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Multimedia Communications for Construction Foremen

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Where construction foremen fit into the construction automation process is an issue that needs considerable consideration. As part of the workforce, and yet the linking bridge between the workforce and the supervisory personnel, foremen play an important role in construction operations, which includes providing job-specific information for management. With more and more information technologies being incorporated into the construction business, foremen need to be equipped with information tools appropriate for their use. Multimedia information provides considerable use in construction documentation, problem-solving, and improving project management efficiency, while reducing overall project costs. This paper discusses current multimedia communications for construction foremen, and those communications that will be available in the near future. This paper also explores the technological issues in a nontechnical sense, related to these multimedia information tools.

In the years to come, information systems and communication technologies will continue to have their greatest impact on the construction site and the management work there [5]. Although behind other industries, the construction industry has seen various off-the-shelf software and information tools being used in daily construction business. A better picture of future construction is indeed conceivable with the promise of information technologies, which are changing rapidly. Future construction staff will electronically input daily logs, automatically record complete payroll information, equipment usage, and materials received for invoice verification and payment [5].

Even now, more and more construction information is being computerized. Traditional drawings are being replaced by computer aided design (CAD) drawings and will be phased out in a few years. Previously paper-based simple bar charts are still in use, but they also are being computerized and will give their role over to more sophisticated electronic critical path method (CPM) programs such as Primavera Planner (or Microsoft Project Manager.) Volumes of construction specifications are being transformed into computerized information that can be stored on a CD-ROM, which costs less than one dollar, and this information can be accessed easily by a handheld computing device or via a computer network. Millions of hours and dollars have been saved due to reduced transcription errors and paper work.

Many benefits have already been recognized through harnessing current ready-to-use information tools, and many more are promised by the future development of computer and communication technologies. Yet when we look at the workforce makeup of this industry, one cannot help asking the question, where do typical workers, including foremen, fit in this presumably sophisticated information-oriented construction scene?

This paper will discuss the role of construction foremen in the construction process and their place in construction automation. Multimedia communications for construction foremen will be illustrated, and the legitimacy of proposed communication tools will be explained.

The Background of Construction Foremen

Foremen are a unique group of people working in the construction industry. The nature of their job is semisupervision, while often they are also involved in hands-on work. The characteristics of foremen are similar to the construction laborers who they supervise. These individuals are normally promoted to this position due to hard work, an excellent performance record, and leadership. Because of their similar background, foremen can understand the language used by construction workers, which often is mixed with slang that management may find difficult to understand. Most foremen have many years of construction experience with no education beyond high school [4].

Construction foremen have often come through some form of apprenticeship program where they learned a trade that has allowed them to earn a living and provide for their family. Often they have developed a skill level that engenders confidence while at the same time providing a form of job security. Ignorance in any phase of their work could be devastating to their self-image, and accordingly to their work product. With more and more computer technologies applied in construction and computerization becoming a trend for the future, foremen may feel the need to become computer literate. Productivity, quality, and safety are concerns that foremen must address on a regular basis. If construction foremen can employ automated tools in their daily work to address these issues, their productivity will be improved, which in turn should lead to increased job security and job satisfaction.

The Role of Foremen in Construction

Foremen play an important role in construction project control. From the standpoint of the organization theory, the position of foreman is the linking bridge between the levels of supervision and the workforce who actually do the physical work (see figure 1). The nature of the job can also be regarded as semisupervisory, since they direct workers. A job instruction could be issued by the construction manager, all the way down to the project engineer, the superintendent, and the assistant superintendent, but how well the work is done is directly determined by how effective the communications between the management, the supervisors, and workers are.

Foremen are also a vital part within the design implementation

process (see figure 2). Architects' or engineers' designs are implemented eventually through foremen's involvement. After receiving the architect's or the engineer's plans, a project manager will develop corresponding means and methods to implement the plans. Project engineers will monitor the means, methods, and quality control in this implementation process, but it is foremen who are responsible for conducting the job-site documentation, putting implementation means and methods into practice, and fulfilling the project quality control. Foremen are also responsible for recording the changes made on job, which constitute the source for as-built documents and drawings. Project engineers then can produce the as-built drawings based on the change documentation made by the foremen, which are eventually fed back to the architect, who renders the project design.

