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Bar Coding and the Construction Industry in Georgia and Alabama

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BAR CODING AND THE CONSTRUCTION INDUSTRY

IN GEORGIA AND ALABAMA

by

Herbert Marion Barber, Jr.

A Thesis Submitted to the Faculty
of the College of Graduate Studies
at Georgia Southern University
in Partial Fulfillment of the
Requirements for the Degree of
Master of Technology

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of the College of Science and Technology

Statesboro, Georgia

June, 1997
BAR CODING AND THE CONSTRUCTION INDUSTRY

IN GEORGIA AND ALABAMA

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CHAPTER ONE

Introduction to the Study

Introduction

Effective construction project management relies on data that can be processed into information (Bernold, 1990). Therefore, information on the construction project plays a key role in construction project management (Abudayyeh, 1991). Consequently, information management on the construction project is vital to the success of the construction project (Rasdorf, 1990). Bar coding is one option that can be used in the construction industry as an effective means of managing information (Stukhart, 1987).

The retail and manufacturing industries have used bar coding technology for several years to manage information (Bell, 1988) although the use of bar coding technology to manage information in the construction industry is only beginning to gain notable attention (McCullouch, 1994). As a result, the construction industry operates at a grave disadvantage when compared to the retail and manufacturing industries although the technology necessary to implement bar coding into the construction industry has existed for several years (Bernold, 1990).
Statement of the Problem

The problem of this study was to determine the need for implementing bar coding technology into the construction industry in Georgia and Alabama as perceived by construction companies.

Subproblems

The following subproblems were derived from the main problem in this study:

1. Does the construction industry in Georgia and Alabama consider bar coding as a possible effective means of tracking tools in the construction industry?

2. Does the construction industry in Georgia and Alabama consider bar coding as a possible effective means of tracking equipment in the construction industry?

3. Does the construction industry in Georgia and Alabama consider bar coding as a possible effective means of tracking material in the construction industry?

Limitations of the Study

The following were limitations of the problem for this study:

1. Data was collected during the year 1997.

2. The construction companies that participated in this study were listed as construction companies operating in Georgia and Alabama as listed in McGraw Hill Publications' Engineering News Records' 1995-1996 edition of the Directory of Contractors. For construction companies to be listed in the Directory of Contractors, each construction company had to complete a survey conducted by Engineering News Record and state that their construction company's annual contract volume was not less than one million dollars.
3. The participants' lack of knowledge regarding the associated costs involved with the implementation of a bar coding system into the construction industry, specifically the participant's own construction company, may affect the results of the study.

**Statement of the Need**

While some applications of bar coding technology have been applied to a few construction projects on a trial basis, the U.S. industrial construction industry does not yet have a broad base of experience with bar coding technology. However, other industries have developed uniform standards and educational programs and achieved industry-wide vendor compliance through their respective industry action groups (Bell, 1988). While the construction industry is continually seeking methods of improving cost effectiveness and productivity, bar coding technology remains nearly dormant in the construction industry. Only recently has bar coding technology finally began to gain some acceptance in the construction industry (McCullough, 1994).

In recent years bar coding has found many applications in the retail and manufacturing industries (Bernold, 1990), and all indications are that the retail and manufacturing industries will continue to find other applications for bar coding (Czaplicki, 1988). Some of the more significant applications found by Bernold (1990) include:

1. Production process monitoring.
2. Inventory control.
3. Receiving.
4. Warehousing.
5. Automatic sorting and routing.

6. Updating of data bases.

7. Inspection.

Some of the applications noted by Bernold (1990) can be adapted and integrated into the construction industry. Studies performed by Bell in 1988 suggested particular applications of bar coding that could be integrated into the construction industry as a means of improving information management and ultimately improving cost effectiveness. Some of the applications suggested were:

1. Quality takeoff.

2. Field material control.

3. Warehouse inventory.

4. Equipment maintenance.

5. Timekeeping and cost engineering.

6. Tool and consumable material usage.


9. Scheduling.

10. Office operations.

The idea of using bar coding technology for items such as tracking tools, equipment and material in an industrial setting is obviously not new, nor is the idea of using bar coding technology in the construction industry (Bell, 1988), however, the construction industry has not implemented bar coding technology, at least not on an
industry wide basis (Bernold, 1990). Although researchers have determined several areas within the construction industry that would benefit from the use of bar coding technology (Bell, 1988) and although the retail and manufacturing industries have benefited from the use of bar coding technology (Bernold, 1990), the construction industry as a whole still has not implemented bar coding technology. The use of bar coding technology in the construction industry is only just beginning to gain acceptance by the construction industry as a possible means of improving information management and, in turn, controlling project costs and increasing productivity; the use of bar coding is on a very limited basis at present (McCullouch, 1994).

Although all ten of the applications stated by Bell (1988) can play an important role in effective construction management, the tracking of tools, equipment and material on the construction site plays a particularly vital role in improving the cost effectiveness and productivity of a particular construction project. By accurately identifying equipment surpluses and needs, the overall level of rental equipment on the construction site can be efficiently determined in an effort to reduce costs. Likewise, by tracking tools and material on the site, costs can be reduced and productivity increased (Rasdorf, 1990).

**Procedures of the Study**

After all preliminary research was completed and the participants of the study were selected, the survey instrument was developed. The preliminary research and the survey instrument were put in the form of a proposal. The proposal was then reviewed for face validity by a thesis committee consisting of Dr. Keith Hickman, Dr. David Williams and
Dr. Charles Perry and by for content validity Dr. Saleh Altayeb, Mr. Lynn Fine, Mr. William Zabel and Mr. Gary Duncan in the building construction and contracting program at Georgia Southern University. After the thesis committee approved the proposal and the building construction and contracting faculty was satisfied with the survey instrument, the survey instrument was sent to all 171 participants of the study.

The participants of the study were allowed three weeks to return the completed survey instrument. After that time, the data from the returned surveys were extracted and analyzed. Conclusions were drawn from the research and recommendations made for further study.

**Definition of Terms**

Three terms were used extensively in this study. These terms are defined below.

