig. 3). This Standards file can then be copied over to the project level and tailored to the specific needs of the project at hand. Alternatively, project problem-source codes and descriptions can be entered directly. Currently, allowance has been made for 10 groupings and nine sources in each. Typically, less than 10 problem sources comprise the group most commonly cited on completed reports.

Once the daily diary report is completed by field personnel, its contents can be keyed into the computer, at either the site or the head office, depending on the division of duties. For smaller projects, it is feasible to enter daily site data directly into the computer. For this case, a hard copy of the completed daily diary should be printed and signed by the superintendent.

The format of the data entry screen is shown in Fig. 4. General information about work-environment data (Fig. 5), work-force data, and other data is entered followed by activity status and performance information. The capital letters in Fig. 4 indicate actual activity status for that day; the exclamation marks indicate that one or more problem source codes and/or comments have been entered against the activity status for that day.

Specification of the status of an activity is shown in Fig. 6, and elaboration of a problem source in terms of its responsibility if applicable, extended description, measurable effects and possible follow-up actions is shown in

DAILY SITE/PROBLEM CODES E:\REP198\PROJ10\CIVUI

Revise Print rEport Quit

CODE	CATEGORY/DESCRIP	REM	CODE	CATEGORY/DESCRIP	REM	CODE	CATEGORY/DESCRIP	REM
10	WEATHER	N	20	OWNER/CONSULTNTS	N	30	SITE CONDITIONS	N
11	Excess Precipitn	N	21	Decisions Reqd.	Y	31	Poor Grnd Condit	N
12	Insuff Precipitn	N	22	Changes Request.	N	32	Insuff Storage	N
13	High Temperature	N	23	Interference	N	33	Ext Access Prob	N
14	Cold Temperature	N	24	Extra Work Reqd.	N	34	Int Access Prob	N
15	High Wind Speed	N	25	Insp/test Delay	N	35	Congestion	N
16	Excess Humidity	N	26	Excess Quality	N	36	Site Not Availbl	N
17	Freeze-thaw Cycl	N	27		N	37	Unantic. Grnd Cd	N
18		N	28		N	38	Dirty Work Space	N
19		N	29		N	39	Insuff. Power	N

N
N
N
N
N
N

Remark: This problem code relates to delays, sequence changes, work stoppages, etc caused by late or no owner decisions.

