Bar Code Applications in Construction

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Abstract: Although the construction industry does not yet have a broad base of experience with bar code technology, a wide range of applications has recently been developed by member firms of the Construction Industry Institute. The findings of a research project supported by the Construction Industry Institute are summarized. Specific applications in the areas of quantity takeoff, field material control, warehouse inventory and maintenance, tool and consumable material issue, timekeeping and cost engineering, purchasing and accounting, and document control and office operations are discussed. Research findings indicate that bar code use in construction can improve the speed and accuracy of computer data entry, and produce tangible cost savings similar to those that have been documented in other industries.

Introduction

The construction industry lags behind the automotive, retail grocery, and other industries in the widespread use of bar code technology. Other industries have developed uniform standards and education programs and achieved industry-wide vendor compliance through their respective industry action groups. Realizing the tremendous potential for cost savings that is associated with bar code technology, the Construction Industry Institute (CII) funded a formal research project in 1987 to explore the potential applications and the resulting cost-saving benefits of bar code use in the construction industry. This paper summarizes the findings of the recently completed CII research project.

CII Bar Code Research

Research Objectives

The CII bar code research project was conducted by the writers to address the following objectives:

1. Determine the status of bar code use in other industries.
2. Determine the status of bar code use in the construction industry.
3. Evaluate the resulting costs and benefits associated with bar code use.
4. Formulate guidelines for widespread construction industry implementation, and recommend industry-wide standards that may be needed to achieve implementation.

Research Methodology

To address the objectives stated above, a comprehensive literature survey was conducted to document the status of bar code implementation

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in other industries (McCullouch 1988). A bar code advisory committee was created within CII for the purpose of guiding the research effort and identifying specific bar code applications that have been developed by CII member firms. The 63 member firms of CII were contacted and were requested to forward to the project researchers information pertaining to bar code applications that have been implemented, or that were being contemplated, within their organizations.

During the course of the research, the writers performed a number of site visits to CII engineering contractors who have actually applied bar code technology to their construction projects. (The term engineering contractor is used herein to refer to a large industrial contractor that performs both construction and engineering design services.) The writers also visited selected industrial facilities that are using bar code applications, and they attended a number of industry-action group meetings, seminars, and short courses relating to bar code technology.

Bar Code Technology

Symbology and Standards

A bar code can be defined as a self-contained message with information encoded in the widths of bars and spaces in a printed pattern (Harmon and Adams 1984). Bar codes permit rapid and error-free data entry into virtually any type of computer system. Assuming that the typical bar code consists of 12 data characters, a bar code can be scanned by a hand-held wand at least twice as quickly as the data can be entered by a skilled data processing operator using a keyboard. Whereas keyboard data entry generally results in one error for every few hundred keystrokes, industrial bar code scanning is accurate to the order of only one error for several million characters entered (Allias 1985).

The term "symbology" refers to the structural characteristics of the bar code symbol. In recent years, various symbologies (Two of Five, UPC Symbol, Code 39, and others), with their respective advantages and disadvantages, have been proposed and adopted by different industries. At present, the Code 39 (also known as Code 3 of 9) symbology, which permits the coding of both numeric and alphabetic data, has evolved as the standard in the automotive, defense, manufacturing, and construction industries.

To enhance quality and promote consistency throughout their industries, the automotive, health, fabric, retail grocery, and defense industries have developed symbology standards. These standards define requirements for bar code printing (print dimensions and tolerances, print density, reflectivity), readability requirements, shipping label layout, label data content, and label size. Some of these industries have also set standards pertaining to data identifiers, which are symbols inserted into the bar code to tell the computer what type of information follows the symbol. For example, if the letter P is coded within the overall bar code symbol, the number following the P is a part number.

Scanning Devices

Bar code scanners can be stationary or hand-held devices tied to a computer keyboard (or communication terminal), or portable and pro-

grammable devices that capture and store the entered data. An inexpensive wand (light pen) reader can easily be connected to a computer keyboard through a "wedge," permitting simultaneous entry of keyboard and bar-coded data. A hand-held laser reader is more versatile than a wand in that the laser reader does not have to be in direct contact with the bar code being read. Portable devices, with a wand or laser reader attached, can be programmed to prompt the user for bar code and/or manual data entry. The portable device stores the captured data (pertaining to a warehouse inventory, for example) which can then be loaded into a computer file at a later time.

