EFFECTIVENESS OF THE CONCRETE REINFORCING PLACEMENT INSPECTION PROCESS

BY

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Abstract of Thesis Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Masters of Science in Building Construction

EFFECTIVENESS OF THE CONCRETE REINFORCING PLACEMENT
INSPECTION PROCESS

By

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Chair:  Dr. Raymond Issa
Major Department:  School of Building Construction

Communities could benefit from a well-trained, consistent and thorough concrete
reinforcing inspection team as it could increase the safety and useful life of structures
with these components. The final placement of reinforcing members in concrete is
crucial because incorrect placement can cause accelerated corrosion in the reinforcement
as well as deficiencies in the load bearing capacity. This study examined the responses of
field supervisors, who were directly involved in the concrete reinforcement inspection
process regarding building inspectors’ performance, with the following criteria: 1) Were
the contract plan requirements referenced? 2) Were the building codes referenced in the
contract plans in order to establish code compliance? 3) Was the inspection performance
thorough and were results consistent with other building inspectors? Building inspectors’
performance was reviewed because they have the authority to both reject design errors
and deny the approval of misplaced rebar. The sample of respondents was drawn from
Gainesville, Florida, commercial construction project sites. The chi-squared and chi-
squared heterogeneity statistical tools were used to test the hypotheses. The alpha levels
for all tests were 0.005. The results indicate that in the perception of the respondents, building inspectors could improve their performance regarding concrete reinforcing inspections. Some suggestions for improvement were discussed and include the following: devoting some of the continuing education hours required for re-certification to coursework involving concrete reinforcing placement methods and designs, developing and implementing a specific inspection checklist, increasing the time devoted for each inspection, and enacting field experience requirements similar to current on-the-job training minimums that journeyman apprenticeship programs currently follow.
CHAPTER 1
INTRODUCTION

“Failure to achieve the specific cover is probably the most influential factor in premature reinforcement corrosion – which, in turn, is the principle form of deterioration in concrete structures” (Dakin et al. 2001, p. 20). “The need for quality supervision and field inspection is more evident with this material than for many others” (Feld and Carper 1997, p. 238).

Background

Reinforced concrete, since its introduction in the mid 19th century, has been widely used throughout the industry in a broad range of structural and architectural applications. Concrete’s initial plasticity, low tensile strength and resistance to high temperatures combined with steel’s high tensile strength and low resistance to high heat makes reinforced concrete a safe and versatile building tool used in many construction applications. The drawbacks associated with this combination are concrete’s permeability to corrosive agents and steel’s vulnerability to those agents. These findings came as early as the beginning of the 20th century when salt water was used to mix concrete for reinforced concrete. The salt accelerated the rebar corrosion, which rapidly reduced the useful life of the structures. “The common defects that tend to shorten the life of a reinforced concrete building all stem from a simple cause. The enemy of durability is nearly always water, the vulnerable element is the steel reinforcement, and trouble is certain if the concrete fails to keep them apart” (Building Research Station 1956). “Design details must provide such protection and construction must not reduce
the thickness of cover nor the imperviousness of the concrete” (Feld and Carper, 1997 p. 282). As evident in these two quotes, rebar corrosion and the quest to stop or slow this corrosion are currently of great concern in design planning and predicting service life of reinforced concrete. With these criteria, building codes have been established to set minimum depths and coverage for reinforcement steel, dependent upon the type of component exposure and local environmental conditions. These minimums were created to provide the rebar with adequate protective coverage, while giving uniformity to service life prediction. With an established code, the greatest variations affecting rebar corrosion are a design that does not follow code and the physical misplacement of rebar.

With the continued use of reinforced concrete as a major building component, any improvement in a variable that directly affects the safe, useable life of these structures will be beneficial. The reasons why and finding the determining causes of how corrosion occurs were the main focus of the literature review and are presented in Chapter 2. Upon completing the literature review, one of the major potentially correctable causes of rebar corrosion was found to be to human error. The key parties involved in either the design or physical placement of rebar are the project architect, structural designer, residential engineer, inspector, contractor (head office), contractor (site staff), contractor (workman), and operator (crane, vehicle, ship, etc.) (Eldukair and Ayyub 1991).