F1:Help F10:Confirm Esc:Exit

F1:Help F10:Confirm Esc:Exit

FIG. 3. Problem-Source Standards

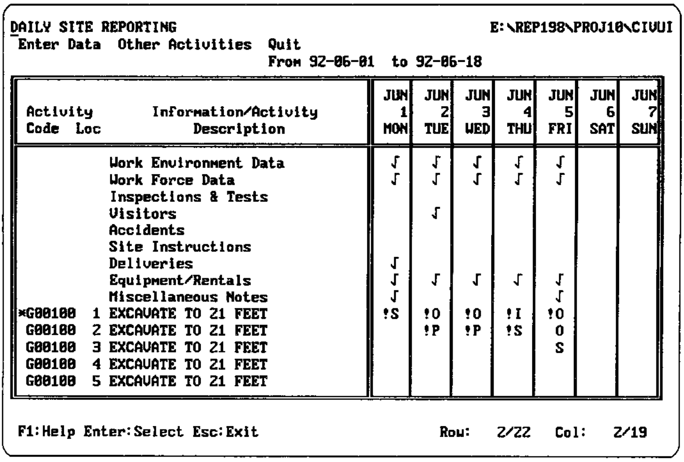


FIG. 4. Entering Daily Site Data

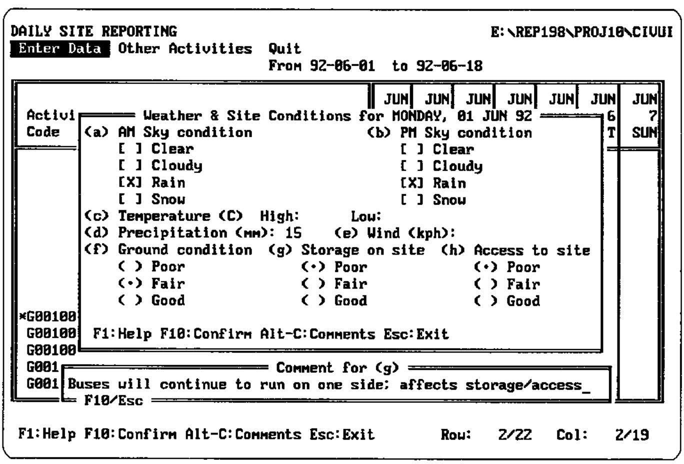


FIG. 5. Specifying Work Environment Data

Fig. 7. Multiple problem sources can be recorded for an activity for a given day. The fields labelled "ADJ" reflect adjustments made to field estimates of man-hours and/or time lost after a broader assessment of the problem source and its implications. These values are entered through a separate screen (not shown), where explanation of the basis of the adjustment is made. The initial field estimates are not altered directly because of the legal implications in case of claims. As shown in Fig. 7, allowance has been made for links with a document-control system (e.g., letters and memos) in the future.

Once activity status data has been entered for one or more days, the project manager or scheduler may choose to initiate the updating process. As a first step, daily site data can be reviewed through the update menu item under Planning and Scheduling. System-forecast completion dates and

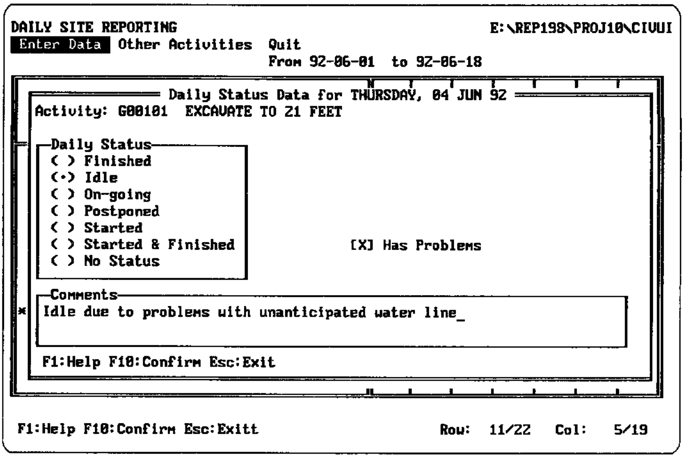


FIG. 6. Activity Status

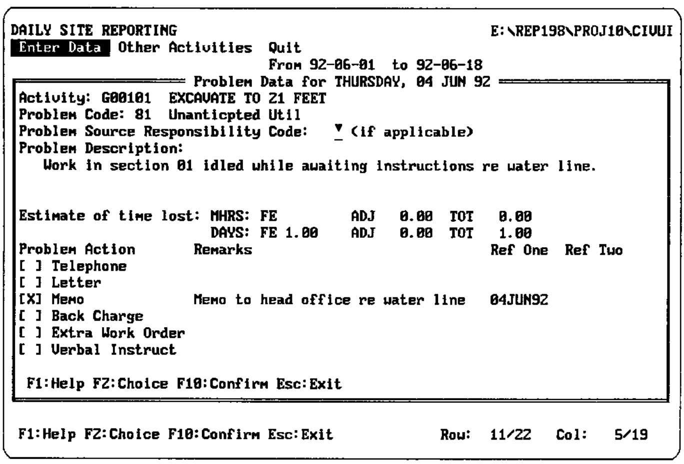
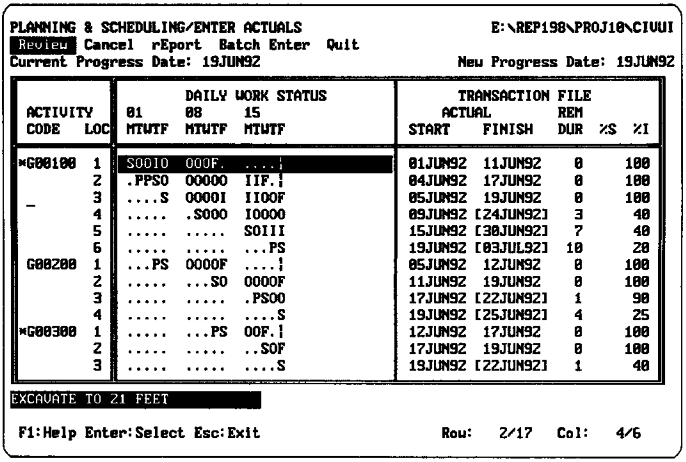


FIG. 7. Activity Problem Source Information

progress percentages for ongoing activities can be modified by the user as required, and the results batch-entered into the project files. Part of the batch-enter-actuals review spreadsheet is shown in Fig. 8. The immediate benefit from the link between daily site records and the planning-and-scheduling system is the ability to incorporate frequently actual activity performance into the schedule so that site personnel are always working with a current schedule. Hence, the schedule gains more credibility with site staff as it reflects what is actually happening, and personnel become more committed to providing useful information in the daily site report because there is a direct return.