1. **Bar Code** - a self-contained message with information encoded in the widths of bars and spaces in a printed pattern (Bell, 1988).

2. **Information Management** - the planning of all ideas, knowledge and other data in order to control particular aspects of a system.

3. **Materials Management** - the planning and controlling of all necessary efforts to ensure that the correct quality and quantity of materials and installed equipment are appropriately specified in a timely manner, are obtained at a reasonable cost and are available when needed (Plemmons, 1995).
Assumptions of the Study

The following were assumptions of the problem for this study:

1. The data collected from the survey was valid.
2. The participants in this study had a general understanding of bar coding.
3. The participants in this study were a representative sample of the construction industry in Georgia and Alabama.

Overview of the Study

The problem of this study was to determine the need for implementing bar coding technology into the construction industry in Georgia and Alabama as viewed by construction companies. More specifically, this research was designed to determine how construction companies viewed the use of bar coding technology as a possible effective means of tracking tools, equipment and material on the construction site as a means of better managing information.

The survey instrument was developed to gather information in an effort to determine the need for implementing bar coding technology into the construction industry as viewed by construction companies. More specifically, the survey instrument was designed to gather data regarding: (1) the possibility of using bar coding technology to track tools in the construction industry, (2) the possibility of using bar coding technology to track equipment in the construction industry, and (3) the possibility of using bar coding technology to track material in the construction industry.
After the survey instrument was sent to the participants of the study, the data was returned to the researcher. The returned data was assessed and conclusions were established based upon the data collected.

**Summary**

The problem of this study was to determine the need for implementing bar coding technology into the construction industry in Georgia and Alabama as viewed by construction companies. Only construction companies operating in the states of Georgia and Alabama were asked to participate in this study. The subproblems of this study were established to answer specific questions regarding bar coding in the construction industry. The subproblems were specifically aimed at determining the participant’s view regarding the possibility of using bar coding technology as a possible effective means of tracking tools, equipment and material on the construction site.

The limitations of the study were stated, the statement of the need for this study was established, and the procedures of the study were presented. Also, key terms used in this study were defined, assumptions of the study were stated, and an overview of the study was given.

The review of related literature is presented in the following chapter. The review of related literature presents the background for the study. It presents research done by other researchers that is similar to the research conducted in this study.

Chapter Three outlines the methodology of this study. The methodology of the study describes the methods that this study used to determine the results of the study.
The findings of the study are presented in Chapter Four. The findings, or results, of the study are presented in graphical form with explanations.

The study is concluded with Chapter Five. This chapter is used to show the conclusions of the study and give recommendations for further research in construction bar coding technology.
CHAPTER TWO
Review of Related Literature

Introduction

Information management on the construction site is vital to the success of the construction project (Rasdorf, 1990). Many construction projects suffer cost overruns that are a direct result of poor information management practices. To increase the possibility of completing a successful construction project, information must be managed in an effective manner for it plays a key role in construction management (Abudayyeh, 1991). One method of increasing the possibility of completing a successful construction project by better managing information is the implementation of a bar coding system on the construction site (Bernold, 1990).

Bar coding has been used to better manage information by the retail and manufacturing industries for several years. Over time the retail and manufacturing industries have perfected bar coding technology such that it has greatly benefited these industries. Bar coding is accurate to the order of only one error for several million characters entered (Bell, 1988) and has proven repeatedly as an effective collection technology that has accuracy rates approaching 100 percent (Fales, 1992). However, despite recent developments that have been achieved in bar coding technology by the retail and manufacturing industries, the construction industry still has yet to fully capitalize upon
the advantages that bar coding technology offers (Blakey, 1990) while the retail and manufacturing industries require the use of bar coding and consequently, reap the benefits of such (Higgs, 1994). Bar coding is only recently beginning to gain acceptance and find applications in the construction industry (McCullouch, 1994).

There are many applications offered by bar coding technology (Bell, 1988). As bar coding technology advances, the areas in construction that could benefit from bar coding in the construction industry increases. Among these areas, the construction industry could use bar coding technology in the areas of tool tracking, equipment tracking and material tracking to better manage information.

**Tracking of Tools, Equipment and Material**

Clough (1986) stated that no one organizational pattern could possibly be appropriate for every construction company. However, every construction company must maintain some method of organization to manage information in an effective manner in order to reduce costs and increase productivity.

There are at least three areas of construction that could benefit from using bar coding technology in an effort to reduce costs and increase productivity by better managing information. These three areas involve the tracking of tools, the tracking of equipment and the tracking of material (Bell, 1988).

Construction companies often have difficulty tracking tools on the construction site. Whether the construction project is very small or very large in size, the tracking of tools can be a cumbersome process if appropriate methods are not used to manage tool
information. Using bar coding as a means of tracking tools can be an effective automated data acquisition tool for the purpose of identifying and tracking a variety of construction resources, including the tracking of tools (Rasdorf, 1990).

Other industries that have had extensive experience in using bar coding technology have reported substantial cost savings as a result of bar code implementation. The Department of Defense reported savings as a direct result of using bar coding technology in tool management. One automated tool control system using bar coding technology to track tools produced an estimated $400,000 savings when implemented at two Army depots. Another savings was incurred at a shipyard when a tool tracking system using bar coding technology was implemented, reducing tool replacement costs and reducing tool checkout time (Bell, 1988).

Another area of the construction project that must be managed properly in an effort to manage information involves the tracking of equipment. Improperly managed, equipment costs on the construction site can escalate, driving the cost of construction projects up rapidly.

In general, the problems encountered with equipment management on the construction site are complex. The techniques used by construction companies for evaluating equipment costs have greatly oversimplified an exceedingly complex problem. At best, equipment costs are often difficult to estimate and control (Tsimberdonis, 1994). Equipment inspection and maintenance procedures could be significantly improved if a bar coding system was adopted and used on the construction site (Rasdorf, 1990).
Most construction equipment inspection and maintenance reports are still performed by hand. This process of reporting is both time consuming and complex (Rasdorf, 1990). Besides being time consuming and complex, the accuracy and quality of these construction equipment inspection and maintenance reports are totally dependent on the personnel completing the forms, for whom administrative duties are secondary to their main responsibilities (Blakey, 1990). Since the accuracy of bar coding technology is approaching 100 percent (Fales, 1992), bar coding technology could be used to easily eliminate these problems by individually identifying each piece of equipment on the construction site, making it relatively easy to capture equipment data (Bell, 1988). The current system of manually performing construction equipment inspection and maintenance reports could be replaced by a bar coding system which would allow for easy data entry and retrieval (Rasdorf, 1990) and be much more accurate (Fales, 1992).