There are various factors affecting the effectiveness of the communication in construction. First of all, the education levels of participants affect this communication process greatly. Construction industry is an industry that requires specialized knowledge, which often requires a systematic training or school education for the participants to comprehensively understand and apply the construction know-how and techniques.

Generally, management-level personnel have known the construction profession very well through many years of practices. Some of the supervisory people are also familiar with this trade after years of experience while others are college graduates who do not have extensive construction-related experience. Above all, they all know the construction profession and technical aspects very well and tend to use technical terms and jargons in their daily work.

Most construction laborers, however, received little or no formal education and adequate training in construction safety and quality control. It is a fact that the construction industry is an easy-entry industry and workers can come to the industry with virtually no construction background, training, or expertise. In this age of more and more

advanced technologies and tools being applied to industry in general, the ability to use these technical means has become a notable issue. When worker training is minimal, past experience will determine how construction workers perform their tasks.

Language is a problem that cannot be overlooked in the construction industry. Management tends to use a lot of technical words that construction workers might not understand, thereby causing a void in communication. Similarly, because construction workers use slang that management does not understand, this further widens the communication gap [3].

In summary, the above factors tend to form a barrier to effective communication between management, supervisory personnel, and the labor force. To eliminate this problem, a well-coordinated communication system needs to be implemented to keep projects progressing smoothly and as planned. In this regard, foremen are at this pivotal position to convey the information upward and downward in the project organization.