Printing Devices

Bar code symbols can be printed by commercial printing processes, by computer-driven dot matrix printers, impact printers, thermal printers, laser printers, laser engravers, and other devices. Maintaining acceptable bar code print quality is an important element in any bar code application. Inexpensive printing devices (dot matrix printers) may not produce reliable machine-readable labels. Typical problems encountered when using inexpensive printing devices include bar edge roughness, voids in the printed bar, marks in the spaces between the bars, and low print contrast. Bar code printing and printing specifications are discussed in detail by Burke (1984) and Allias (1985).

Construction Applications

Overview

The U.S. industrial construction industry does not yet have a broad base of experience with bar code technology. Although a wide range of applications has been developed by CII member firms, most applications have only been applied to single construction projects, with some being applied to a few projects on a trial basis.

During the course of the CII research effort, two categories of applications were found to exist. In the first category, bar code tags or labels are applied to materials, equipment, and containers, and/or to the paperwork used to control those items. In the second category, bar-coded menus are used specifically for the purpose of improving the speed and accuracy of data that will be entered into a computer system. All construction bar code applications observed by the writers as part of the CII research used the Code 39 symbology.

Most observed bar code applications are used in conjunction with previously developed project-control computer systems, although some additional data loading and sorting routines were required. Light pen and laser scanners are being used with the "wedge" interfaces, as are portable programmable readers. When portable readers are used, some investment in time to learn how to program the readers is usually required. Bar code labels are being printed using dot matrix and high quality laser printers. One engineering contractor is bar-coding design drawings using a CAD system plotter.

Quantity Takeoff

When a computer aided design (CAD) system is used to generate design drawings, the bulk materials requirements are automatically generated,

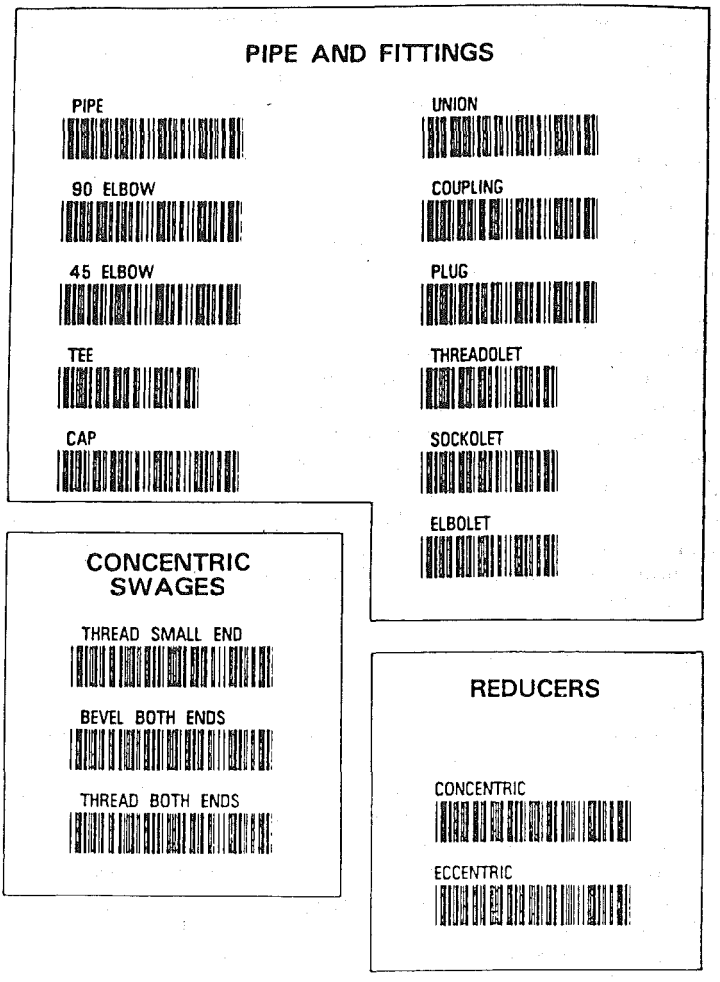
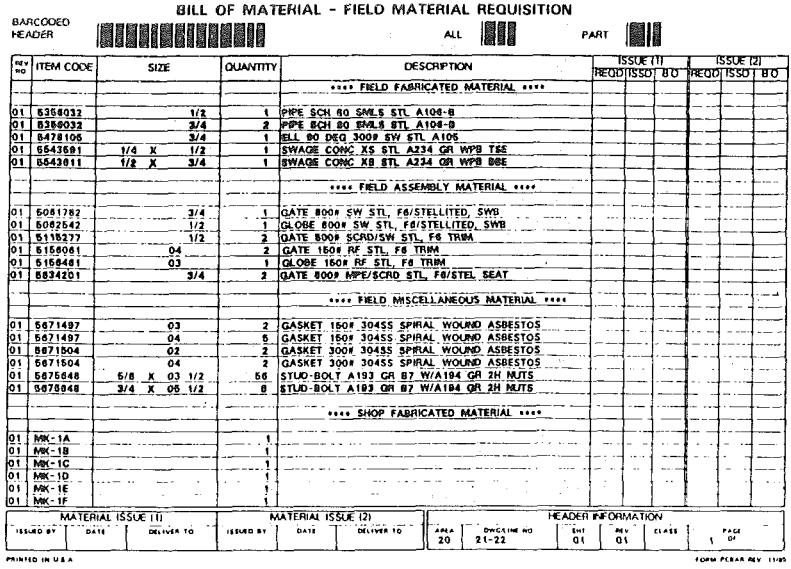