An extensive text-based reporting system has been included that treats all of the information categories shown in Fig. 4. An activity history report is presented in Fig. 9 and a work environment report in Fig. 10. There is


PLANNING & SCHEDULING/ENTER ACTUALS E:\REP198\PROJ10\CIVUI

Review Cancel rEport Batch Enter Quit

Current Progress Date: 19JUN92 New Progress Date: 19JUN92

ACTIVITY CODE	LOC	DAILY WORK STATUS 01 MTWTF	08 MTWTF	15 MTWTF	TRANSACTION FILE ACTUAL START	FINISH	REM DUR	%S	%I
*G00100	1	SOOIO	OOOF.	....¦	01JUN92	11JUN92	0		100
	2	.PPSO	OOOOO	IIF.¦	04JUN92	17JUN92	0		100
_	3	....S	OOOOI	IIOOF	05JUN92	19JUN92	0		100
	4	.....	.SOOO	IOOOO	09JUN92	[24JUN92]	3		40
	5	.....	.....	SOIII	15JUN92	[30JUN92]	7		40
	6	.....	.....	...PS	19JUN92	[03JUL92]	10		20
G00200	1	...PS	OOOOF	....¦	05JUN92	12JUN92	0		100
	2	.....	...SO	OOOOF	11JUN92	19JUN92	0		100
	3	.....	.....	.PSOO	17JUN92	[22JUN92]	1		90
	4	.....	.....	....S	19JUN92	[25JUN92]	4		25
*G00300	1	.....	...PS	OOF.¦	12JUN92	17JUN92	0		100
	2	.....	.....	..SOF	17JUN92	19JUN92	0		100
	3	.....	.....	....S	19JUN92	[22JUN92]	1		40

EXCAVATE TO 21 FEET

F1:Help Enter:Select Esc:Exit Row: 2/17 Col: 4/6

FIG. 8. Daily-Site-Dates Spreadsheet for Updating

no end to the requests for being able to filter data in more and more ways so as to focus in on specific issues. To help meet such requests, the ability to export daily site data to a relational data base has been included.

Experience to date demonstrates that improved reporting in terms of quality of information obtained can be achieved, and that the schedule can be updated on a more frequent basis, enhancing its credibility with site personnel. Additionally, the reports generated provide useful insights into problem causes and help in negotiations with subtrades, consultants, and the owner as well as general problem solving.

Success of the approach requires a carefully crafted implementation strategy, including training of site personnel, with occasional reinforcement. Success is more likely to occur with site staff that see a future with the firm, i.e., they have not just been hired for the project at hand. This plus smaller-scale projects and a company policy accompanied by a procedure backed with resources have resulted in the greatest benefits being obtained by the general contractor to date. On the other hand, the potential for significant benefits from effective use of the approach lies with the larger, more complex civil engineering projects.

Use of the system has demonstrated the difficulty of accurately determining and recording activity status and problem sources. The greatest impediment deals with the personnel charged with the task of daily reporting. As noted previously, site personnel vary greatly in their level of education and attitude toward recording daily site information. Recent experience on a typical heavy-civil construction project reinforces this observation. The cross section of site personnel responsible for recording daily site information covered those highly educated (e.g., engineers), experienced, and willing to document work progress, productivity, delays and problems on one end to those who are uneducated and have difficulty writing (and therefore documenting daily site information) on the other. Not only does the level of reporting skill vary among these people but their willingness to record problems in the work also varies and is related to their tendency to align themselves with either the field or the office. Those who are "pro-field" and "anti-management" (which can include engineers) tend to shun

