TOWARDS AN ELECTRONIC SITE DIARY

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ABSTRACT

On most construction sites, a considerable volume of records will be amassed by the main parties and the records kept will cover a variety of aspects of the construction work. It is recognized that a very important source of information about the progress of the works is the site diaries, kept by the engineers and clerks of works on a daily basis as the work proceeds. Although recent research has identified these diaries as probably the most important single source of information, it has also identified a number of deficiencies in the diaries typically kept. They are often said to be very difficult to access, sometimes illegible, occasionally inconsistent and may also lack continuity. An obvious way to address some of these problems would be to produce the records in an electronic format and it is the steps being taken towards this goal that are being reported in this paper.

Because of the constraints imposed by site conditions and the fact that some of those who must compile diaries will not be computer-literate, the option of inputting the records by a keyboard was considered unrealistic. Instead, a Newton Messagepad, that allows the user to write with a stylus on a screen which is then recognized by the Messagepad, was chosen. This allows the recordkeeper to write his/her records in normal handwriting into a file, which can then be transferred to diary software on a p.c. where it will appear as normal text.

The paper describes the work to date, explains how such records can be shown to be contemporaneous through use of digital signature technology and also explains the advantages to be gained from this approach. The obvious and immediate advantage in having the records in machine readable format is that it will allow almost instantaneous searches of the data to find when specific activities took place. This is an essential procedure invariably needed when contractual claims are either being prepared or assessed.

INTRODUCTION

All organizations need to keep records of their activities for a wide variety of reasons, including fulfilling the needs of auditors, payment of creditors and pursuit of debtors. The records kept by the parties on construction sites, however, have other very important uses, principally relating to quality, finance and progress.

To be able to confirm that the quality of materials and workmanship is in accordance with the specification, records need to show that tests were carried out on samples of the materials; it will also usually be important to show that checks were made on their correct positioning within the works. For many contracts, payment of the contractor will be made at intervals throughout the job and to justify the levels of payment made in each period, there will need to be a detailed assessment of the work done and an appraisal of rights to contractual claims. These calculations and the documents produced from them may be seen as the financial records. Perhaps the most difficult records to circumscribe are those

that endeavour to confirm what actually happened during the construction phase: the progress records. These records will ideally provide a detailed account of when the various activities took place, with what resources and the impact of any delay or disruption. It is primarily the progress records that will be considered in this paper, but it should be recognized that although a particular record may be kept ostensibly for a particular purpose, it may also serve other purposes. If it is impossible to find when (say) the wearing course for a length of roadway was laid from the site diaries (progress record), it will be clear that it must have been laid by the date at which the levels of the pavement course were checked (quality records). Equally, site diary records may contain details of agreements about payments to be made.

Having accepted that the sub-division of records into categories is not without difficulty, those records that are normally seen as progress records will now be considered. They are: minutes of progress meetings, daywork sheets and agreed records, photographs, weekly progress reports and site diaries and it is suggested that their main applications will be:

- to confirm that work, in particular varied work, has been carried out and to record the resources employed such that proper payment may be made;

- to assess the progress of the works in the light of the contract programme in order to permit action to be taken, where necessary, to ensure timely completion;

- as a major source of information detailing exactly what occurred during construction of the project, so that claims for additional costs and/or time may be backed up with well-founded facts (contractor), and assessed in a proper manner (supervisor).

In this last context, in particular, the literature has found progress records to be often inadequate to give a full picture of exactly what happened on the site. The following comment from Major and Ranson (1980) is typical:

> 'It is all too common, when seeking to establish what actually happened on a project, to find that even a considerable amount of investigation will produce only an incomplete picture. It will often be necessary to analyse minutes of progress meetings, valuations, diaries and various charts and programmes which neither individually nor collectively enable an actual progress chart to be produced or a detailed history of the project to be written. This is a common area of failure in site and head office management.'

In an attempt to gain a greater understanding of these problems such that sensible recommendations could be made to help overcome them, a research programme was instigated at the University of Newcastle upon Tyne, Department of Civil Engineering. Initial studies involved investigating the records kept on a 'live' site and also on a site where the records had been archived. The insight which this allowed, enabled a detailed questionnaire to be written which was mailed to 150 organizations who acted as supervisors on construction contracts. Sixty five returns were received. In this paper, an overview will be given of those records usually seen as progress records followed by a summary of the results of this study which relate specifically to site diaries. This will be followed by details of a recommendation that site diaries will be greatly enhanced by sensible use of computer systems.