Another advantage to using bar coding technology for the tracking of equipment in the construction industry is that of equipment location and use. The identification of where construction equipment is and what it is being used for can prove to be very beneficial information when determining the frequency of equipment use or its maintenance and servicing requirements (Rasdorf, 1990).

Inspection and maintenance and the ability to identify equipment locations and uses, are vital steps in information management in order to obtain successful completion of a construction project. Bar coding technology could play an effective role in reducing
costs and increasing productivity by better managing information and, in turn, help insure successful completion of a construction project.

In order for a construction company to properly manage information, it must also have an effective means of tracking material. Only recently has there been a growing awareness that materials management needs to be addressed as a comprehensive, integrated activity. Materials management functions have too often been performed on a fragmented basis with no clear communications established between the owner, engineers and contractors (Bell, 1986).

Bar coding technology can play an instrumental role in tracking material in the construction industry. Although it is often difficult to prove the cost effectiveness of materials management systems (Bell, 1987), effective material tracking methods as part of information management are essential to the success of a construction project. Whether the construction is tracking bulk materials or engineered equipment, or both, which is normally the case, bar coding technology can be used as an effective method in controlling construction costs (Bell, 1988). However, while many projects suffer adversely from ineffective cost control procedures due to the inefficient management of information (Abudayyeh, 1991), the construction industry still lags behind other industries in the use of bar coding technology as an effective means of controlling costs and increasing productivity (Bell, 1988).

A case study comparing the construction of two commercial construction projects performed by Thomas (1989) noted obvious differences in the methodologies used by each construction company to manage material. These differences in each company's
methodology proved to have a definite impact on the costs associated with each respective construction project.

Both construction projects were monitored during the erection of its structural steel. The total cost of Construction Project A was approximately $3.5 million and consisted of approximately 172 tons of structural steel. Construction Project B’s total cost was approximately $2.6 million and consisted of approximately 180 tons of structural steel.

Construction Project A resulted in a schedule overrun of 19 percent and subsequently cost overruns while Construction Project B was completed in a more timely manner. Thomas and his team of researchers attributed the overruns of Construction Project A and the successes of Construction Project B with ineffective material management techniques and effective material management techniques, respectively. Clearly, construction companies must consider the advantages of using appropriate material management techniques.

Although there seems to be little effort put forth from the construction industry as a whole toward implementing a bar coding system into the construction industry, recent research does indicate some interest in implementing a bar coding system into the construction industry to manage material. Stukhart (1990) found that although their research showed a minimal current use of bar coding technology for tracking material, there was a considerable interest in using it. Of the Construction Industry Institute’s companies that participated in Stukhart’s study in 1990, 19 percent currently use bar
coding technology and 58 percent are considering using bar coding technology to track and manage material. Stukhart (1990) concluded that this level of response indicates a considerable level of interest among the participants in using bar coding technology for tracking and managing material in the construction industry.

**Summary**

Chapter Two presented information extracted from literature of related topics. Specifically, this chapter presented research performed by other researchers regarding the use of bar coding technology as an effective means of tracking tools, equipment and material on the construction site in an effort to better manage information, reduce cost and increase productivity.

In 1988 Bell concluded that there were several areas of construction that could benefit from the use of bar coding technology. Three of these areas involve the tracking of tools, the tracking of equipment and the tracking of material. Chapter Two noted research that was performed by others relating to these three areas.

Chapter Two noted that Bell (1988) stated that the Department of Defense reported a savings of $400,000 by using bar coding technology to manage tools and noted that Rasdorf (1990) concluded that equipment could be more effectively managed if bar coding technology was used. Chapter Two also noted that Thomas concluded after performing a case study in 1989 involving the management of material on two separate construction projects that one construction project benefited as a result of effective material management and the other construction project suffered as a result of poor material management.
CHAPTER THREE
Methodology of the Study

Introduction

The problem of this study was to determine the need for implementing bar coding technology into the construction industry in Georgia and Alabama. To address the problem of this study, a survey instrument was developed to determine: (1) if the construction industry in Georgia and Alabama views bar coding as a possible effective means of tracking tools in the construction industry, (2) if the construction industry in Georgia and Alabama views bar coding as a possible effective means of tracking equipment in the construction industry, and (3) if the construction industry in Georgia and Alabama views bar coding as a possible effective means of tracking material in the construction industry.

Participants of the Study

The McGraw Hill Publications' Engineering News Record's 1995-96 edition of the Directory of Contractors listed 107 construction companies operating in the state of Georgia and 64 construction companies operating in the state of Alabama for a total of 171 construction companies. The Directory of Contractors obtained information from each construction company as a result of a survey conducted by Engineering News
Information gathered by Engineering News Record included the name of the company, name and title of an officer, address, telephone number, fax number, types of work performed and the annual contract volumes of each company. In addition to completing the survey conducted by Engineering News Record, each construction company also had to have a minimum annual contract volume of one million dollars in order to be listed in the Directory of Contractors.

Gathering of Data

This study sought to determine the need for implementing bar coding technology into the construction industry in Georgia and Alabama. To determine this need, data was obtained from selected construction companies operating in the states of Georgia and Alabama through a survey instrument.

The questions appearing on the survey instrument were developed to be easily understood by readers with various educational backgrounds. Leedy (1993) states that it is imperative that the survey instrument be specifically designed to fulfill the objective of the research. Therefore, much effort was put into the development of the questions for the survey instrument.