**Statement of the Problem**

The preliminary question of “Which party has the greatest objectivity and authority to curb poor design and improper rebar placement?” will first be determined. Then an attempt to answer the question “What is the current rating of that party’s performance?” will remain as the main focus of this study.
In answer to the first question, the party with greatest objectivity is the building inspector. The inspector has no financial involvement in the project and no drive for extra monetary gain. In a building project the inspector’s objectivity insures that no corners are cut and the codes and contract documents are followed. The party with the authority to both curb design errors and deny the approval of misplaced rebar is also the building inspector. This study will focus only on building inspectors as defined in the following Florida Building Code Statute:

Chapter 486, Part XII of the Florida Statutes: Building Code Administrators and Inspectors.

468.603. (a) “Building inspector” means a person who is qualified to inspect and determine that buildings and structures are constructed in accordance with the provisions of the governing building codes and state accessibility laws.

This statute points out the importance of the building inspector to the entire project team. The importance of a building inspector can be explained by the analogy of the federal government. The federal government has three branches: the legislative, executive, and judicial. No one branch has 100% of the power and each branch runs a checks-and-balances system on each other so the balance of power remains. The major branches in construction as related to direct building safety and quality are the owner/architect/engineer (legislative), general contractor (executive), and the building inspector (judicial). The owner/architect/engineer is responsible for legislating a safe design, while the general contractor is obligated to execute all of the work stipulated under the contract with the owner according to the required specifications. The owner gives payment (balance) to the general contractor only when portions of the work are
carried out, and the building inspector inspects (governs) the work performed by the general contractor and the design of the owner/architect/engineer to make sure that all of the specifications and code requirements are correctly followed. Even though the contractor’s work is subjected to inspection, the purpose of rating the building inspector’s performance is not to imply that the general contractor is not responsible for maintaining good quality control.

“What is the current rating of building inspectors’ performance?” The following does not answer the question of current rating, but offers a surveyed historical rating of inspector error or omission. Of the parties identified as being involved in either the design or physical placement of rebar, the participants involved with the most failure cases from greatest to least were the contractor (site staff), structural designer, resident engineer, and the inspector, respectively. In a survey done by Eldukair and Ayyub in 1991, the distribution of failure cases with respect to sources of error by participant, inspectors accounted for 27.6% of failure cases. A 27.6% is a high percentage of failure cases that suggests all of the errors may not be common mistakes and there may be room for improvement.

This research is focused on identifying whether or not building inspectors are performing well by how they are rated by the individuals who are responsible for placing the work the building inspector is inspecting. Data on key reinforced concrete performance criteria were collected to provide a means of evaluating building inspectors’ performance.
Research Objectives

The purpose of this study is to collect and analyze data that will help examine current building inspector expertise and consistency in relation to the concrete reinforcing inspection on commercial construction projects valued at over one million dollars. These data have the potential for helping identify areas where there is a need for a more formally educated and consistent building inspection force that may increase the longevity and safety of commercial buildings.

Hypothesis Statements

The hypotheses tested for each performance determinant were as follows:

1) $H_0$: Field supervisors agree that building inspectors refer to the contract documents to decide if the reinforcement is correct.

2) $H_0$: Field supervisors agree that building inspectors reference the Florida Building Code to decide if the contract plans follow the code.

3) $H_0$: Field supervisors agree that building inspectors thoroughly inspect reinforcing for concrete and yield results consistent with those of other building inspectors.
CHAPTER 2
LITERATURE REVIEW

“Failure to achieve the specific cover is probably the most influential factor in premature reinforcement corrosion – which, in turn, is the principle form of deterioration in concrete structures” (Dakin et al. 2001, p. 20). Reinforced concrete was first introduced in the 1850’s and gained popularity as a structural building component by the end of the 19th century (Allen 1999). Today, reinforced concrete structures are commonplace all around the world and will continue to be a preferred building component. With many reinforced concrete structures being built, identifying all of the variables and predicting the actual safe, useful life is very important.

