Time-Lapse Video Applications for Construction Project Management

By John G. Everett,[1] Member, ASCE, Hasan Halkali,[2] Associate Member, ASCE, and Thomas G. Schlaff,[3] Member, ASCE

Abstract: Time-lapse recording allows lengthy construction processes to be recorded and played back in a much shorter time for subsequent analysis. Over the past decade, time-lapse video cassette recorders (TL VCRs) have replaced time-lapse film movies for detailed productivity analysis and improvement in construction operations. This paper describes some of the technical features and options of time-lapse video recording equipment. The paper presents a valuable new application for time-lapse video in monitoring construction field operations. Rather than concentrating on individual workers or crews, time-lapse video can also be used to document and observe construction projects in their entirety. This innovative application has been extremely beneficial in historical documentation of project progress, operations analysis and improvement, public relations, fund raising, and dispute resolution. This paper presents lessons learned from several years of experimentation and experience with time-lapse video and two cases where time-lapse video recordings have been used to resolve claims and disputes on construction projects.

INTRODUCTION

For many years, photographic film movies have been used to record construction field operations for documentation and analysis. Standard 8-mm and later Super 8-mm film cameras were widely available. That technology has become nearly obsolete. In the past decade, video recording has replaced film movies. Video cameras and camcorders have become less expensive and easier to operate than film movie cameras, and the video tape is ready for immediate playback.

A major problem with recording lengthy construction operations in real time is that the time required to view the film or video is equal to the time required to perform the original operation. Time-lapse film and time-lapse video allow the analyst to compress the information so that lengthy operations can be viewed in a much shorter period of time.

In the past, time-lapse film and time-lapse video have been used for productivity analysis and improvement of construction operations, typically focusing on an individual craft worker or a crew of several workers. Oglesby et al. (1989) provide an excellent description of this subject.

The objective of this paper is to present a valuable new application for time-lapse video in monitoring construction field operations. Rather than concentrating on individual workers or crews, the paper focuses on some of the benefits of observing and documenting the activity on construction sites in their entirety. This innovative application has been extremely beneficial in historical documentation of project progress and dispute resolution.

TIME-LAPSE RECORDING TECHNIQUE

Time-lapse filming is a recording technique that can be used effectively to document a lengthy process such as the construction of a building. This technique is executed by taking still pictures at selected intervals with a special camera. The interval selected is based on the amount of detail needed. An interval between 1 and 5 s is most common for the observation of construction processes. In contrast, standard movie cameras take either 18 or 24 frames per second (fps) that allows movements projected on a screen to appear life-like and smooth. When a time-lapse film is played back at the normal projector speed, actions appear very fast and jerky. Nevertheless, time-lapse filming has the advantage of greatly reducing the amount of time spent viewing, while allowing viewers to accurately interpret the construction operations.

Just as video camcorders and videotapes have replaced Standard 8-mm and Super 8-mm cameras and film, time-lapse videocassette recorders (TL VCRs) are replacing time-lapse film cameras. The principles behind recording and playing time-lapse movies are similar in TL VCRs and time-lapse film equipment. However, the technology of video recording is far more sophisticated than that of film recording.

In video recording, video cameras and camcorders use a scanning technique that converts an image into electronic signals on a magnetic tape. This is done by breaking up the image into a sequence of individual elements that can be reassembled into the proper positions to re-create the image during playback. The advantage of scanning with an electron beam is that the beam can be moved with great speed and can scan an entire image in a fraction of a second. The eye of the scanner sweeps over the entire picture in much the same way as the eye of a reader sweeps over a page of print, word by word and line by line. In scanning, a large number of lines are used and the pattern is scanned in two interlaced parts called fields. The integration of two fields produces a single static picture called a frame, which is similar to a single frame of motion picture film. As the pattern is repeated many times per second, changes in a moving image are recorded, and these changes blend into continuous motion for the viewer.

Each frame of video is separated into two fields, each containing every other line on the screen. The fields are displayed sequentially—first one field and then the other. In the United States, for standard color TVs and VCRs, broadcasters and receiver manufacturers have agreed on the National Television Standards Committee (NTSC) system with 525 horizontal lines per frame and a frequency of 29.97 fps (often rounded to 30 fps or 60 fields/s).