FIG. 1. Portion of Bar-Coded Menu Tablet Used for Quantity Takeoff

and a manual takeoff is not required. When a manual takeoff is required, a bar-coded menu can be used to speed the entry of takeoff data into a materials requirements computer data file.

The microcomputer bar code takeoff procedure used by one CII engineering contractor begins by first entering general identifier data relating to the drawing: contract number, line number, drawing sheet number, area, and a line class specification number. Then, for each material commodity on the drawing, the user enters certain item parameters using a bar-coded menu and light pen reader. Item parameters entered from the bar-coded menu include item description (45 elbow, concentric reducer, etc.), quantity, control code (to denote field or shop fabrication, etc.). A portion of the bar-coded menu used for this application is shown in Fig. 1.

Since this engineering contractor maintains a bulk-materials commodity



BILL OF MATERIAL - FIELD MATERIAL REQUISITION

BARCODED HEADER ALL PART

REV NO	ITEM CODE	SIZE	QUANTITY	DESCRIPTION	ISSUE (1) REQD	ISSD	B O	ISSUE (2) REQD	ISSD	B O
				**** FIELD FABRICATED MATERIAL ****						
01	8356032	1/2	1	PIPE SCH 80 SMLS STL A106-B						
01	8356032	3/4	2	PIPE SCH 80 SMLS STL A106-B						
01	8478105	3/4	1	ELL 90 DEG 3000 SW STL A105						
01	8543691	1/4 X 1/2	1	SWAGE CONC XS STL A234 GR WPB TSE						
01	8543611	1/2 X 3/4	1	SWAGE CONC XS STL A234 GR WPB BSE						
				**** FIELD ASSEMBLY MATERIAL ****						
01	5081782	3/4	1	GATE 800# SW STL, F6/STELLITED, SWB						
01	5082542	1/2	1	GLOBE 800# SW STL, F6/STELLITED, SWB						
01	5115277	1/2	2	GATE 800# SCRD/SW STL, F6 TRIM						
01	5158061	04	2	GATE 150# RF STL, F6 TRIM						
01	5158461	03	1	GLOBE 150# RF STL, F6 TRIM						
01	8834201	3/4	2	GATE 800# MPE/SCRD STL, F6/STEL SEAT						
				**** FIELD MISCELLANEOUS MATERIAL ****						
01	5671497	03	2	GASKET 150# 304SS SPIRAL WOUND ASBESTOS						
01	5671497	04	5	GASKET 150# 304SS SPIRAL WOUND ASBESTOS						
01	5671504	02	2	GASKET 300# 304SS SPIRAL WOUND ASBESTOS						
01	5671504	04	2	GASKET 300# 304SS SPIRAL WOUND ASBESTOS						
01	5675648	5/8 X 03 1/2	56	STUD-BOLT A193 GR B7 W/A194 GR 2H NUTS						
01	5678948	3/4 X 05 1/2	8	STUD-BOLT A193 GR B7 W/A194 GR 2H NUTS						
				**** SHOP FABRICATED MATERIAL ****						
01	MK-1A		1							
01	MK-1B		1							
01	MK-1C		1							
01	MK-1D		1							
01	MK-1E		1							
01	MK-1F		1							

MATERIAL ISSUE (1) ISSUED BY	DATE	DELIVER TO	MATERIAL ISSUE (2) ISSUED BY	DATE	DELIVER TO	HEADER INFORMATION AREA	DWG/LINE NO	SHT	REV	CLASS	PAGE OF
						20	21-22	01	01		1

PRINTED IN U.S.A. FORM PCBAR REV. 11/85

FIG. 2. Bar-Coded Field Materials Requisition

code catalog that consists of approximately 35,000 items, it is not practical to scan commodity code numbers to identify a unique material component as the takeoff progresses. The computer system avoids this problem by linking material components to the line specification in the data file. Thus when the bar code description and size are scanned on the menu, a unique commodity code is determined by the computer, using the previously entered line specification.