Determining Causes of Rebar Corrosion

One of the variables that affect the useful life of reinforced concrete was discussed in a study of rebar corrosion due to surface cracking (François and Arliguié 1998). This study observed the corrosion effects of reinforced concrete beams that were subjected to loading, varying temperature and a corrosive environment. Since, “corrosion of rebars is the major cause of the deterioration of reinforced concrete structures,” they wanted to know what mechanism has the largest effect on corrosion. The solution of micro-cracking and cracking that occur from loading was looked at as a possible cause, but the test results concluded: “reinforcement corrosion is not influenced by the widths of the cracks (for widths less than 0.5mm) or by the existences of the cracks themselves. However, it seems obvious that the load applied to a reinforced concrete beam plays a
significant role in the penetration of aggressive agents and then in the corrosion of the reinforcement” (François and Arliguie 1998, p. 143,149).

In order for steel reinforcing to begin deleterious corrosion, the protective outer layer on the rebar must be destroyed. In a study done by Williamson and Clark in 2000, they found that the destruction of this layer “forms a major part of the United Kingdom construction workload, with similar situations existing throughout the world. The most significant form of deterioration is reinforcement corrosion” (Williamson and Clark 2000, p. 155). Williamson and Clark’s research also examined the effects of corrosion in reinforced concrete and they concluded:

(a) Reduction in steel area, resulting in losses in strength of reinforced concrete members.

(b) The corrosion products occupy a volume larger than the original steel. At the onset of corrosion, these products migrate into any void adjacent to the concrete. At this stage, although the effective bar area is reducing, the corrosion does not affect the integrity of the surrounding concrete.

(c) The nature of the bond between the steel and concrete changes and can deteriorate, resulting in loss of composite action and change in mode of structural behavior. (Williamson and Clark 2000, p. 155,156)

Another study on reinforcement corrosion focused on the differing permeability of concrete in relation to its location within a member (Williamson and Clark 2001). The upper layer of concrete was found to be of lower quality than the “heartcrete,” or underlying material, in the lower portion of the member. The lower-quality upper concrete has a larger variation of the resulting overall quality and is more porous. This higher porosity allows corrosive agents to penetrate the steel faster. Some of the reasons the upper layer is subject to this variation were determined to be the following:
(a) Air and water move upwards in the fresh concrete creating a water/cement ratio, and therefore also porosity gradient.

(b) The wall effect influences the uniformity of distribution of large particles near to a molded surface.

(c) The effects of different compaction methods and quality.

(d) The adequacy of curing – the surface layer of concrete is susceptible to drying effects and hence incomplete hydration. (Williamson and Clark 2001, p. 53)

In a study of building failures, reinforced concrete was examined as having many different factors that can alter the predicted outcome of the final product (Feld and Carper 1997). Feld and Carper, as well as others believe that the skill and competence of the workforce has a direct effect on the resulting strength and quality of reinforced concrete. “The need for quality supervision and field inspection is more evident with this material than for many others” (Feld and Carper 1997, p. 238). The study goes on to state, “good-quality dense concrete with adequate cover over the reinforcement is the principle key to durability” (Feld and Carper 1997, p. 283).

In a 1991 study of U.S. construction failures, as shown in Table 2-1, 604 structural and construction failures were analyzed between years 1975-1986 (Eldukair and Ayyub 1991). Due to the age and broad range of sample area in the 1991 study, the current localized results of this study’s results may vary. However, the component failure mechanisms analyzed in the 1991 study have not changed with the conditions today. New research and testing has led to the introduction of corrosion-resistant materials, but they are more expensive than using traditional steel rebar and are generally only used in special applications. These corrosion-resistant materials do slow the corrosion process giving the final reinforcing bar location more tolerance than steel, but
in order to transfer building loads correctly they must still follow the design plans.

Reviewing Eldukair and Ayyub's research today raises the question: how many more buildings from this period are suffering from a weakened structure but have not collapsed yet? In the buildings analyzed by the 1991 study, “most of the failure cases indicated that reinforced concrete elements were predominant…86.4% percent of the failures recorded deficiencies in reinforced concrete elements” (Eldukair and Ayyub 1991, p. 63). Human error was found to be a major contributor to not achieving predicted design strength ultimately decreasing the structures overall safety and useful life.