A cover letter accompanied each survey instrument. The cover letter explained that the purpose of the study was for educational research only, that the participant’s participation was vital to the research being conducted, that the participant’s anonymity would be protected and that there were no right or wrong answers. The cover letter also gave directions for completing and returning the survey instrument to the researcher. The
cover letter concluded by thanking the participant for participating in the study. A copy of the cover letter is shown in Appendix A.

The Survey Instrument

Under the guidance of the research committee and the building construction and contracting faculty at Georgia Southern University, the survey instrument was developed. The survey instrument was developed in such a manner as to fulfill the specific objective of the research.

The questions included in the survey instrument were arrived at based on preliminary research. The questions were also based on individual general conversations the researcher had with a tool, equipment and material management group that used bar coding technology on a pulp and paper industry construction project in Georgia.

The conversations between the tool, equipment and material management group and the researcher were of a general nature as the researcher casually made inquiries regarding the use of bar coding technology to track tools, equipment and material on the construction site. The conversations occurred on a random basis since the researcher worked on the same construction project with the tool, equipment and material group. The conversations were not intended to answer specific questions regarding the use of bar coding, rather the conversations were intended to better acquaint the researcher with the use of bar coding technology on the construction site in general.
The questions for the survey instrument were written with multiple choice responses. Multiple-choice type questions were used in an effort to make the interpretation of the results easier to evaluate.

The survey instrument was divided into two parts. Part One of the survey instrument was titled Demographics and Part Two of the survey instrument was titled Bar Coding.

Part One of the survey instrument was designed to obtain information about the individual completing the survey instrument and the construction company employing this individual. Part One consisted of three questions. The participant was asked to answer questions regarding the participant’s job function and the company that employed the participant.

Part Two of the survey instrument consisted of ten questions. The participant was asked to answer specific questions regarding the use of bar coding technology in construction. Specifically, the questions contained in Part Two of the survey instrument were developed to determine whether the participant considers bar coding technology as a possible effective means of tracking tools, equipment and material in construction.

**Development of the Survey Instrument**

Preliminary questions to be included in the survey instrument were written by the researcher. The preliminary questions were reviewed by the research committee for face validity and by the building and contracting faculty for content validity and revised by the researcher as necessary until it was concluded that the questions for the survey instrument
were stated in an appropriate manner. The research committee which reviewed the survey instrument for face validity consisted of Dr. Keith Hickman, Dr. David Williams and Dr. Charles Perry. The survey instrument was reviewed for content validity by faculty members in the building construction and contracting program at Georgia Southern University and consisted of Dr. Saleh Altayeb, Mr. Lynn Fine, Mr. William Zabel and Mr. Gary Duncan.

The survey instrument consisted of two parts. Part One of the survey instrument contained questions regarding demographics of the participant and the participant’s company. Part Two of the survey instrument contained questions regarding the participant’s interest in using bar coding technology in the construction industry. The questions for the survey instrument were written under each appropriate part, either Part One or Part Two, and allowed the participant to select the appropriate response by choosing from several answers.

The back of the survey instrument contained the address of where the completed survey instrument was to be returned. A postage stamp, purchased by the researcher, was placed on the back of the survey instrument in what would become the upper right-hand corner of the survey instrument to be returned after the survey instrument was appropriately folded.

The survey instrument was designed in a manner such that it could be tri-folded and taped at the bottom. The survey instrument could then be used as its own envelope containing the correct return address and appropriate postage.
Administration of the Survey Instrument

The survey instrument, containing a cover letter, was placed and sealed in an envelope and mailed to all 171 participants of the study. The survey instrument was mailed to the participants on February 24, 1997. A copy of the cover letter is shown in Appendix A, and a copy of the survey instrument is shown in Appendix B.

The addresses of the participants of the study were obtained from the Directory of Contractors. The Directory of Contractors, published by McGraw Hill, is a data bank of construction companies operating in the United States and abroad.

Directions for returning the survey instrument were specified in the cover letter. The cover letter thanked the participant and directed the participant contact the researcher via the telephone should any questions arise regarding the survey instrument.

Three weeks were allowed for the participants to complete and return the survey instrument. At the end of the three-week period, the results of the survey were tabulated.

Analysis of the Data

After the survey instruments were returned to the researcher, the data was collected, analyzed, and charted in order to graphically represent the results. Bar charts and pie charts were chosen to graphically represent the results of the data. The charts were created using MicroSoft Excel 5.0. In addition to each graphical representation, the responses to each question were also detailed in Chapter Four.
Summary

Chapter Three presented the methodology of the study. It began with a brief introduction regarding the objective of the study and the participants of the study.

Chapter Three then described how data were gathered by detailing the survey instrument and its construction and administration. After stating where a copy of the cover letter and survey instrument could be found in the study, a brief explanation was given describing how the data were represented.
CHAPTER FOUR

Findings of the Study

Introduction

The survey instruments that were sent to the selected construction companies operating in Georgia and Alabama were designed to determine the need for implementing bar coding technology into the construction industry in Georgia and Alabama. Of the 171 construction companies in Georgia and Alabama, 69 completed and returned the survey instrument. This represents a 40 percent response rate.

From the surveys that were returned, the data collected were represented graphically in charts. These charts can be found on the following pages in Chapter Four.

Part One - Demographics

Questions 1 through 3 were contained in Part One of the survey instrument. Part One posed questions relating to the demographics of each participant and each participant’s company.
Question 1:

What best describes your job function?

- CEO/President/Vice President
- Project/Engineering Manager
- Operations Manager
- Project Engineer
- Warehouse Manager
- Construction Manager
- Superintendent
- Other (specify)

Sixty-eight responses were received from a total of 69 returned surveys. Forty-nine of the responses indicated that their job function was CEO/President/Vice President. Of the remaining respondents, seven indicated that their job function was Operations Manager, five indicated that their job function was Project/Engineering Manager, two indicated that their job function was Warehouse Manager, two indicated that their job function was Other, one indicated that their job function was Project Engineer, one indicated that their job function was Construction Manager and one indicated that their job function was Superintendent. One of the participants who chose Other specified that their job function was Purchasing, and the other participant specified that their job function was Safety Director.
Figure 1. Participant's Job Function

Legend

CEO - CEO/President/Vice President
OM - Operations Manager
P/EM - Project/Engineering Manager
Other - Purchasing, Safety Director
WM - Warehouse Manager
PE - Project Engineer
CM - Construction Manager
SPT - Superintendent
Question 2:

What areas of construction does your company provide services?