SELECTION OF EQUIPMENT

Time-Lapse Videocassette Recorders

TL VCRs are manufactured by leading electronic companies and are distributed through catalogs, surveillance equipment

[1]Asst. Prof. of Civ. and Envir. Engrg., Univ. of Michigan, 2352 G. G. Brown, Ann Arbor, MI 48109-2125.

[2]Proj. Engr., Keating Building Corp., One Bala Ave., Bala Cynwyd, PA 19004; formerly, Grad. Student, Dept. of Civ. and Envir. Engrg., Univ. of Michigan, 2352 G. G. Brown, Ann Arbor, MI.

[3]Dir. of Constr. Mgmt., Univ. of Michigan, 326 E. Hoover St., Ann Arbor, MI 48109-1002.

Note. Discussion open until November 1, 1998. To extend the closing date one month, a written request must be filed with the ASCE Manager of Journals. The manuscript for this paper was submitted for review and possible publication on March 10, 1997. This paper is part of the ***Journal of Construction Engineering and Management***, Vol. 124, No. 3, May/June, 1998. ©ASCE, ISSN 0733-9364/98/0003-0204–0209/$8.00 + $.50 per page. Paper No. 15422.

J. Constr. Eng. Manage., 1998, 124(3): 204-209

dealers, and specialty electronic stores. Since TL VCRs are also used in other industries such as surveillance, bioengineering, and medicine, they come with several features that appeal to a wide range of users. Thus, it is important to understand the particular characteristics of a TL VCR to optimize its use for a specific application. Table 1 lists some of the features available on TL VCRs. The features available on any particular model will vary.

The number of horizontal lines displayed on the screen is only about half the number displayed by a normal VCR. Hence, the total number of lines on a time-lapse screen is about the same as the number lines in a field of a regular VCR. Accordingly, manufacturers refer to a complete TL VCR image as one field. Hereafter, we too will describe a complete image displayed on a screen by a TL VCR as a field.

The numbers across from "Record time on a 2-h tape (T-120)" in Table 1 indicate the number of hours of action that can be compressed into a standard (T-120) 2-h video tape. Recording time is adjusted by changing the number of fields per second recorded by the TL VCR. In the preceding text, a standard NTSC system VCR records 60 fields/s. Thus, if 12 h of real time were to be condensed into a 2-h tape, the frequency of the field recording would have to be reduced by a factor of 6 (12 h/2 h = 6). As a result, the TL VCR would record one field every 1/60 s × 6 = 0.1 s. The intervals for the various recording times in Table 2 are calculated analogously.

Manufacturers offer preset recording TL VCRs as well as adjustable recording models. Adjustable models are capable of recording at some of the various speed modes listed earlier. In addition to having the ability to record at different speeds, adjustable models can playback tapes at different modes. For example, a TL VCR that has 2-, 12-, 24-, 48-, and 72-h recording capability, can also play back a tape at these different speeds. Different playback modes allow the viewers to watch a tape at slower rates than it was originally recorded. The shortest time in which a 2-h videotape can be viewed in the regular play mode is 2 h, whereas the longest amount is 960 h. Some TL VCRs also have a fast search function that works the same way as in a regular VCR. Using this option, the observer can advance the tape to a desired frame at a high speed.

The principles behind the playback and recording modes are exactly the same. Since an NTSC system VCR displays 60 fields/s at the regular speed (2-h mode in terms of TL VCRs), a TL VCR playing at the 12-h mode would show 60 fields/s ÷ (12 h/2 h) = 10 fields/s. Because a time-lapse recorded tape has a fewer number of fields per second than a regular videotape does, images stay on the screen for a longer period of time than with a conventionally recorded tape. For example, as shown in Table 2, a 2-h tape recorded at the 72-h mode displays a field every 0.6 s when played back at the 72-h speed. However, if this tape were played at another one of the playback modes such as the 48-h mode, the TL VCR would display a field every 0.67 s × (48 h/2 h) = 14.4 s.