Table 2-1. Distribution of Failure Cases with Respect to Sources of Error by Participation

<table>
<thead>
<tr>
<th>Description of Participant</th>
<th>Error by Participation Failure Cases (%)</th>
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<tr>
<td>Project architect</td>
<td>3.0</td>
</tr>
<tr>
<td>Structural designer</td>
<td>48.2</td>
</tr>
<tr>
<td>Resident engineer</td>
<td>31.1</td>
</tr>
<tr>
<td>Inspector</td>
<td>27.6</td>
</tr>
<tr>
<td>Contractor (head office)</td>
<td>3.8</td>
</tr>
<tr>
<td>Contractor (site staff)</td>
<td>59.6</td>
</tr>
<tr>
<td>Contractor (workmen)</td>
<td>17.4</td>
</tr>
<tr>
<td>Operator</td>
<td>2.8</td>
</tr>
</tbody>
</table>

(Source: Eldukair and Ayyub 1991, p. 64)

**Building Inspector Duties and Educational Requirements**

Since the adoption of the 2001 Florida Building Code by the Florida Governor and Legislature becoming effective on March 1, 2002, the new code is the most pertinent information regarding reinforced concrete inspection. To supplement the 2001 Florida Building Code, a review of the Chapter 468, Part XII of the Florida Statutes: Building Code Administrators and Inspectors has been included in this section.
The following was taken from the 2001 Florida Building Code, Building Volume regarding reinforced concrete:

1908.6 Concrete Protection for Reinforcement

1908.6.1 Concrete cover shall be provided for reinforcement in cast-in-place (not-pre-stressed) in accordance with Table 1908.6.

1908.6.3 In corrosive environments or other severe exposure conditions, the amount of concrete protection shall be suitably increased, and denseness and non-porosity of protecting concrete shall be considered, or other protection shall be provided.

1908.6.4 Exposed reinforcement, inserts and plates intended for bonding with future extensions shall be protected from corrosion.

105 Inspections

105.6 Required Inspections. The building official upon notification from the permit holder or his agent shall make the following inspections, and shall either release that portion of the construction or shall notify the permit holder or his agent of any violations which must be corrected in order to comply with the technical codes. The building official shall determine the timing and sequencing of when inspections occur and what elements are inspected at each inspection.

Building

1. Foundation Inspection: To be made after trenches are excavated and forms erected and shall at a minimum include the following building components:
   - stem-wall
   - monolithic slab-on-grade
   - piling/pile caps
   - footers/grade beams

105.8 Reinforcing Steel and Structural Frames. Reinforcing steel or structural frame work of any part of any building or structure shall not be covered or concealed without first obtaining a release from the building official. (Florida Building Commission 2001)
The following is a review of the duties, education, and experience requirements as stated by the 2002 Chapter 468, Part XII of the Florida Statutes: Building Code Administrators and Inspectors:

468.603. (a) “Building inspector” means a person who is qualified to inspect and determine that buildings and structures are constructed in accordance with the provisions of the governing building codes and state accessibility laws.

468.609. (2) A person may take the examination for certification as a building code inspector or plans examiner pursuant to this part if the person:

(a) Is at least 18 years of age.
(b) Is of good moral character.
(c) Meets eligibility requirements according to one of the following criteria:

1. Demonstrates 5 years' combined experience in the field of construction or a related field, building code inspection, or plans review corresponding to the certification category sought;

2. Demonstrates a combination of postsecondary education in the field of construction or a related field and experience which totals 4 years, with at least 1 year of such total being experience in construction, building code inspection, or plans review;

3. Demonstrates a combination of technical education in the field of construction or a related field and experience which totals 4 years, with at least 1 year of such total being experience in construction, building code inspection, or plans review; or

4. Currently holds a standard certificate as issued by the board and satisfactorily completes a building code inspector or plans examiner training program of not less than 200 hours in the certification category sought. The board shall establish by rule criteria for the development and implementation of the training programs.