SITE PROGRESS RECORDS

Minutes of progress meetings

Progress meetings will usually be held once a month, when the supervisor and contractor, and members of head office staff from both organizations, will come together. At these meetings they are likely to discuss any matters affecting the work in hand or soon to be undertaken, and to consider the current progress of the works and of any claims negotiations. Charts are often prepared for these meetings to indicate which activities are presently being worked on and how their progress compares to the expected or planned progress. On some sites, these charts may well give a good representation of progress over time, but it is believed that what is produced on many sites will fail to provide this information, for the following reasons:

- Rather than being a record of when work took place on activities, the chart is likely merely to indicate percentage completions of those activities under way at the date of the meeting. This will certainly allow the start and finish of those activities shown to be traced to within a month of when they actually took place, but will not permit the number of days worked on a particular activity to be identified.

- Not all activities as shown on the contractor's programme are typically shown; only the main activities are plotted.

The research identified that the principal source of information for preparing these charts was the site diaries.

Daywork sheets and agreed records

The records kept for varied work on a contract are often much more detailed than the records for the rest of the contract work as extra payments will be involved and the extent of the payment will be fixed by these additional records. Indeed, it is principally to ensure that proper payment may be made that these records are held at all. Although they may be helpful in identifying the durations of delays resulting from additionally instructed work, the fact that most of the contract work is not covered by them makes them of limited use in preparing a full record of progress.

Photographs

Photographs of the site at intervals throughout the construction period will provide a wealth of information which could only be recorded on paper by making copious notes which would by their very complexity be extremely inaccessible. Just as drawings convey certain types of data much more efficiently than the printed word, so photographs reveal the exact state of construction at distinct points in time. Of course, unlike drawings, these photographs are instantaneous representations of a continuously changing scene and the fact that they are only taken perhaps every week, means that they are of little assistance in giving a complete view of site progress.

Weekly progress reports

These reports, often prepared by the supervisor, aim to provide information to higher levels of management. Although ostensibly called progress reports, much of what is contained in

them will be to do with complaints from the public and problems likely to lead to significant increases in costs and/or delays. There will, however, be a summary of progress on the site and this will be helpful in piecing together an overall picture of contract progression, but the research indicated that such reports are unlikely to refer to activities in the form defined by the contract programme. It was also evident that site diaries would be the main source of the information contained in these weekly reports.

Personal site diaries

This is an extremely important fund of information which should be well ordered, with staff at every level in the site management hierarchy well aware of just what aspects of site activity they should be recording. At the lowest level, detailed records of what plant and labour were used for all activities within the individual's area of responsibility should be available. At the highest level, the record is more likely to consist of notes of meetings and discussions with a much more general review of site activity.

During holiday periods and periods of sickness, arrangements should be made for another member of staff to keep the records of the absentee. It should always be realized that the quality of these most important records will be fundamentally affected by the quality of staff employed and by the instructions that those staff receive as to what is expected of them.

Taken together, these progress records may well contain most of the information needed to produce a detailed overview of the progress of construction. However, the quality of the main sources of information depends ultimately on the quality of the personal site diary records, and the research showed that these are often flawed.

Problems with personal site diary records

From the initial study previously described, a number of difficulties were identified with the site diaries investigated, both on the 'live' site and on the contract where the records had been archived. The main problems involved accessibility, legibility, continuity and consistency, as follows:

accessibility   These problems relate to the considerable time and effort required to access certain types of information from the site diaries. The information may be available, but because of the way in which it has been recorded, individual items are difficult to find and later attempts to build up a complete picture of progress from the diaries are tediously slow. Particular problems include lack of meaningful headings and failure to relate work carried out to the programme activities.

legibility   Some of the records perused were particularly difficult to understand because the handwriting was illegible, or nearly so. This would increase the frustration of anyone trying to find information in such diaries and adds to the problems of accessibility.

continuity   Gaps exist in the information, possibly because of illness or holidays, but the result is that site diary pages are blank and so the records for a part of the site have not been kept.

consistency These problems occur when records of the same events kept by two or more record-keepers do not agree.

In the national survey, site supervisors were asked whether they had experienced these difficulties and to indicate the severity of such problems. Analysis of the responses revealed that almost 85% of supervisors had experienced problems with legibility and continuity, while 78% and 68% admitted the existence of problem with accessibility and consistency, respectively. Accessibility, legibility and consistency were said to be of equal concern, but the problem of continuity was said to be most severe. Other problems were also highlighted by the survey which mainly concerned the lack of experienced staff and the lack of detail in the records actually kept.

As the site diaries were identified as the most important source material on the progress of the works, these problems are of great concern and led to the view that improvement of site diaries would lead to an improvement in record-keeping generally. The use of computers was an obvious way forward.