TABLE 1. Selected Specifications of Time-Lapse Video Cassette Recorders

Features (1)	Specifications/options (2)
Signal system	Standard of National Television Standards Committee
Video recording	Rotary, 2 head
Horizontal resolution (VHS)	300–350 lines (Black and White) 230–300 lines (color)
Record time on a 2-h tape (T-120)	2-, 12-, 24-, 48-, 72-, 84-, 120-, 168-, 180-, 240-, 480-, 720-, and 960-h modes available
Search speed	Between 11.12 and 33.35 mm/s
FF/Rewind time	Between 1.5 and 5 min
Time and date display	Available on some models
Time and date search	Available on some models
Recording modes	Conventional and real motion time-lapse recording
Size and weight	Similar to a standard VCR

TABLE 2. Record Mode and Corresponding Recording Interval

Record time (h) (1)	Interval (2)
2	1 field per 1/60 s = 1 field/0.017 s
12	1 field/0.1 s
24	1 field/0.2 s
48	1 field/0.4 s
72	1 field/0.6 s
84	1 field/0.7 s
120	1 field/1.0 s
168	1 field/1.4 s
180	1 field/1.5 s
240	1 field/2.0 s
480	1 field/4.0 s
720	1 field/6.0 s
960	1 field/8.0 s

The record time format does not determine the amount of time it takes to view a 2-h tape. Rather, it affects the amount of time each field stays on the screen. The various playback modes can be thought of as different slow-motion speeds that determine how long a 2-h tape will take to view.

The adjustable record and playback options require careful selection of combinations by the viewer. It may be helpful to keep in mind that if a construction operation is recorded at the regular 2-h mode (real time), it is always possible to make copies of the original tape at various time-lapse recording modes. On the other hand, if an operation is initially recorded at a time-lapse mode, the tape can only be viewed at a speed slower than or equal to the original recording. But since time-lapse recording is a timesaving process for construction managers, only those activities that require special attention for viewing should be recorded at the regular speed.

The time and date display provides a record of when the activities on the tape actually took place. This feature gives observers a sense of the passage of time, enabling them to understand how fast activities are actually happening, which is a crucial component of productivity analysis and improvement. The data may be displayed at different locations on the screen so that it does not obstruct critical information.

To warn the operator, some recorders have an alarm function that sounds when the end of a tape has been reached, so that a fresh tape can be added. A feature on some models is the time and day search. This advanced search method allows the user to seek for and play back a specific portion of the video, starting at a programmed date and time.

Real motion time lapse, also known as virtual real time, is a relatively new method of recording that displays more motion within a given time interval. In other words, a real motion TL VCR records more frames per second than a conventional TL VCR. For example, when used on the 24-h mode (with a T-160 tape), a conventional TL VCR records 5 fields/s whereas a real motion TL VCR records 20 fields/s. With this high-density recording feature, the real motion time-lapse playback images appear smoother. Fig. 1 illustrates schematically the difference between the two methods of time-lapse recording.

List prices for TL VCRs with adjustable recording speeds range from about \$800–\$2,000, whereas a preset recording time TL VCR lists for about \$600–\$1,100, depending on the manufacturer and features selected.

J. Constr. Eng. Manage., 1998, 124(3): 204-209

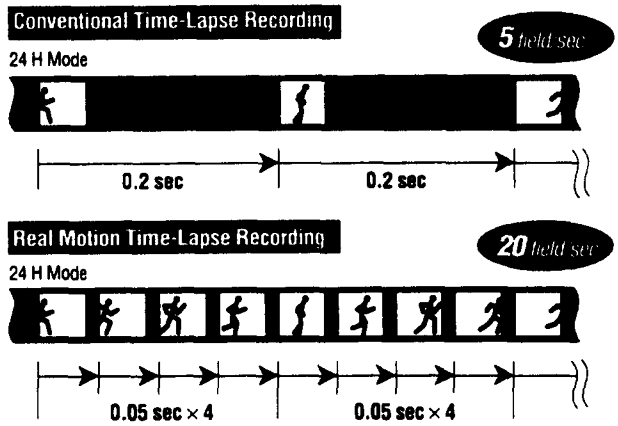

FIG. 1. Conventional Time-Lapse versus Real Motion Time-Lapse Recording (Figure Courtesy of Panasonic Video Imaging Systems Company, Secaucus, NJ)

Related Equipment

All of the time-lapse functions described earlier are performed by the TL VCR. Conventional video cameras and camcorders can be plugged into the TL VCR to provide the video input. The video camera or camcorder provides a continuous video signal, but the TL VCR only records at the appropriate intervals.