Field Material Control

Bar codes can be used in a number of ways for the field control of both bulk materials and engineered equipment. A typical large industrial construction project has a number of distribution centers that receive, inspect, store, and issue equipment, materials, consumables, spare parts, and other items that can be controlled through the use of bar code technology.

Very few construction materials manufacturers or vendors are applying bar codes to their products. The owner or contractor purchasing the materials and equipment must therefore either supply bar code labels to the vendor, or apply bar code labels to the items (and/or to the associated paperwork) at the time of material delivery. The on-site materials management computer system can be programmed so that the scanning of bar-coded items or paperwork will generate receiving reports and instructions for inspection, environmental protection, storage location, and the current status of the material with respect to the need for immediate issue.

Material withdrawal requisitions can also be preprinted with a bar code number that, when scanned, will produce or access a computer-generated issue report. As materials are being pulled from their warehouse storage locations, bar-coded item numbers at the storage locations can be scanned as the issue report is being completed. Bar codes on the badges of the

FIG. 3. Sample Bar-Coded Warehouse Bin Labels

employees issuing and/or receiving the materials can also be scanned and entered into the computer system. A bar coded field materials requisition is shown in Fig. 2 and sample bar code labels for warehouse bins in Fig. 3.

QA/QC (Quality Assurance/Quality Control) inspections are frequently performed in vendor shops or at other locations remote from computer system access. When the material components being inspected have bar code tags, inspection data can be captured in the field through the use of preprogrammed portable scanners.

Items that are prefabricated or assembled in various stages on-site may require extensive schedule monitoring. A bar-coded tag attached to the fabrication assembly can be used to generate computer reports detailing assembly status, and/or instructions for actions that need to be taken at a particular assembly station.

The manner in which bar codes are used for field material control will, in part, be determined by the structure of existing materials-management computer systems. One CII engineering contractor has developed two microcomputer database programs, one for the control and installation of piping materials (valves, spools, hangers, and welds), and the other for the control and installation of electrical materials (cables, raceways, electrical equipment, terminations, and jumpers). A minicomputer CAD (computer-aided design) system is used for piping and electrical design, generating materials requirements as part of the design process. Unique code numbers are generated for major materials and equipment items that are specified during the design process, and then downloaded to the micro-

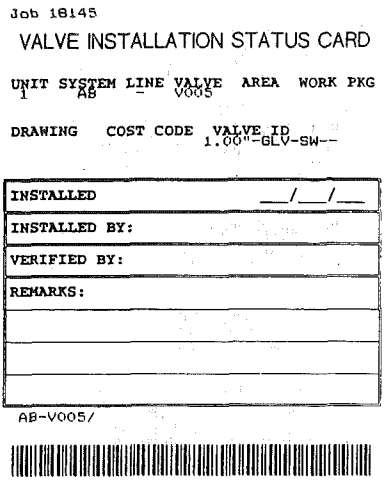


FIG. 4. Sample Bar-Coded Status Card for Field Material Control

computer (PC) materials-management system database. The PC materials management system is capable of printing bar-coded status cards similar to the card shown in Fig. 4. When the item is delivered, is installed, or undergoes a similar change in field status, the bar-coded card is completed and the status data are entered into the materials-management computer system. This CII engineering contractor has successfully applied the piping database program that uses bar-coded status cards to three construction projects. A typical project would use about 15 MB of PC fixed disk space and track about 1,500 valves, 1,500 hangers, and 1,500 spools, with about 30 fields of information stored for each valve, spool, or hanger.

Warehouse Inventory and Maintenance

When received materials are placed in a warehouse storage location, that location can be entered into the materials-management computer system by scanning bar code labels that have been applied at the storage location or placed on a menu tablet. Placing bar code labels on actual storage locations is useful for performing warehouse inventories using portable bar code scanners. In a similar manner, as periodic maintenance is performed on stored items, maintenance data can be captured using the portable scanner. This approach also applies to any routine data status requirement, such as the maintenance and fueling of construction vehicles and equipment.