Electronic diaries

An example of a computerized diary currently exists in the software market and is called *Lotus Organizer* (figure 1). It was developed by the Lotus Corporation (1996). This software provides more sophisticated facilities than a paper-based organizer and is intended to be used as a personal time manager. It works as a computerized diary as well as providing many other functions such as notepad, planner and managing names and addresses. Additionally, the organizer also provides some other useful functions that use the computer's powerful
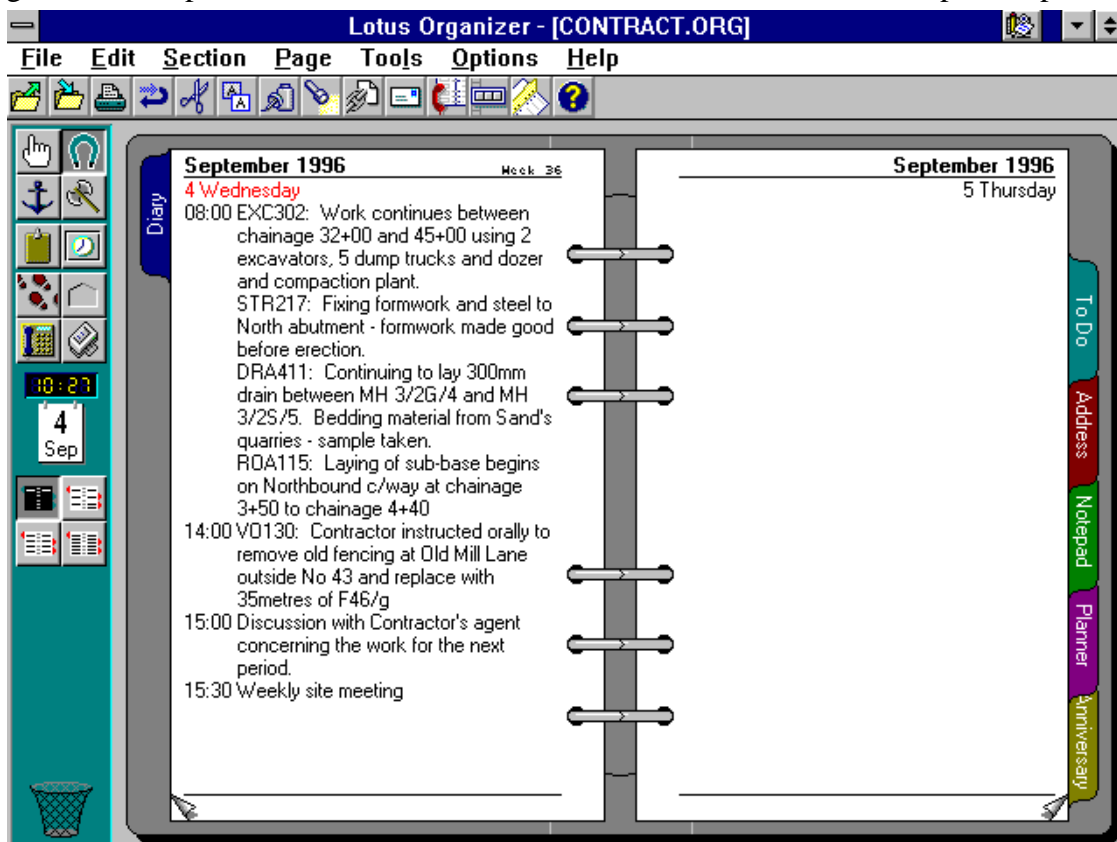

Figure 1: Lotus Organizer diary page

facilities, such as searching for specific information and cross-referencing or linking information maintained within the context of the organizer. Although not intended to be used as a site diary, this software, even as it stands, could be used on sites and would bring benefits, as will be shown in the next sections.

Keeping an electronic site diary

In this section, the intention is merely to give a brief description of how the different parts of the *Lotus Organizer* can be used for keeping site diary records. Instead of using the ordinary diary or standard form, the staff member would simply enter the daily information in the appropriately defined sections of the organizer appearing on the computer's screen. Of course, a copy of the daily records could be printed out when required.