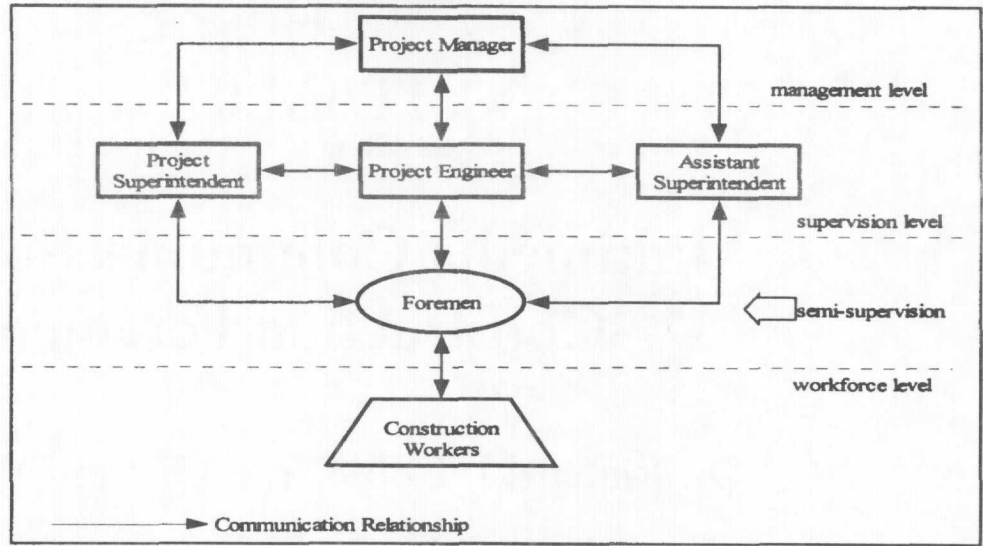


Figure 1—Foremen's Pivotal Role in a Contractor's Project Organization

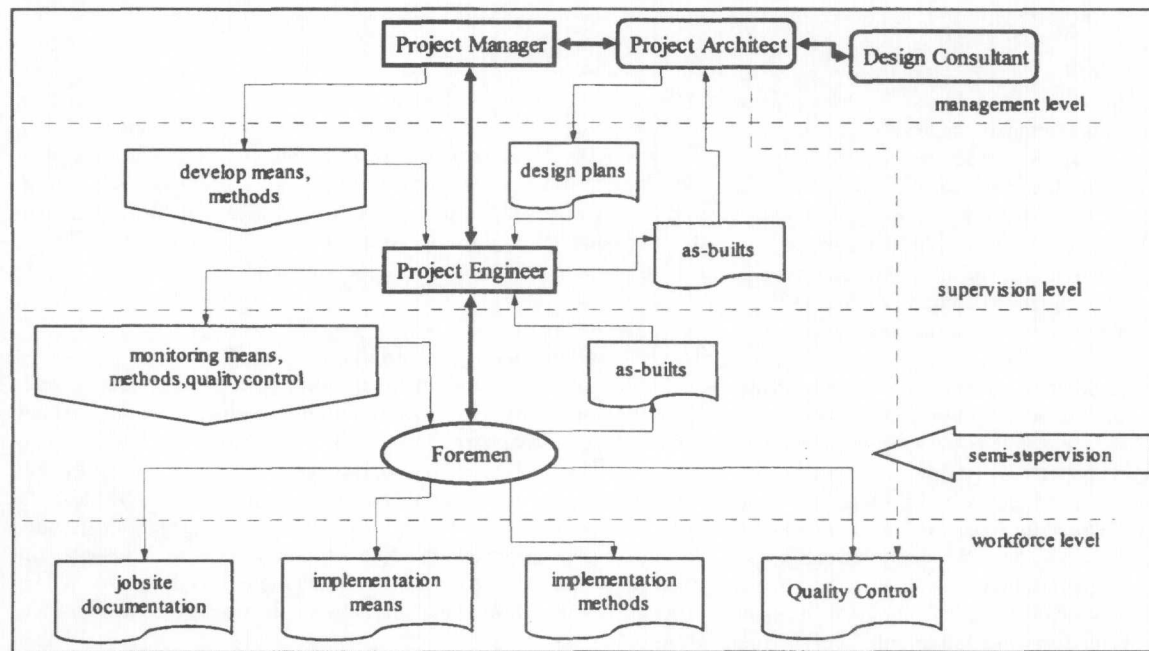


Figure 2—Foremen's Role Within Design Implementation

Foremen and Construction Automation

Construction foremen are the "last frontier" to become computerized in construction management [3]. The ability of foremen to understand the instructions from their supervisors and to know how to use the technologies employed in construction directly affect the construction product and how the task is performed. Advancement of computer technologies is creating more and more opportunities for automating work in the construction industry. Desktop and laptop



computers are commonly used in management personnel's work. Various kinds of software for construction shop drawing production, contract administration, estimating, scheduling, and accounting have already become management tools for the home-offices and field-offices of construction firms. At present, e-mail and file transfer programs are no longer magic to management personnel, whereas in construction, the working fashion of construction foremen still stays the same. They hardly touch computers and normally the only chances they have to relate to computers are through computer printouts. As the computer technology continues to improve and more managers in the construction industry are trained in the use of computers, the communication gap grows between the management and the workforce. Yet because of construction foremen's important role in construction, they must also be enabled to use certain computer and automation technologies to truly automate the construction process.

A previous study also finds construction foremen's productivity can be improved through automation. Management needs specific job information from the foremen, but much of what they need is repetitive from day to day [4]. Part of their job responsibilities include filling out some standardized forms for different purposes such as daily reports, accident investigations, daily safety reviews required by OSHA regulations, and internal report forms for management's job performance monitoring. The information collected is used to make job cost tracking, productivity measurement, and legal evidence, which relies on the accuracy and timeliness of the data acquisition process. Often, the working conditions and a reluctance to do the repetitious paperwork prevent the construction foremen from fulfilling the field data collection in time, therefore, there is a great need to automate the work of construction foremen.

Construction foremen have mixed feelings about current computer technologies. On one hand, they have the aspiration to learn how to manipulate computers proficiently, yet on the other hand, their limited knowledge background inhibits them from moving forward. Prior research finds that foremen often have a resistance to computer technologies due to the intensive training needs and knowledge background needed to attain that goal [3]. It should be noted that the need of foremen for computer technologies is different from the need of management personnel. Foremen need computing devices that have an easy-to-use user interface and do not require a lot of prerequisite computer knowledge to operate them.

Well-planned work that can best be characterized in a repetitive format is most often supervised by foremen on a construction site [3]. The need for construction foremen to be able to access and capture job-related information is extremely critical. Without the link of foremen in the automation chain, the whole construction automation process will be of no use because of disjointed information flow.

Multimedia Communications for Construction Foremen

Different perspectives have developed over the years as to how sophisticated computer and communication technologies can be used by those with limited educational background. However, since the need for easy-to-use devices and interfaces is critical, it is reasonable that sophisticated technologies can be implemented at a user-friendly level.