Tool and Consumable Material Issue

The issue of tools and consumable materials (rainsuits, gloves, safety glasses, etc.) is subject to potential abuse on construction projects. One CII engineering contractor has recently converted a manual consumable-materials checkout system (one that recorded employee number, quantity, and item number in a notebook) to a computer system that uses a portable bar code reader to record the same issue-data. Although some time is saved by recording the issue data electronically, the principal benefit of the

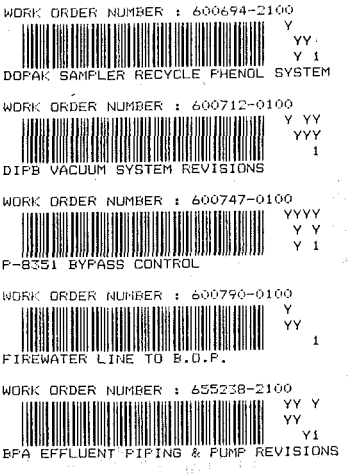


FIG. 5. Sample Bar-Coded Work-Order Numbers for Man-hour Reporting

bar code computer issue system is the fact that employees are less likely to abuse a system that involves capturing data into a computer system. Since initiating this application, the contractor has observed a one-third decrease in the issue of consumables on a major project.

Timekeeping and Cost Engineering

Preprinted time cards can be bar-coded with any combination of descriptors to indicate employee number, crew designation, cost account code, work area, and so on. After the time cards have been manually completed (work hours, work accomplishment, and other data entered) the time card data can be rapidly entered into a computer system by scanning the bar codes on the time card and scanning bar codes on a menu tablet that correspond to the data that were manually entered. Portable bar code scanners are useful for capturing work accomplishment data at site locations remote from the computer terminal. In a similar manner, productivity data that include measurements of productive work time, delay time, delay cause, and so on, can be captured with portable bar code scanners.

One CII engineering contractor has developed a standard man-hour reporting system that uses portable bar code scanners. The program has been effective in minimizing the paperwork requirements of the project foremen. For this application, foremen scan bar codes associated with the employee badge number, work order number, activity or cost code, and work-order variance number. These bar codes are maintained in a menu tablet format in a foreman's notebook. The efficient entry of data into the portable reader depends on the ability of the foreman to quickly locate and scan the appropriate bar code in the notebook. The notebook should, therefore, contain only work order numbers, badge numbers, and cost codes that pertain to that foreman's crew and work responsibilities. Sample bar-coded work order numbers and badge numbers used for this application are shown in Figs. 5 and 6, respectively.

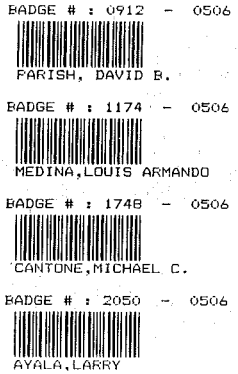


FIG. 6. Sample Bar-Coded Employee Badges for Man-hour Reporting

Purchasing and Accounting

Most standard forms used for purchasing- or accounting-related functions can be printed with bar-coded information. A bar-coded purchase order form used by one CII engineering contractor is shown in Fig. 7. Vendors are supplied this type of form and asked to include the form with the material shipment to facilitate the execution of a field-receiving report.