* Diary section

The diary can be used to schedule activities on a daily basis and for specific events to record exactly when they occurred. The diary format can be displayed in a number of ways, e.g., day per page, week per page, etc., and the start and end time of the work day can be set to the nearest hour, e.g., 8am to 6pm. The time slots between records on any day can also be controlled and may vary between 5 minutes and 60 minutes. Thus, for work progressing all day, this would probably be recorded against a time of (say) 8.00am, whereas for work that only started in the afternoon, this would be recorded as starting at (say) 2.00pm. The times at which specific instructions were given could also be recorded as shown in the example (figure 1). It is clear that the searching process would be simplified if the activities recorded in the electronic diary were kept with specific codes and for this purpose, the activities in the contractor's plan would normally be the basis for categorization. A coding system is used in the example.

* Notepad section

The notepad section of the organizer can be used to keep notes or memos, which on a normal non-computerized organizer would be written on paper. In the computer version, the diarist can type as much text as s/he would like and can scroll up and down the text if it is longer than one page. The contents of the notepad can easily be arranged into a number of chapters, which for a site diary might include: list of activities, site instructions, delays, problems encountered, information requested, etc., and would appear in a table of contents at the first page of the notepad (see figure 2). This would facilitate easier access in a very systematic manner to the information maintained and would also allow easy addition of information related to each chapter. By relating each of the activities/ delays/ site instructions, etc., to a code number, the diary pages can simply report work progressing on an activity by referencing its code, which could be looked up in the notepad section for further details.

Effect on site procedures

It is believed that for an automated system to be successfully implemented, the procedures should not differ too much from the ordinary procedures currently in use. It is also believed that whatever automation method is implemented it must not require any more effort or time than is currently required on the part of the user. A possible system would involve each member of site staff responsible for keeping records being provided with a personal digital assistant (PDA) such as a Newton MessagePad 120, as described by Branscombe (1995) (see
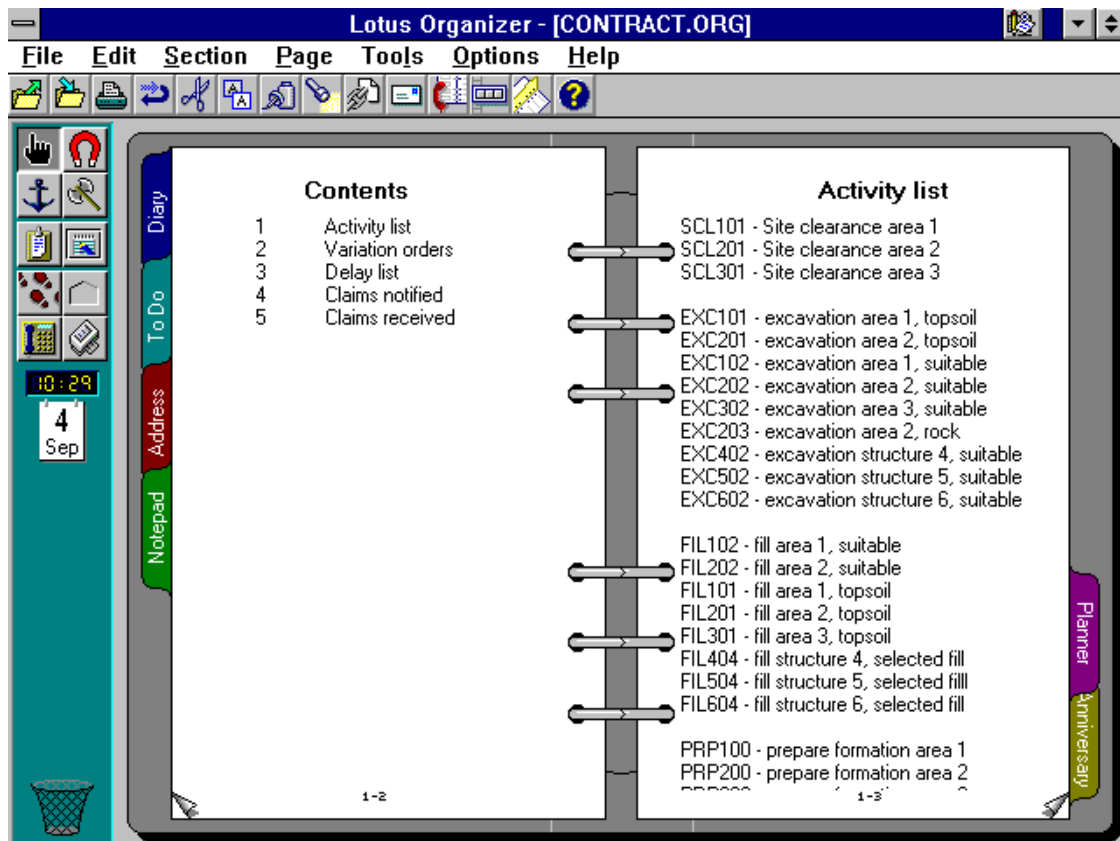
Figure 2: Lotus Organizer notepad section