___ Pulp & Paper
___ Chemical/Petrochemical
___ Manufacturing
___ Power/Nuclear
___ Residential
___ Heavy Civil
___ Commercial/Office
___ Utilities
___ Institutional
___ Other (specify)

All sixty-nine of the respondents that returned the survey responded to question 2. The question allowed the participant to choose any of the services listed for which their company performed. Of the ten choices, 187 choices were selected. Commercial/Office was chosen 49 times, Institutional was chosen 36 times, Manufacturing was chosen 30 times, Chemical/Petrochemical was chosen 15 times, Utilities was chosen 14 times, Pulp & Paper was chosen 13 times, Heavy Civil was chosen 13 times, Other was chosen seven times, Power/Nuclear was chosen six times and Residential was chosen four times. Of the seven respondents that chose Other, the responses specified were Food & Beverage,

**Figure 2:** Areas of Construction Provided by Participants

**Legend**

- C/O - Commercial/Office
- Inst. - Institutional
- Mfg. - Manufacturing
- C/P - Chemical/Petrochemical
- Util. - Utilities
- P/N - Other

(Figure showing the areas of construction provided by participants with specific details on the scale and categories)
P&P - Pulp & Paper

Other - Food & Beverage, Sports, Health Care, Telecommunications, Environmental Services, Distribution

P/N - Power/Nuclear

**Question 3:**

What is your company's gross annual contract volume?

___ $1 million - $10 million

___ $10 million - $50 million

___ $50 million - $100 million

___ $100 million - $250 million

___ $250 million - $500 million

___ $500 million +

All 69 respondents that returned the survey responded to question 3. Of the 69 respondents, 26 stated that their company's gross annual contract volume was $10 million - $50 million, 18 stated that their $1 million - $10 million, 11 selected $50 million - $100 million, six selected $100 million - $250 million, five selected $500 million+ and three selected $250 million - $500 million.
Figure 3: Company’s Annual Contract Volume

Legend

10 to 50 - $10 million - $50 million
1 to 10 - $1 million - $10 million
50 to 100 - $50 million - $100 million
100 to 250 - $100 million - $250 million
500+ - $500 million+

250 to 500 - $250 million - $500 million

Part Two - Bar Coding

Questions 4 through 13 were contained in Part Two of the survey instrument. Part

Two posed questions relating to the participant’s use, interest and need for using bar
coding technology as an effective means of tracking tools, equipment and material in the construction industry.

**Question 4:**

Does your company use bar coding to track tools, equipment or material?

___ yes

___ no

When asked if the participant’s company uses bar coding to track tools, equipment and material, 95 percent stated no, while only 5 percent stated yes. Sixty-five participants responded to question 4.

![Pie Chart]

**Figure 4:** Company Use of Bar Coding
**Question 5:**

If you answered "yes" to question 4, rate the bar coding system's effectiveness.

(1 is least effective; 5 is most effective)

___ 1
___ 2
___ 3
___ 4
___ 5

Of the 69 returned surveys, only three participants answered this question. All three participants who stated that their company used bar coding to track tools, equipment and material in question 4 also answered question 5. Of the three respondents, one selected item 3, one selected item 4 and one selected item 5.
Question 6:

Does your company have an organized system by which tools, equipment and material can be tracked?

___ yes
___ no

Sixty-seven participants responded to question 6. Of these, 55 percent indicated that their company does have an organized system by which tools, equipment and material can be tracked and 45 percent stated that their company did not.

Figure 5: Companies With Organized Tool, Equipment and Material Tracking Systems
Question 7:

Please rate the effectiveness of the system your company currently uses to track tools, equipment and material.

(1 is least effective; 5 is most effective)

1 2 3 4 5

Fifty-six participants chose to respond to question 7 regarding the effectiveness of their company’s current tool, equipment and material tracking system. Of these, 28 percent selected item 4, 25 percent selected item 2, 25 percent selected item 3, 18 percent selected item 1, and four percent selected item 5.

Figure 6: Effectiveness of Companies’ Current Tracking System
Question 8:
If currently not using bar coding, would you be interested in implementing a bar coding system to track tools, equipment and material at your company?
___ yes
___ no
___ depends upon the cost

Of the 65 participants that responded to question 8 regarding their interest in implementing a bar coding system to track tools, equipment and material, 48 percent stated that it depended upon the cost, 26 percent stated that they would be interested, and 26 percent stated that they would not be interested.

Figure 7: Interest in Using Bar Coding
**Question 9:**

How often do your construction projects suffer adversely from poor tool, equipment and material management?

___ never
___ sometimes
___ often

Sixty-seven participants responded to question 9. Seventy-seven percent stated that their construction projects suffer adversely sometimes, 13 percent stated that their construction projects never suffer adversely from poor tool, equipment and material management and 10 percent stated that their construction projects often suffer adversely.

![Pie chart showing percentages of responses to question 9]

*Figure 8: Projects Suffering Adversely*
Question 10:

How important is tool, equipment and material management on the construction project?

- very important
- moderately important
- rarely important

Sixty-seven participants responded to question 10 regarding the importance of tool, equipment and material management on the construction project. Fifty-one percent stated that it was very important, 40 percent stated that it was moderately important and 9 percent stated that it was rarely important.

Figure 9: Importance of Tool, Equipment and Material Management
Question 11.

Does your company typically hire a subcontractor to manage tools, equipment and material on the construction site?

___ yes
___ no
___ sometimes

Sixty-eight participants responded to question 11 when asked whether their company typically hired a subcontractor to manage tools, equipment and material on the construction site. Of these, 94 percent stated that they did not typically did hire a subcontractor and six percent stated that they did. No participant stated that their company hired a subcontractor sometimes.

![Pie chart showing 6% for yes and 94% for no.]

Figure 10: Companies Hiring Tool, Equipment and Material Management Subcontractors
**Question 12:**

How often do employees on your construction projects misplace tools, equipment or material?