Recording with a camcorder enables the user to move the camera to various locations without worrying about moving the TL VCR or the video cable connecting the camcorder to the TL VCR. However, camcorder recording requires a two-step process, first the real-time recording, then copying the real-time camcorder tape to the TL VCR tape. Although there are no time-lapse camcorders currently available on the market, a major computer manufacturer has announced that it has such a camera under development. The company also intends for the new camera to be able to send out live video stream that can be placed directly on the Internet.

Fixed-position video cameras with advanced features are often employed to capture lengthy activities. The useful features of these cameras include tilting, 360° panning, high-power zoom lens, auto focus, light-weight, and outdoor mounting capabilities. Usually, TL VCRs are kept in a trailer or an office where the equipment is protected and within the reach of the user for ease in performing operations such as changing tapes, modes, etc.

The various functions of a fixed-position video camera are controlled by a system controller. The system controller is primarily a remote control device that can be used for different cameras on various parts of a project.

The monitoring of construction projects may be enhanced by using multiple cameras providing different views. In this situation, a device called a switcher is employed to enable the observer to select and control the scenes taken by different cameras. Videos taken from various cameras may then be viewed on one or more monitors.

Table 3 lists approximate retail list prices for the equipment described earlier.

CASE STUDIES AND LESSONS LEARNED: UNIVERSITY OF MICHIGAN CONSTRUCTION MANAGEMENT OFFICE

Historical Background

In the 1970s, the uses of time-lapse film recording in construction were introduced to students in a civil engineering construction methods course at the University of Michigan. In this course, Prof. Robert B. Harris presented a 15-min time-lapse film containing the entire 3-month construction of a pedestrian bridge at the University of Michigan's main campus. The purpose of this presentation was to introduce students to the techniques of analyzing construction activities. During the presentation, students were instructed to consider questions such as

TABLE 3. Approximate Retail Prices for Time-Lapse Video Equipment

Item (1)	Price range (2)
TL VCR (adjustable)	\$800–\$2,000
Video camera	\$1,500–\$4,400
Controller	\$750–\$1,100
Monitor	\$100–\$400
Switcher	\$250–\$550

- Was the contractor utilizing the most efficient means of site access?
- Was the material hoisting process efficient?
- Were there periods of idle construction time due to a lack of material or manpower

These questions were more effectively answered using the time-lapse recording of the construction process.

Many years later, a former student in that class, now the Director of the Construction Management Office at the University of Michigan decided to implement time-lapse recording for construction projects on campus. In the summer of 1989, the University of Michigan accepted a bid proposal from a general contractor to construct a new "sports service building," later named Schembechler Hall, in the university's South Athletic Campus. The university awarded the contract to the lowest bidder who had successfully completed previous building projects without a history of presenting false contractor delay claims. Nevertheless, there was still the possibility for a subcontractor to make a time delay or scheduling claim against the general contractor, potentially resulting in a general contractor claim against the owner.

Prior to the notice to proceed, the university's Construction Management Office investigated the opportunity of installing an outdoor video camera on the roof of an adjoining building to record the construction of the new facility. The primary idea of recording the construction operations was to provide the university, the owner in the construction contract, with a valuable as-built record of the actual construction operations. The recording would provide a powerful tool for the owner that could be used in a claim case against the university. A dated video of the entire construction process would be an indisputable record of the contractor's performance.