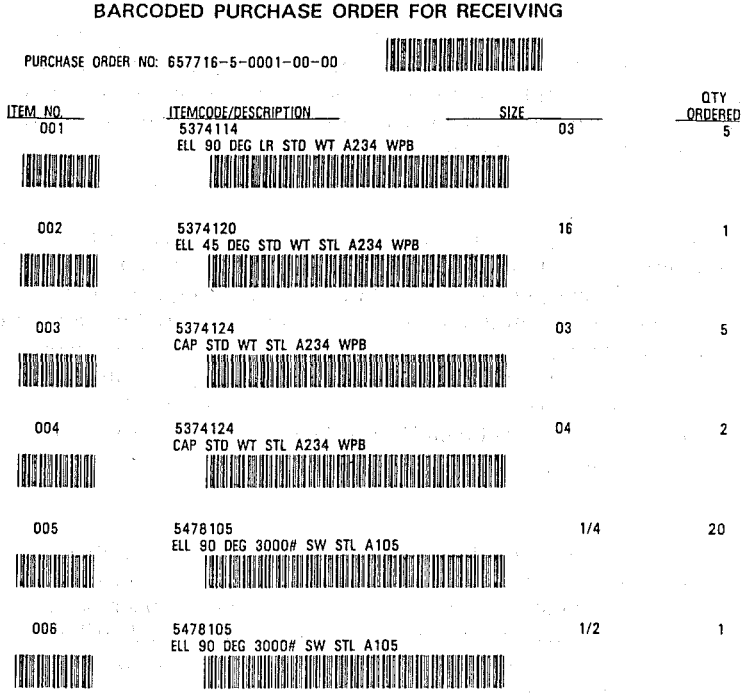


FIG. 7. Sample Bar-Coded Purchase Order

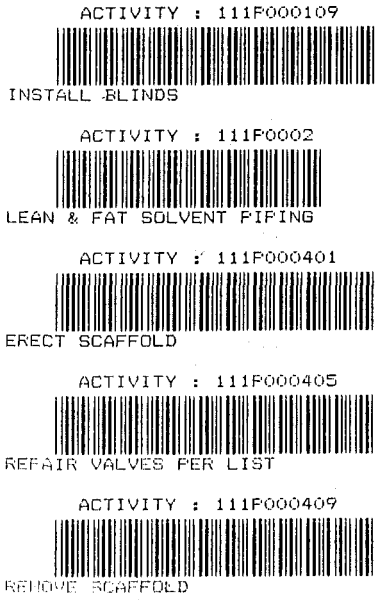


FIG. 8. Portion of Bar-Coded Menu Tablet for Project Schedule Updating

Bar codes can also be used as a word processing supplement for generating documents with various formats or contents. A bar-coded menu tablet could, for example, be used to select alternative terms and conditions for a purchase order, or to select the names of vendors who would receive selected price quotation correspondence.

Scheduling

Bar code technology can be used with commercial software packages to speed the input of the required program data. Project schedule updating is a typical project-management activity that requires frequent, tedious data entry. Computer program input data can either be entered directly into a commercial software package by scanning bar-coded menus when program prompts appear, or by creating input data files using portable bar code scanners. A portion of a bar code menu used by a CII engineering contractor to create an input data file for the commercial software package Quicknet is shown in Fig. 8.

Document Control

Bar codes indicating drawing and revision numbers can easily be placed on design drawings, shop drawings, vendor drawings, and other documents. As drawings move from one user to the other, the user can scan the drawing bar code to generate reports pertaining to drawing distribution and approval status, or to enter approval and other data into the document-control computer system.

Almost any CAD system can be programmed to bar code drawings during the design process, or bar-coded labels can be attached to the

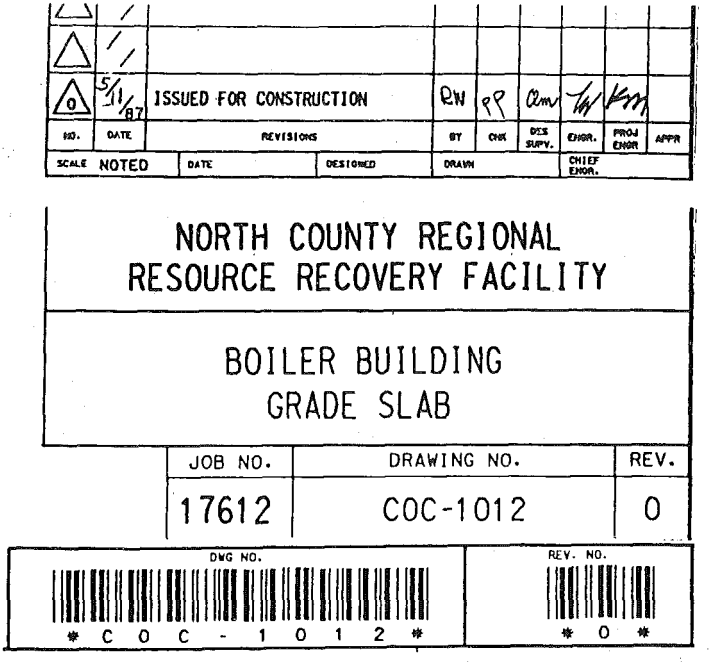


FIG. 9. Sample Bar-Coded Drawing Title Block

drawings later. A bar-coded design drawing title block used by one CII engineering contractor is shown in Fig. 9.

Design drawings and other documents can be organized for storage at the completion of a project by placing documents into bar-coded boxes or containers. A computer database can then be established linking the bar code on the container to the container contents. As a result, documents can be easily inventoried using portable bar code scanners.