___ frequently

___ sometimes

___ never

Sixty-seven participants responded to question 12. Eighty percent stated that their employees sometimes misplaced tools, equipment or material, 19 percent stated that their employees frequently misplaced tools, equipment or material on their construction projects, and one percent stated that their employees never misplaced tools, equipment or material.

![Pie chart showing percentages](image)

**Figure 11:** Misplacement of Tools, Equipment or Material
Question 13:

Who on your construction projects is typically responsible for the management of tools, equipment and material?

___ materials management group
___ subcontractor
___ project manager
___ superintendent
___ foreperson
___ other (specify)

Sixty-seven participants responded to question 13 when asked who was typically responsible for the management of tools, equipment and material on their construction projects. Sixty-five percent stated that the superintendent was responsible, 16 percent stated that a foreperson was responsible, nine percent stated that the project manager was responsible, six percent stated that a subcontractor was responsible and four percent stated that a materials management group was responsible. No participant selected other.
Chapter Four detailed the results of the data that was gathered through the survey instrument. In general, the information gathered using the survey instrument addressed the need for implementing bar coding technology into the construction industry in Georgia and Alabama. Specifically, the survey instrument addressed the subproblems of the study. The subproblems of this study were to determine (1) if the construction industry in Georgia and Alabama views bar coding as a possible effective means of tracking tools in the construction industry, (2) if the construction industry in Georgia and Alabama views bar coding as a possible effective means of tracking equipment in the construction industry, and (3) if the construction industry in Georgia and Alabama views bar coding as a possible effective means of tracking material in the construction industry.
CHAPTER FIVE
Findings, Conclusions and Recommendations

Introduction

Effective construction management relies on information that can be processed into information (Bernold, 1990). Bar coding technology offers a process by which information relating to the management of tools, equipment and material in the construction industry can be handled more efficiently as part of an effective construction management program.

The retail and manufacturing industries have used bar coding technology for several years to manage information (Bell, 1988). Despite the documented benefits that have been reaped from using bar coding technology to manage information by the retail and manufacturing industries, the construction industry has yet to implement such a system.

The problem of this study was to determine the need for implementing bar coding technology into the construction industry in Georgia and Alabama. In order to determine the need for implementing bar coding technology into the construction industry, selected construction companies were asked to participate in this study in an attempt to gain valuable information regarding bar coding technology.
A survey instrument was designed and sent to 171 construction companies operating in Georgia and Alabama. The survey instrument was specifically designed to determine: (1) if the construction industry in Georgia and Alabama considers bar coding technology as a possible effective means of tracking tools in the construction industry, (2) if the construction industry in Georgia and Alabama considers bar coding technology as a possible effective means of tracking equipment in the construction industry, and (3) if the construction industry in Georgia and Alabama considers bar coding technology as a possible effective means of tracking material in the construction industry.

**Major Findings of the Study**

This study sought to determine the need for implementing bar coding technology into the construction industry in Georgia and Alabama. In an effort to determine this, a survey instrument was sent to 171 construction companies operating in Georgia and Alabama. This study determined the following:

1. When asked if the participant’s company used bar coding to track tools, equipment or material, 95 percent of the participants responding to the question stated no and five percent stated yes.

2. Fifty-five percent of the participants responding when asked if their company had an organized system to manage tools, equipment and materials stated yes and 45 percent stated no.

3. When asked to rate on a scale of 1 to 5, with 5 being the most effective, the effectiveness of the participant’s company’s system used to track tools, equipment and
material, 28 percent of those responding selected 4, 25 percent selected 2, 25 percent selected 3, 18 selected 1 and four percent selected 5.

4. Of the participants responding when asked if they would be interested in implementing a bar coding system to track tools, equipment and material at their company, 48 percent stated that it would depend upon the cost, 26 percent stated yes and 26 percent stated no.

5. When asked how often their construction projects suffer adversely from poor tool, equipment and material management, 77 percent of the participants responding to the question stated sometimes, 13 percent stated never and 10 percent stated often.

6. When asked to state the importance of tool, equipment and material management on the construction project, 51 percent of the participants responding to the question stated that it was very important, 40 percent stated that it was moderately important and nine percent stated that it was rarely important.

7. Ninety-four percent of the participants responding to question 11 stated that their company does not typically hire a subcontractor to manage tools, equipment and material on the construction project. Six percent of those responding stated that their company hired a subcontractor for this.

8. When participants were asked how often employees working on their construction projects misplaced tools, equipment or material, 80 percent of those responding to the question stated sometimes, 19 percent stated that their employees
frequently misplaced tools, equipment or material and one percent stated that their employees never misplaced tools, equipment or material.

9. When participants were asked who was typically responsible for the management of tools, equipment and material on their construction projects, 65 percent of those responding to this question selected superintendent, 16 percent selected foreperson, nine percent selected project manager, six percent selected materials management group and six percent selected subcontractor. No participant selected other.

Conclusions of the Study

The purpose of this study was to determine the need for implementing bar coding technology into the construction industry in Georgia and Alabama. Specifically, this study attempted to determine the need for implementing bar coding technology into the construction industry in Georgia and Alabama as a means of tracking tools, equipment and material.

This study determined that the construction industry, as a whole, in Georgia and Alabama does not use bar coding technology as an effective means of tracking tools, equipment and material in the construction industry. Ninety-five percent of the participants stated that their company did not use bar coding. The findings of this part of the study paralleled the findings of other researchers who have conducted studies regarding the use of bar coding technology in the construction industry.

The most significant finding of this study regarded the interest that companies had in implementing bar coding technology into the construction industry as a means of
tracking tools, equipment and material. When participants were asked if they were interested in implementing bar coding technology into the construction industry as an effective means of tracking tools, equipment and material, 48 percent stated that it would depend upon the cost and 26 percent stated that they were interested. Only 26 percent stated that they were not interested at all in such an implementation.

From this research, it is apparent that construction companies must organize as an industry to implement bar coding technology. The construction industry has the need and interest to implement bar coding technology as an effective means of tracking tools, equipment and material.