After consulting with a few local commercial audio–video equipment suppliers, a relatively inexpensive Panasonic video camera was selected. The camera was mounted in an outdoor Panasonic camera housing that contained a thermostatically controlled heater element to avoid interior condensation inside the camera housing. An overhead coaxial communications cable was run to an on-site construction trailer where the Panasonic TL VCR was set up. The camera housing selected was a standard fixed unit, permanently mounted, pointing in the same direction at all times. The fixed position was considered to be best suited for viewing and editing of recordings. The ability to play back the tape to view the construction activities, without the additional confusion of having different viewing angles, made the end product more natural and pleasing to view. Furthermore, this system was less complicated and less expensive to install than a rotating camera housing.

The 480-h mode was found to be a suitable recording speed after some experimentation in the beginning of the construc-

J. Constr. Eng. Manage., 1998, 124(3): 204-209

tion. When played back at a normal tape player speed the actual movement of construction equipment on the project site was surprisingly smooth. Moreover, selecting this relatively slow recording speed for a 2-year long project reduced the number of video tapes required to about 12–15 standard 2-h tapes. Subsequent experiments of time-lapse video recording revealed that the performance of the professional grade VHS tapes, as opposed to regular grade tapes, outweighed their cost. The time-lapse videotaping of this project required no further expertise than an electrician's wiring and was performed by the existing staff.

Over the past 6 years, since the completion of Schembechler Hall, the university's Construction Management Office has expanded its video monitoring and time-lapse recording to all construction projects. Now, instead of housing the time-lapse recorders in a trailer at the site, video from cameras on each project is transmitted live to the university's Construction Management Office. For the transmission of live video, the university's preexisting campus-wide coaxial broadband cable system is used. Now, the contract administrators of each project have live access to all of their construction sites from their offices.

Case Study: Earthmoving Claim

On some of the projects mentioned earlier, time-lapse videotaping has served as a valuable tool to the university's Construction Management Office. One instance involved a unit price contract for bulk stripping of earthwork. The base contract for this job included a rough estimate of 765 m^3 (1,000 yd^3) of noncompacted loose stripping excavation and off-site disposal. During construction, direction was given by the landscape architect to provide stripping down to a variable contour to allow for a 1% drainage gradient in landscaped lawn areas to storm drainage structures, increasing the quantity of stripping significantly. Daily truckload tickets were maintained by the contractor and subsequently compiled and submitted. The disposal quantity the contractor claimed for the job was over 2,290 m^3 (3,000 yd^3), which appeared surprisingly high to the university's project manager. In review of the excavator's daily truck tickets and summary sheets, there were discrepancies in the dates of disposal and quantity of trucks for each day of work. To investigate the true amount of the excavation, the project manager decided to review the time-lapse video of the job. During careful examination of the videotapes, the total quantity of gravel trucks filled for disposal were logged and counted, and the actual total number of trucks that removed soil from the site was accurately confirmed. In addition, the video revealed that it took the end-loader a total of 11 full scoops to fill the claimed 31 m^3 (40 yd^3) in each of the truck/trailer trains (six scoops in the front and five scoops in the rear trailer). The simple calculation revealed that the end-loader had to scoop an average of 2.8 m^3 (3.6 yd^3) each load to dump the 31 m^3 (40 yd^3) in 11 scoops. The project manager found it improbable that the bucket on the end-loader was capable of scooping such a large amount. The video confirmed that the amount filled in each truck/trailer was less than 31 m^3 (40 yd^3), and a reduced cost was negotiated and settled.

Case Study: Earth Retention System Claim

In another building project on campus, the installation of a hillside earth retention system was required that was comprised of a system of permanent steel, reinforced concrete caissons and tiebacks. After the project was started, the contractor made an underground "obstruction" claim involving additional costs and additional project time. Due to the alleged underground boulders and/or buried debris, the contractor sought recovery for extended general conditions.

The university's Construction Management Office confirmed that the extra work claim was limited only to a small portion of the earth retention system where it crossed an existing old rock building foundation. As a result, the overall cost claim and time delay claim could not be substantiated from the basis of actual field conditions.