Typically defined as electronically-based text, voice, video, still picture, and some other emerging information types, multimedia communications for construction foremen will now be discussed in more detail.

Text Information

Although there is no need for foremen to access and compose pages of text information, key construction information, such as short descriptions of completed tasks in the day and some numeric information is and will still be critical in feeding the job performance tracking system and further extracting information for monthly or quarterly cost

reports. The way that foremen deal with text-based information will be daily logs (labor hours expended, materials consumed, etc.), safety inspection or quality control checklists, and occasional short descriptions of construction related problems. There should be less need of key-strokes for inputting information. Figure 3 shows an example of quality inspection checklists to be filled out by construction foremen. With this kind of electronic checklist forms, construction foremen can record key information including date, time, concrete mix design, starting pour time, rate, status, and possibly signature captures provided they are equipped with handheld computing devices with electronic ink capable screens. After all the lists have been checked off, foremen will be able to send this information back to a field office server via digital wireless communications.

Voice—Analog and Digital

Analog one-way radios have been widely used in the construction industry. Voice instructions assisted by radios in operations such as concrete pouring, material transportation, and heavy structural steel component fitting have been found very useful and this actually has already become one of the tools of current construction foremen. Digital voice radios are also available now and they are more reliable and secure through scrambled data packets. Digital radios can be used with handheld computers and there are now some Windows CE-based handheld computers that have digital voice recorders.

Messages can be saved as files and transferred to a remote place. This will be a valuable tool when the foremen need technical assistance while real-time voice communication is not available.

Video—Live Versus Still

Videos and pictures are capable of describing a construction situation in great detail. Video clips can be used to report a problem or show the project progress status to management. Although video cameras can be set up around a construction site for security or job-monitoring purposes, video conferencing for construction foremen and other mobile users on the construction site still needs further justification and technological support. Video conferencing, a high bandwidth consuming technology, will be difficult to implement on wireless-based handheld computers for construction foremen. Instead, high quality still digital images and short video clips will be more practical on the construction site. For example, progress digital images acquired by construction foremen can be attached with the monthly progress payment request, an

CHECK ITEMS	STATUS	DATE	TIME	INITIAL
FORMWORK				
Line & Grade	OK	04/12/98	1:17 PM	QT
Grade Slabs	OK	04/13/98	2:46 PM	QT
Screeds	Not OK	04/12/98	2:23 PM	QT
Chassis Strips	Not Applicable	04/12/98	1:00 PM	

Figure 3—An Example of Quality Control Checklists for Construction Foremen

activity that often needs back-and-forth justifications on completion percentages between owners and contractors. Multimedia-assisted payment requests will ease this job and reduce contentions.

Other Types of Information

With advancements in computer and communication technologies, other types of multimedia information are also emerging. Geographically-related information is gradually being considered very useful in construction with recent explorations of using geographic information systems (GIS) technologies in construction. When combined with project site CAD drawings, geographic locations can be captured to record certain construction activities and project management tasks. Maps and geographic coordinate information then become part of multimedia information that foremen will deal with in the future. Figure 4 shows an example of how GIS and digital still images can be used in recording change orders. With information such as name, location, date, time, materials, and labor hours consumed, and digital images captured by foremen on the construction site, changes occurring on a job can be well documented and organized as hyper-linked points on the site map, which is created from project CAD drawings. When a user clicks on one of these change points, the system will pop up two windows, one for text descriptions of the change work, and the other one showing a digital image of the change work. In this way, regardless of the number of changes, they can be represented visually and persuasively and can reduce the chances of disputes that often occur from poorly-documented change information.

Multimedia Communications Tools and Technologies for Construction Foremen

There is no complete off-the-shelf system that can fulfill all the multimedia communication capabilities described above for construction foremen. Multimedia communications for construction foremen entail several technologies to make up a usable system. Wireless networking technologies, handheld computing technologies, digital imaging technologies, and mobile GIS technologies will be the key types of components for such a specialized information tool.