**Recommendations of the Study**

This study utilized as its sample population only a small number of the construction industries operating in the southeastern United States by selecting only construction companies operating in Georgia and Alabama. Future studies of this nature could examine a larger population by including all of the construction companies listed to be operating in the southeastern United States.

Along with including more construction companies in a replica study, future studies could divide the surveys by job title into three different groups of participants. The researcher could distribute the same survey to the president of the company, a project manager of the company, and a superintendent of the company. The data gathered could then be analyzed and the results of the survey compared between job titles, thus allowing specific ideas and opinions of each group to be evaluated.
Summary

The purpose of this study was to determine the need for implementing bar coding technology into the construction industry in Georgia and Alabama. Specifically, this study sought to determine whether the construction industry in Georgia and Alabama viewed bar coding technology as an effective means of tracking tools, equipment and material in the construction industry.

Information was gathered from construction companies operating in Georgia and Alabama through a survey instrument. The survey instrument was designed specifically to gather information regarding the construction industry's need for implementing bar coding technology.

As a result of this study, it was determined that the majority of the construction companies responding to the survey did not use bar coding as an effective means of tracking tools, equipment and material. However, it was determined that the majority of the construction companies responding to the survey had a definite interest in using bar coding technology to track tools, equipment and material in the construction industry.
REFERENCES


APPENDIX A

Copy of Cover Letter
February 17, 1997

119 St. Clair Drive
Leesburg, GA 31763

Dear Sir/Madam:

I am a graduate student at Georgia Southern University earning a master’s degree in industrial management. In partial fulfillment of the requirements for this degree, I am conducting research on the need for implementing bar coding technology into the construction industry in Georgia and Alabama. In order to complete this research and my master’s degree, I am seeking your input regarding your company’s interest in using bar coding on your construction projects as a means of tracking tools, equipment and material.

Enclosed is a short survey that should take about 10 minutes to complete. I would very much appreciate you completing it. Your participation in this survey is valued and your confidentiality is assured.

After you complete the survey, please tri-fold the survey, with the survey questions on the inside, tape the bottom of it and mail the survey back to the address on the back of the survey.

Should you have questions regarding the completion of this survey or you would like to view the results of the survey, please feel free to call me at (912)883-2000, ext. 2959. Thank you for your time in helping me complete my master’s degree.

Sincerely,

Herbie Barber

enclosure: survey
APPENDIX B

Copy of Survey Instrument
PART ONE  Demographics

*Please check the appropriate box.*

1. What best describes your job function?
   - [ ] CEO/President/Vice President
   - [ ] Project/Engineering Manager
   - [ ] Operations Manager
   - [ ] Project Engineer
   - [ ] Warehouse Manager
   - [ ] Construction Manager
   - [ ] Superintendent
   - [ ] Other ____________________________

2. What area(s) of construction does your company provide services?
   - [ ] Pulp & Paper
   - [ ] Chemical/Petrochemical
   - [ ] Manufacturing
   - [ ] Power/Nuclear
   - [ ] Residential
   - [ ] Heavy Civil
   - [ ] Commercial/Office
   - [ ] Utilities
   - [ ] Institutional
   - [ ] Other ____________________________

3. What is your company’s gross annual contract volume?
   - [ ] $1 million - $10 million
   - [ ] $10 million - $50 million
   - [ ] $50 million - $100 million
   - [ ] $100 million - $250 million
   - [ ] $250 million - $500 million
   - [ ] $500 million +

PART TWO  Bar Coding

4. Does your company use bar coding to track tools, equipment or material?
   - [ ] yes   [ ] no

5. If you answered “yes” to question 4, rate the bar coding system’s effectiveness. (1 is least effective, 5 is most effective)
   - [ ] 1   [ ] 2   [ ] 3   [ ] 4   [ ] 5

6. Does your company have an organized system by which tools, equipment and material can be tracked?
   - [ ] yes   [ ] no

7. Please rate the effectiveness of the system your company currently uses to track tools, equipment and material. (1 is least effective, 5 is most effective)
   - [ ] 1   [ ] 2   [ ] 3   [ ] 4   [ ] 5
8. If currently not using bar coding, would you be interested in implementing a bar coding system to track tools, equipment and material at your company?

   ___ yes       ___ depends upon the cost
   ___ no

9. How often do your construction projects suffer adversely from poor tool, equipment and material management?

   ___ never       ___ sometimes       ___ often

10. How important is tool, equipment and material management on the construction project?

    ___ very important       ___ moderately important       ___ rarely important

11. Does your company typically hire a subcontractor to manage tools, equipment and material on the construction site?

    ___ yes       ___ no       ___ sometimes

12. How often do employees on your construction projects misplace tools, equipment or material?

    ___ frequently       ___ sometimes       ___ never

13. Who on your construction projects typically is responsible for the management of tools, equipment and material?

    ___ materials management group       ___ project manager
    ___ subcontractor       ___ superintendent
    ___ foreperson       ___ other (specify)

Thank you for completing this survey. Please tri-fold the survey, tape it and mail it back to the researcher. Should you have any questions regarding this research, please feel free to contact the researcher at (912)883-2000, ext. 2959.
Herbie Barber
119 St. Clair Drive
Leesburg, GA 31763

place tape here
APPENDIX C

Committee Corresponder
May 5, 1996

119 St. Clair Drive  
Leesburg, GA  31763

Dr. Keith Hickman  
Dept. of Industrial Technology  
Georgia Southern University  
Statesboro, GA  30460

Dear Dr. Hickman:

I am sending you the first chapter of my thesis for your review. Dr. David Williams told me last week that he would also like to review it before you send it back to me. If you like, Dr. Charles Perry can also review it before you send it back since he is also on my committee.

My goal is to complete this thesis by the end of summer quarter. I believe that I can complete it by then, but it will be difficult at best. If there is absolutely no way for me to complete it by summer quarter, I will have to settle for a fall quarter completion.

Should you have any questions regarding this, I can be reached at (912)439-1460 by telephone or fax. I would appreciate as much correspondence by fax as possible due to the summer quarter deadline I am trying to meet. Thank you for your help.