In addition, the soils engineer believed that the real cause of the time delay was associated with the earth retention subcontractor's inadequate auger-caster drilling equipment, which was in poor working order. The soils engineer also believed that more suitable drilling equipment should have been used to adequately perform the work in the ground conditions identified in the bidding documents. A review and analysis of the time-lapse video tape recording of the actual construction of the earth retention system convinced the owner that the claim was falsely based. A comparison of the contractor's planned schedule for the installation of the earth retention system and the actual progress of the work revealed a number of conflicting elements.

The Construction Management Office believed that these elements were solely under the contractor's control. For example, the planned schedule indicated a dual installation of permanent caissons simultaneously with the installation of temporary H-piles. However, the time-lapse recordings showed that the actual installations of the caissons and the H-pile were performed sequentially, extending the overall duration of earth retention work. The time-lapse video also recorded the delivery date of the auger-caster equipment to the site and the 2-week duration of welding repairs to the equipment before it began working. The lengthy repairs not only delayed the start of the job, but supported the soil engineer's contention that the equipment was unsatisfactory. Evidently, the work delay had nothing to do with any alleged underground obstruction claim. Although this dispute has not yet been resolved, the time-lapse video recording again proved to be a valuable resource in construction project management.

Lesson Learned: Presentation of Construction Process

The Schembechler Hall project described earlier was completed without any major problems, and at the end of the project, 14 time-lapse recorded videotapes of the entire 2-year project were condensed into a 12-min presentation. This was done by selecting a very short segment of time-lapse video (approximately 1/2 s) from each day at the same time (i.e., at 1 p.m.) and splicing them all together. Several local television stations used this video to put some fanfare into their stories about the University of Michigan football team's move into its new facilities in Schembechler Hall. It soon became clear that yet another valuable aspect of recording construction projects was unfolding, namely, the historical perspective of the university's changing campus as a positive tool for public relations and fund raising.

This first attempt at a presentation video was performed in-house by the Construction Management Office. While successful, it was quite time-consuming to produce. On two subsequent projects the services of a professional video production firm have been used to not only splice together video of the actual construction process but to add an introduction to the project complete with a history of the university campus, background music, narration, recognition of significant individuals in the project, etc. These videos have been shown at the opening festivities for the projects and copies presented to donors, the architect, university historians, and others. Such videos have proven to be powerful tools in education, special events, fundraising, media use, and other positive public relations needs.

J. Constr. Eng. Manage., 1998, 124(3): 204-209

Lesson Learned: Placement of Video Camera

It has been found from experience that it is best to set up the video camera on a nearby building or light pole, set the zoom and focus, and leave it alone. While it may be tempting to pan back-and-forth across the site, zoom in and out, connect multiple cameras to one TL VCR, or move the video camera from place to place, when the video is replayed at many times normal speed, the action becomes very confusing and impossible to follow.

There may come a time in some projects where the building envelope is installed and, although there is plenty of work taking place indoors, it appears that not much can be gained from continued video recording from the exterior. Videographers should resist the urge to dismantle the recording system. There may still be site work to complete, and it may still be valuable to document weather conditions, the presence or lack thereof of subcontractors (as shown by their vehicles in the parking lot), material deliveries, etc.

On one university project, a disagreement arose about when the building was sealed so that painting could commence. While everyone agreed that the brick facade and windows were installed at a certain date, the discussion centered around when the windows were caulked. This was easily seen on the time-lapse video although little other exterior work had been performed for some time.

In the early stages of most building projects, the entire site and all of the work can be seen from one location. As the project develops, the building itself may obstruct the view of the side(s) away from the camera. It would be possible to set up multiple cameras, each with its own TL VCR, but this has not been necessary in the experience of the university. For very large or complex projects, multiple cameras may be worth considering.

On a related note, experience has shown that it is critical to have the time-lapse system up and running on Day 1 of the project. In the hustle and bustle of mobilizing and getting things moving, there may be a tendency to delay implementation of the video recording until there is a lull in the action. Such a lull may never arrive. Many disputes arise early in the project, when normal project control systems may not be fully operational, and the project may not yet be fully staffed. Unforeseen underground conditions are likely to be discovered early in the project as excavation and other site work commences.