Office Operations

Bar code tags can be applied to office equipment, computers and peripherals, and office furnishings to facilitate periodic inventories with portable bar code scanners. The receipt, distribution, and return of education and training materials, personnel records, and other items can be controlled by bar coding the items and records that will be issued or tracked, as well as the badges of the employees using the issued materials.

Costs and Benefits

General

Bar coding hardware is relatively inexpensive and requires only very basic employee training and education. Hardware costs are, of course, variable, but in general, a "wedge" will cost about $500, a light pen wand scanner about $200, a laser scanner about $1,200, and a portable programmable reader about $1,600. Industrial-quality bar code label printers will

cost from about $2,000–$10,000. Bar coding can be adopted and linked to existing management computer systems with little or no additional programming effort. For many applications where the user has not as yet developed a computer system, PC database programs can easily be written, and wand or portable scanners can be used to enter the data. The PC software package dBASE III is a popular choice for most PC-based applications.

The benefits that are produced as the result of the implementation of bar code technology can not always be determined precisely. The reductions in time associated with improved data entry and inventory operations can be accurately measured, but the benefits associated with improved data accuracy, information flow, and employee morale can not always be evaluated. Also, bar code applications are frequently implemented at the same time that a more sophisticated computer system is being put in place. When this occurs, it is not clear which benefits can be attributed to the computer system and which benefits can be attributed to the bar code technology.

Other Industries

Other industries that have had extensive experience with bar coding have reported substantial cost savings as the result of bar code implementation. The retail grocery industry claims that bar coding produces a savings equivalent to 1.5% of gross sales receipts (Burke 1984). A Department of Defense (DOD) cost benefit group has projected that the total annual DOD tangible savings for use of bar code scanning instead of conventional methods of data entry in selected areas will be $113,900,000 ("Final report" 1981).

The Department of Defense has also documented the costs and benefits associated with bar code implementation projects at various DOD installations (*LOGMARS* 1987). For example:

1. A bar-coded munitions inventory system has reduced the time required to perform an inventory by 80%.
2. An automated tool control system that uses bar-coded tools and employee badges produced an estimated $400,000 savings when implemented at two Army depots.
3. An equipment management system that tracks scheduled maintenance, location, warranty information, and so on, for $0.5 billion in equipment will produce $4,000,000 in savings over the life of the equipment because of reduced manpower, reduced potential for fraud and waste, and improved tracking of loaned equipment.
4. An asset-control system has resulted in tighter material control, less pilferage loss, improved turn-in of excess material, and elimination of duplicate requisitioning.

Tangible cost and benefit data, when available, are useful for ranking potential applications and for guiding other installations that are planning to implement similar applications. For example, as the result of a prototype test program, DOD estimated that certain maintenance control and inventory applications will produce greater tangible cost-saving benefits than shipping and receiving applications ("Final report" 1981).

A major manufacturer of bar code equipment has also documented cost-saving benefits that can be attributed to bar code use ("Intermec" 1987). Some examples of cost-saving benefits in areas that are similar to the construction applications discussed above include the following:

1. A bar-coded document tracking system at a nuclear plant (750,000 engineering drawings, with 800 drawings in and out of a central file each day) reduced database data entry time from 2 hr per day to 7 min per day.
2. A ball bearing manufacturer the cut time required to perform a physical inventory by 87%.
3. A shipyard tool tracking system reduced tool replacement costs, reduced tool checkout time, and significantly improved employee morale.
4. An aerospace firm increased inventory accuracy by 20% in 6 months, which resulted in a $2,200,000 savings in reduced carrying costs, and a $1,000,000 savings in reduced surplus inventory.

Construction Industry

As part of the CII research site visits and other contacts, some tangible cost and benefit data were obtained for recently completed, ongoing, and planned CII-member-firm construction projects. Typical applications are summarized below and are reported in more detail by McCullouch (1988).

The project engineer responsible for certain process unit "turnaround" construction services at a refinery/chemical facility carefully researched potential bar code applications for this project and convinced the facility owner that a timekeeping and progress-reporting bar code application could be undertaken for a one time cost of $8,000, $2,500 of which would be for training. It was also estimated that these costs would be recovered within 6 months. After implementing the application for a period of one month, the project engineer estimated that costs would be recovered in a shorter time.