Sincerely,

Herbie Barber
July 8, 1996

119 St. Clair Drive  
Leesburg, GA  31763

Dr. Keith Hickman  
Landrum Box 8046  
Dept. of Industrial Technology  
Georgia Southern University  
Statesboro, GA  30460

Dear Dr. Hickman:

Here is the revised copy of my thesis for your review. It reflects the changes you noted earlier and some minor changes in content that I made.

I have some general questions for you regarding how the writing and reviewing of my thesis from this day forward should be handled so I can complete my thesis by the end of Fall, 1996. I will try to call you today to discuss this matter. Any suggestions from you regarding this will be appreciated.

Should you have any questions, I can be reached by phone or fax at 912-439-1460. Thanks for your help.

Sincerely,

Herbie Barber
September 3, 1996

119 St. Clair Drive
Leesburg, GA 31763

Dr. Keith Hickman
Box 8046
Department of Industrial Technology
Georgia Southern University
Statesboro, GA 30460

Dear Dr. Hickman:

Please find attached a copy of my thesis. The information you are receiving includes chapter one, chapter two, chapter three and the survey instrument. Chapters one and two are complete. Chapter three will be completed as my survey instrument is developed and approved. Please review this information and return it by September 20, 1996.

I am available to go to GSU campus any Friday to meet with the committee if this will help expedite the completion of my thesis. I will call you within the next few days to confirm that you received this information.

Should you have any questions, I can be reached at work at (912)883-2000, ext. 2959. Thank you for your help.

Sincerely,

Herbie Barber
January 12, 1996

119 St. Clair Drive
Leesburg, GA 31763

Dr. Keith Hickman
Box 8046
Dept. Of Industrial Technology
Georgia Southern University
Statesboro, GA 30460

Dear Dr. Hickman:

I apologize for taking so much time in returning my updated thesis. I have experienced significant computer hardware and software problems over the past several weeks. I appreciate your patience on this matter.

I want to complete the requirements for graduation March 1997. I have been working on this thesis for over a year and need to complete it. Because of this, I need for the committee to do two things. First, I need for the committee to please review what is being submitted and comment on it. Second, I need for the committee to approve my survey instrument so it can be sent out immediately. If for any reason the committee concludes that I need to rework part of the survey instrument, I need very specific instructions on what I need to do to the survey instrument in order to obtain the committee’s approval.

I need to do whatever is necessary to complete this thesis by this quarter’s end. My computer problems should be over, and there should not be anything that would prevent me from completing this thesis this quarter. If I need to go to Statesboro, I can go any Friday; if I need to take off of work to accommodate your schedule, I will do so. Should you need to contact me, you can call me at work or at home or email me at work or at home.

Please review this and return it as soon as possible. Thank you for your help.

Sincerely,

Herbie Barber

work: (912)883-2000 ext. 2959                     copy: Dr. David Williams
     herbie.barber@fluordaniel.com                     Dr. Charles Perry

home: (912)439-1460
     hbarberjr@worldnet.att.net
February 2, 1997

119 St. Clair Drive
Leesburg, GA 31763

Dr. Keith Hickman
Box 8046
Dept. Of Industrial Technology
Georgia Southern University
Statesboro, GA 30460

Dear Dr. Hickman:

I am faxing you a copy of my updated survey. Please review it and comment if necessary. If you approve of this survey as is, please sign in the space below, along with Dr. David Williams and Dr. Charles Perry, and fax it back to me so I can send it out immediately. Should you have any concerns with this survey, please call me as soon as possible at work at (912)883-2000, ext. 2959.

Sincerely,

Herbie Barber

copy: Dr. David Williams
       Dr. Charles Perry

*Herbie Barber has my permission to send out the survey included with this letter.*
March 21, 1997

119 St. Clair Drive
Leesburg, GA 31763

Dr. Keith Hickman
Box 8046
Department of Industrial Technology
Georgia Southern University
Statesboro, GA 30460

Dear Dr. Hickman:

Please find attached a copy of my completed thesis. Please review this information and return it with any comments by Tuesday, April 8, 1997.

As you know, I have only a few weeks left to complete all editing prior sending the final completed thesis to the graduate school. The graduate school must have the final completed thesis no later than Friday, May 16, 1997. In light of this, please make every effort possible to return the thesis by April 8, 1997.

Should you have any questions, please feel free to contact me at home at (912)439-1460 or at work at (912)883-2000, ext. 2959.

Sincerely,

Herbie Barber

copy: Dr. David Williams
Dr. Charles Perry
April 14, 1997

119 St. Clair Drive
Leesburg, GA 31763

Dr. Keith Hickman
Box 8046
Department of Industrial Technology
Georgia Southern University
Statesboro, GA 30460

Dear Dr. Hickman:

Please find attached a copy of my thesis for your review. This copy reflects all previous changes and, therefore, supersedes any previous copies.

I look forward to seeing you at the thesis defense Thursday, April 17, 1997 at 1:00 p.m. Should you have any questions, I can be reached at home at (912)439-1460 or at work at (912)883-2000, ext. 2959 anytime prior to Thursday, April 17, 1997 at 8:00 a.m.

Sincerely,

Herbie Barber

copy: Dr. David Williams
     Dr. Charles Perry
April 18, 1997

119 St. Clair Drive
Leesburg, GA 31763

Dr. Keith Hickman
Box 8046
Department of Industrial Technology
Georgia Southern University
Statesboro, GA 30460

Dear Dr. Hickman:

Please find attached eight (8) copies of my completed thesis for binding. Four (4) copies are required and four (4) copies are for me. I have also enclosed eight (8) extra copies of the approval sheets in case mistakes are made while they are being signed. After signatures are obtained, the completed copies are to be delivered to Miss Jennifer Melton at the Dean of Graduate Studies’ office.

Thank you for helping me with this matter. Should you have any questions, I can be reached at home at (912)439-1460 or at work at (912)883-2000, ext. 2959.

Sincerely,

Herbie Barber

enclosures: (8) copies of the thesis
(8) extra approval sheets
(1) binding request sheet
(1) personal check for binding fees