ANALYSIS

Since its first introduction to the University of Michigan construction projects in 1989, time-lapse video recording has become a part of all building operations around the university's Ann Arbor campus. Although it was first intended to be used solely as a tool in construction operations analyses, experience revealed surprising new applications and some limitations of this technique.

Operations Analyses and Corrective Action Plan Development

Videotaping of activities provides useful means for accurate analyses and can lead to effective corrective action proposals. This has been the traditional use for time-lapse film and video in construction. As mentioned earlier, Oglesby et al. (1989) present an excellent discussion of this subject and so it has not been described in detail in this paper.

However, to capture the image of an entire project, it is necessary to "zoom out" and it may be impossible to discern what individual workers are doing. Depending on the recording speed selected, the interval between images may be too long to be useful for some types of operations' analyses. In selecting what field or view to capture and what recording speed to use, the videographer may have to balance the advantages of zooming in and recording at a faster speed to maximize usefulness for detailed operations analysis versus zooming out and recording at a slower speed to capture an overall view of a lengthy project.

Live Video Access to Operations

This by-product of the time-lapse videotaping operations has become a timesaving tool widely used among the university's construction managers. Live video access is particularly helpful in such situations as a phone conversation with a contractor or architect/engineer to properly visualize the actual status of a project.

As mentioned earlier, the university has a campus-wide coaxial broadband cable network that has been used to transmit the video signal. In fact, several projects appeared around the clock on the university's cable TV system until the channels were taken over for other uses.

Most construction projects will not have the luxury of being able to transmit high-resolution, full motion live video to distant locations. However, video signals can be transmitted over phone lines or via the Internet. The high-bandwith requirements that plague normal video transmissions over these media are not nearly as big a problem when time-lapse video is used because the intent is to send only one field every few seconds rather than 30 fps. High-speed modems, Integrated Services Digital Network (ISDN) phone lines, satellite transmissions and other emerging or improving technologies are sure to improve long-distance transmission of time-lapse video signals.

Value to Other Parties in Project

The experiences described earlier have been presented from an owner's point of view, but time-lapse video can be equally valuable to contractors, designers, and even the craft workers. As presented in the case studies, videotaping leaves little room for faulty claims against the owner, but the same video documentation can and has been used to support legitimate contractor claims against the owner.

Contractors and designers should consider setting up their own time-lapse recording systems or sharing one system among all interested parties. Copies of tapes could be distributed, or the video signal from a single camera could be transmitted to multiple locations to be used as each party deemed fit.

Whoever has access to the videotapes may have a significant advantage when problems arise, but other benefits accrue to everyone and may even help prevent problems from occurring. For example, TL VCRs may be effectively used as a surveillance device on construction sites to discourage or protect against trespassing, vandalism, theft, and other crimes. Some models may be linked to motion detectors to be used during off-hours that activate the recording mode upon movement in the protected area.

Informing the workers of the videotaping makes them conscious about their performance and gives them an incentive to follow proper procedures in their activities. This may encourage improved safety, improved quality, and improved productivity.

CONCLUSIONS

This paper described an innovative application of time-lapse video recording for construction project management. Through several years of experience and experimentation, the Construc-

J. Constr. Eng. Manage., 1998, 124(3): 204-209

tion Management Office at the University of Michigan has found that time-lapse video can be of great benefit in documenting actual project progress. The video tapes have been used to resolve claims and disputes, for education, public relations, fund raising, and media applications, and to provide project managers a live image of remote projects.

The relative low-cost, easy installation and operation of the time-lapse video equipment have helped it become a part of every project on campus. Currently, time-lapse recording is being performed on 11 University of Michigan building projects.

This paper has been written in the hope that it will stimulate owners, construction managers, contractors, and others to apply the time-lapse video techniques that have been described in their own projects and to develop additional applications.

APPENDIX. REFERENCE

Oglesby, C. H., Parker, H. W., and Howell, G. A. (1989). *Productivity improvement in construction*. McGraw-Hill Inc., New York, N.Y.

J. Constr. Eng. Manage., 1998, 124(3): 204-209