Wireless Communication Technologies

It was not until recent years that technology made it possible to use digital wireless signals to transfer data. The key advantage of wireless communication technologies is that they do not need wires and cables

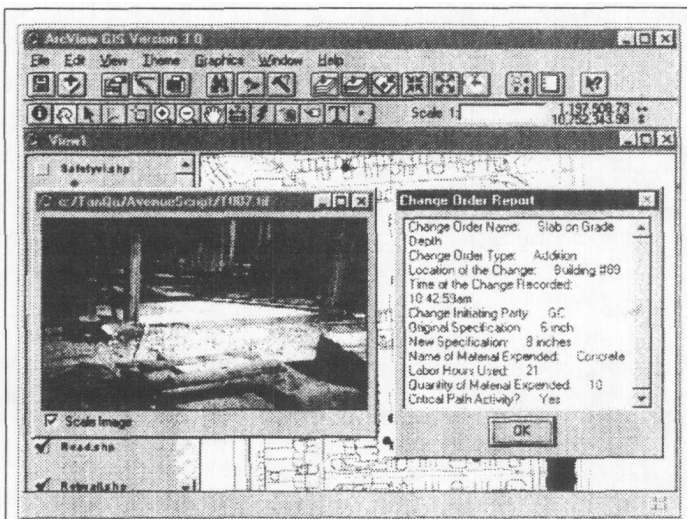


Figure 4—An Example of Using GIS and Digital Images in Recording Construction Changes.

to physically establish network connections with computers and networks. This makes it uniquely ideal for use on construction sites. Mobile users will not be restricted to fix onto certain places to be able to transfer information. Most current wireless local area networks (WLAN) operate in the frequency range of 2.4 to 2.4385 GHz, and this allows traditional walkie-talkie voice radios to continue to work in the frequency range of 902 to 928 MHz. This provides an ideal frequency range use allocation on construction sites (Frequency ranges allocated by FCC for use without charge are the industrial, scientific, and medicine [ISM] bands and they are 902 to 928 MHz, 2.4 to 2.4385 GHz, and 5.725 to 5.850 GHz.)

Wireless communication capabilities will greatly enhance the efficiency of construction foremen. Foremen will no longer need to request superintendents or field engineers to go back to the field office to look up volumes of blueprints or construction document to clarify a simple question. They will use their own handheld devices to make a query to the server to find simple information like well-illustrated construction steps of a certain place of the project. All these back and forth communications will reply on wireless signals, which are invisible and can only be interfered with by microwaves.

Handheld Computing Technologies

Considering the educational background and computing manipulation skills of construction foremen, traditional laptop computers will be cost-ineffective and unsuitable for use by construction foremen. Construction foremen will need small handheld computers that are durable and easy to use. Wireless communication and built-in digital camera will be key functions of the handheld computer. There are currently some Windows CE-based handheld computers that already have digital cameras through the PCMICA interface, but they need more work to integrate with WLAN products. Due to the different nature of handheld computers for construction foremen, they will be different from normal computers for general use, and they can only be specially designed and manufactured to really reach the world of construction foremen.

Mobile GIS and GPS Technologies

Research conducted at the University of Florida found mobile GIS and GPS technologies very useful in construction planning and documenting construction information. Not only at the centimeter accuracy level can GPS technologies be used to automated pile-driving and pavement construction activities, they can also be used in creating geographically linked as-built documents at some lower accuracy level. The role of construction foremen in applying these technologies is in data acquisition. Just like daily logs and various checklists, they also will be able to acquire simple information for management.

Discussions

This paper examined the intrinsic characteristics of construction foremen and their important role in construction operations and management and construction automation. Although foremen have an instinctive resistance to sophisticated technologies when their knowledge is not advanced enough to handle complicated tools, they are eager to be incorporated in the construction automation process. User demographics and the need for easy-to-use devices and interface have been recognized over the years and will continue to be the judge for new information tools for users with limited education such as construction foremen.

Multimedia information is revealing its great usefulness in the construction industry. As part of the workforce and the linking bridge between workers and supervisory personnel in a construction project, foremen will be the source of multimedia information on which engi-

neers and management depend.

Specially designed handheld computers with wireless communication, digital voice recorders, and digital imaging capabilities will be the multimedia information tools for construction foremen, as well as the traditional voice radios. Some other technologies such as mobile GIS and GPS will also be included in this multimedia communication category as the construction automation process develops.

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