A CII engineering contractor who implemented the bar code quantity takeoff system previously described estimates that a 30% savings in labor time has resulted from the use of the bar-coded menu tablet, and that a significant increase in data accuracy has been obtained. The same engineering contractor estimates that the application of bar code technology to the receipt, inventory, and issue of materials has reduced warehouse receiving and inventory man-hours by approximately 50%.

A CII oil company owner has recently completed a formal bar coding feasibility study and plans to implement a pilot field-material control project in 1988. The feasibility study concluded that field material control was not the simplest application within the company (because of unique tagging requirements and the harsh field environment), but that it was the area with the most likely high-benefit potential.

Another CII oil company has developed a bar-coding fugitive emissions system that is used to perform from 100,000–200,000 component inspections per year. The bar code system, which uses bar code tags on all inspected components, has reduced inspection manpower by 50%, resulting in a tangible cost savings of $100,000 per year.

A CII utility firm recently completed a study to determine how bar coding could be used as a method of tracking design drawings. The study concluded that, although the potential benefits would be a function of

construction work load, substantial benefits would result from such a system. It was estimated that one department within the company that processed 12,000 drawings in 1986 could achieve a $19,200 per year labor saving with a bar-coded document control system. Overall, it was estimated that the cost of the document control system (hardware, software, installation, and training) would be $35,000, with resulting total annual cost-saving benefits of $48,000.

Implementation Recommendations

In-House Implementation

Substantial cost-saving benefits can be derived by implementing the bar code applications discussed herein. Industry-wide bar code standards are not required for the development of time-keeping, quantity takeoff, project scheduling, document control, maintenance and QA/QC inspection, and warehouse inventory applications. Construction industry standards would be helpful, but are not necessarily required, for the development of applications in purchasing, accounting, and some areas of field material control.

Companies contemplating bar code development projects should identify operations within their organizations that will provide maximum cost-saving benefits. This identification process is best accomplished by first establishing a company-wide bar code advisory committee. Applications should then be adopted on a pilot-project basis, with careful attention given to hardware selection, training, and cost-effectiveness evaluation.

Firms unfamiliar with bar code technology can make use of elementary references on the subject (Allias 1985; Burke 1984; Bushnell 1986; Harmon and Adams 1984) and various educational materials and conference proceedings that have been published by the Automated Identification Manufacturers ("Automatic ID" 1987). A set of video tapes produced by the Automotive Industry Action Group is another excellent source of educational information.

Industry Implementation

To eventually achieve maximum cost-saving benefits in the construction industry, particularly in applications related to materials management, industry-wide bar code standards should be developed. These standards are needed to establish uniform procedures for vendor product identification. Of particular concern is determining which products (if any) should be identified with a uniform commodity code, which uses the same identifying number, regardless of manufacturer, and which products should be identified with a two-field code, which uses one field to identify the manufacturer and one field to identify a unique product of that manufacturer.

Substantial interaction with a wide range of vendors who supply products for the construction industry will be needed before uniform standards can be adopted. This interaction can best be accomplished by establishing an industry-wide action group similar to the one created in the automotive industry for the purpose of developing their standards ("Bar Code" 1984; "Data" 1987).

Since Code 39 has already become the standard symbology in construction and in most construction-related industries (the single exception being the electrical manufacturers, who recently adopted the UPC symbology), there is no need to debate a standard industry-wide symbology. There is a need, however, to standardize label (tag) formats and data content, purchasing document formats, and symbols that will be used as bar code data identifiers. Minimum specifications for print quality, printing methods, and label materials could probably be adopted, at least on a trial basis, directly from specifications already in force in other industries.

Bar code standards, and education programs to instruct vendors and others in standard compliance, must be developed simultaneously. Unfortunately, industry-wide standards development and education will require a significant financial and manpower commitment from the construction industry. Because of the fragmented nature of the construction industry, it will be difficult for the industry to make this commitment in the forseeable future.

Conclusion

Construction Industry Institute member firms have developed bar code applications for a wide range of applications. It can be concluded from data from other industries, and from the limited data and projections that are available for the construction industry, that bar code technology will produce tangible cost-saving benefits for the construction industry.

However, the construction industry does not at present have a broad base of experience with bar code applications. Some mechanism is needed whereby information pertaining to the trial applications that are developed within the construction industry, including cost and benefit data, are disseminated to others who are contemplating similar applications.

Additional industry-wide experience and education will be required before an industry action group can be effectively formed to develop bar code standards. Owners and contractors should continue developing in-house applications that do not require industry wide standards, and should continue interaction with materials manufacturers, distributors, and other industry action groups so that useful standards can be developed in the near future.

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