figure 3). PDAs are essentially hand-held computers which can run certain software packages, such as word processor and spreadsheet programs, but their most important function is their ability to recognize the diarist's handwriting. Some PDAs are very reliable and can easily fit into the diarist's pocket so they can be kept safely even in a rough environment such as a construction site. Each member of the site staff concerned would keep records as normal, using an electronic pen to write on the PDA screen; this information would then be written to a file. The individual responsible would clearly need to have a good understanding of the construction programme and the way in which the work had been broken down in that programme to enable him/her to input records into the organizer assigned with appropriate codes. This, as stated earlier, will much improve the accessibility of these records. At the end of each working day, the diarist would then download these daily records into the main computer kept in the site office.

Advantages of the proposed system

It has not yet been possible to arrange full site trials of this scheme, but if practical difficulties in the implementation of the technology can be overcome, the advantages are clear. Indeed, the proposal would help in each of the main problem areas previously described, as explained below:

accessibility   This would be the most important benefit arising from the scheme, for the information in machine readable format would be susceptible to a computer search. *Lotus Organizer's* searching facility allows the user to search for any alphanumeric string and will identify every date when that code was used in the diary.

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legibility	Because the handwriting of the diarist is converted into computer recognizable characters, the problem of illegibility is removed.
continuity	The system proposed cannot, of itself, force indolent employees to do a better job or provide records where none have been kept due to absences. However, if each individual keeping records is required to download their daily records every day into a central computer, the person in charge will soon be able to identify the problems and will be able to respond quickly.
consistency	When the full set of records being kept on the site can be inspected every day, the opportunity exists for inconsistencies to be identified and the true facts recorded.

The validity of electronic records

Knowing that site diary records may be used in evidence in dispute resolution, it is reasonable at this point to question what the legal standing of records held in an electronic format would be. The traditional paper diaries, showing obvious signs of frequent entries and with any subsequent amendment readily visible, would appear to have a considerably greater degree of certainty about when they were written. In contrast, electronic records would seem to have much less authority. The opportunity to make amendments to an electronic document, without leaving a trace of the change, is well known and the cause for some concern in this context.

The problem of the legal status of electronic documents has been the subject of much debate in recent years, no doubt driven by the advent of credit card sales on the Internet. An article in the Economist (1996) confirms that in 1996 $200 million worth of goods per

Figure 3: Personal Digital Assistant

year were being sold across the Internet. Estimates of this figure reaching $30 billion by the end of the decade, it is said, will depend on public confidence in the legitimacy of these transactions. The debate is inevitably most advanced in the US, where Rabin (1997) confirms that some states have actually enacted legislation to provide that an electronic document will in defined circumstances be as valid as if it had been written on paper. Brown (1994) also tells us that the IRS allows individuals and businesses to file their tax returns electronically.

Developments in this area have concerned themselves with the need for confidentiality, authenticity, message integrity, non-repudiation and timing of messages sent via the Internet (Merrill, 1996). The systems that have been produced involve software keys that allow messages to be encoded and decoded, hash functions that produce a unique result when applied to an electronic message and date-time stamping, which confirms the date and time a document was certified. It is not possible here to go into any detail about these systems, but this software is commercially available and its use depends on the existence of trusted third party organizations or certification authorities.

The main concern surrounding site diaries would seem to be the need to prove that the records were contemporaneously made and that no changes were made to these records at a later date. With the use of a trusted third party, and the necessary software, this should be readily achieved. Consider a site on which site diaries are being kept electronically. If every month a diary file for that month was sent to a trusted third party, who stamped it with the date of receipt, this would ensure that the third party files were produced during the month prescribed and had not been tampered with since. If the diarist wanted to use his/her own version of the files, it could be proved that these were identical to the third party's files by use of a hash function. Only if the hash function gave the same result when applied to both files could it be said that the two were identical. Of course, there would need to be a system of joining together files for subsequent months back into a single file for the contract, but this should not cause too much difficulty.

CONCLUSION

The professionals, employed by the contractor to manage the construction process and by the employer to supervise the contractor's work, have a wide range of functions to perform. Amongst these is the job of keeping good records of exactly what happened during the construction period. These records are used for a variety of purposes and the progress records, in particular, should permit a detailed review of the progression of the work to be produced at any time during the contract. Because of the difficulties with current methods of keeping records, this procedure is invariably a difficult one and it is strongly believed that the proposed computerization described in this paper will allow considerable improvements to be made.

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