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```
DAILY SITE REPORT/HISTORY                                    E:\REP198\PROJ10\CIVUI
                         Report Period: 01JUN92 to 19JUN92

   | SCHEDULED/EARL    DATE      | PROBLEM
LOC| START   FINISH    & STATUS  | RESP CODE                          REMARKS & PROB
---+----------------  -----------+-----------------------------------------------
Activity: G00100  EXC
---+----------------  -----------+-----------------------------------------------
*01 | 01JUN92 05JUN92   01JUN92  S |   (11) Rain slowing digging.
    |                              |   (33) Excavator waiting because of tru
    |                   02JUN92  O |   (11) Precipitation causing muddy stee
    |                              |   (33) Excavators waiting for trucks be
    |                   03JUN92  O |   (33) Restricted access
    |                              |   (81) Hit old water line. Waiting for
    |                   04JUN92  I |   (81) Work in section 01 idled while a
    |                   05JUN92  O |   (11) Digging slowed because of rain.
    |                              |   (33) Time lost due to trucks queuing
    |                              |   (81) Problem of water line finally re
    |                              |        with the work.
    |                   08JUN92  O |   (33) Restricted access slowing excava
    |                   09JUN92  O |   (33) Restricted access.
    |                              |   (81) Electrical cable in location 3 c
F1:Help F6:Switch ↑↓←→ Tab BkTab PgUp PgDn:Scroll Esc:Exit
```

FIG. 9. Activity History Report

```
DAILY SITE REPORT/WORK ENVIRONMENT                           E:\REP198\PROJ10\CIVUI
                         Report Period: 01JUN92 to 19JUN92

         |NDITIONS          |
         |E ON SITE | ACCESS TO SITE |
  Date   | (g)      |       (h)      |                                      COMME
         |Fair| Good| Poor| Fair| Good|
01JUN92  |    |     |  X  |     |     | (d) Heavy rain
         |    |     |     |     |     | (g) Buses will continue to run on one
02JUN92  |    |     |  X  |     |     | (d) Rain affecting ground conditions.
03JUN92  | X  |     |     |  X  |     | (d) Let up of rain.
04JUN92  |    |     |  X  |     |     | (d) More bloody rain.
05JUN92  |    |     |  X  |     |     |
08JUN92  |    |     |  X  |     |     |
09JUN92  |    |     |  X  |     |     |
10JUN92  |    |     |  X  |     |     |
16JUN92  |    |     |  X  |     |     | (f) Still pumping.
17JUN92  |    |     |  X  |     |     |
18JUN92  |    |     |  X  |     |     |
19JUN92  |    |     |  X  |     |     |
F1:Help F6:Switch ↑↓←→ Tab BkTab PgUp PgDn:Scroll Esc:Exit
```

FIG. 10. Work Environment Report

paperwork. On the other hand, as the number of subcontractors increases on a project, so too does the willingness of the prime contractor's field staff to record problems caused by these subcontractors. Detection and representation of information can be biased because, as often happens in construction, each party is interested in representing selective truth for their own advantage. All of these factors result in a great deal of variation in the quality of information collected in the field.

Conclusions and Future Work

We have described the motivation for and features required in a computerized daily-site-reporting systems, with an emphasis on practicality. Selected details of an operating system have been provided. Observations garnered from use of the system on several projects were presented. By integrating the system with a planning and scheduling system, significant benefits can be obtained through more credible schedules and faster response to problems. Additionally, the potential for much improved documentation of project context variables versus time and activity histories exists, facilitating the pursuit of legitimate claims and the transfer of experience from one project to another. The need for effective training of personnel has been highlighted.

Several issues are worthy of exploration in the future to further enhance the usefulness of the approach described.

For large projects, there is a need to be able to handle subprojects. Data analysis at both the subproject level and overall project levels is required. The latter involves the ability to merge or aggregate subproject daily site data.

The topic of problem-source classification and identification of a comprehensive set of problem sources needs further exploration. Development of one or more leading indicators to describe activity performance to spot trends as early as possible should be pursued. Graphic representation of daily site data would be useful to help identify patterns of problem sources, site conditions, work-force factors and other areas.

Finally, over the longer term, the automated interpretation of daily site records should be attempted for purposes of suggesting possible corrective actions. This is important because of the masses of data generated by projects, making it difficult for project management personnel to review job records in a timely fashion. Work on automated interpretation is already under way using a fuzzy-logic and expert-system framework. This framework is promising because of the complex and imprecise relationships that link problem sources, work environment, and work-force conditions with activity attributes and performance and, in turn, with appropriate corrective actions.

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