After becoming a building inspector, continuing education hours are required to renew certification. A total of fourteen (14) hours of coursework must be taken every
two (2) years that is approved by the Florida Building Commission. Alternative classes involving further specialization or personal interest may be taken with the approval of the Building Code Administrators and Inspectors Board in an hourly exchange. All of the courses counted towards continuing education hours must have a minimum duration of 50 minutes each (Florida Building Statutes 2002).

A clear example of what a building inspector might look at during a concrete reinforcing inspection was found in the American Concrete Institute (ACI) Manual of Concrete Inspection (1992). ACI breaks down the inspection activities by the complexity of the project and categorizes them into general levels. The Level A projects range from high-rise to power plant construction, the Level B projects range from low-rise industrial and commercial to small bridge construction, and Level C projects range from residential to small drainage construction. Reinforced concrete structures generally fell under Level A and B type projects. Both Level A and B recommended inspections require the inspector to be present through, “pre-placement, placement, and post-placement inspection of concrete activities (including curing). With special attention to mass concrete, hot weather concreting and cold weather concreting.” To fortify the importance of concrete reinforcing inspection ACI states, “Improper reinforcement placement can lead to severe cracking, steel corrosion, and excessive deflections (or even failure)” (ACI 1992, p. 203, 65).

In a study of building official certification it was found that there is a recognized “need for uniform, mandatory and continuing training for inspection personnel in the State of Florida” (Hart and Daudelin 1990, p. 3). The information in the survey was obtained from 154 Florida respondents to a building official questionnaire. It was also
found that, “stringent experience requirements should play a major role in the certification process” (Hart and Daudelin 1990, p. 8).

Summary

The literature review, while not exhaustive, covered the implications and causes of rebar corrosion in reinforced concrete, current codes, professional organizational standards, past research regarding human error in the building process, and a study involving building official certification. Rebar corrosion occurs as a chemical process so, in an attempt to slow and predict that process, minimum code and design criteria must be followed. The 2001 Florida Building Code along with the Chapter 468, Part XII of the Florida Statutes establishes design minimums as well as building inspector educational and field inspection requirements. The *ACI Manual of Concrete Inspection* (1992) was quoted to show how the American Concrete Institute recommends field inspections. The 1991 Eldukair and Ayyub study reviewed the key parties involved in a construction project and identified inspectors as one of the parties involved in failure cases. At the time of the study, the sample data suggests room for possible inspector improvement. The 1990 Hart and Daudelin study reviewed building official certification and the findings suggested a need for higher levels of experience and training.

As suggested by the findings of the literature review, the issues of rebar corrosion and past research of building failures may directly link the useable life and safety of reinforced concrete buildings to the building inspection process.
CHAPTER 3
METHODOLOGY

Goals of the Study

The purpose of this study is to analyze a construction supervisor’s view of building inspectors’ performance in relation to concrete reinforcing inspection in an effort to: 1) determine whether the contract plan requirements are referred to, 2) examine whether the building codes are referenced to the contract plans to establish compliance, and 3) ascertain whether inspection performance is thorough and results are consistent with other building inspectors.

Research Methodology

In an effort to support the purpose of this research it was critical to develop a defined and methodical approach to solicit the desired information. In order to satisfy the information required by the goals of the study, it was imperative to obtain the opinions of those currently in the building industry. The implementation of a survey questionnaire fulfilled this need. Figure 3-1 shows the methodology flow chart and provides an overview of this research.

Design of Questionnaire

The questionnaire was created to solicit relevant information regarding the goals of the study. The survey instrument consisted of questions pertaining to the overall performance of a concrete reinforcing inspection by the building inspector. The questionnaire was intended to canvass the opinions of the participants in regards to what they thought of building inspectors’ performance. The key performance
Determine potentially correctable causes of reinforcing placement problems

Literature Review

Qualitative Survey → Statistical Analysis → Survey Result Analysis → Literature Review Results → Conclusions and Recommendations

Figure 3-1. Research Methodology Flow Chart

areas addressed in the questionnaire regarding building inspectors were the following:

1) reference of the contract documents,

2) reference of the building codes with the contract documents, and

3) thoroughness and consistency of field inspection.

A sample of this questionnaire and protocol (approved by the University of Florida Institutional Review Board) is included in Appendix A.

Selection of a Sample Group

Job Site Supervisors

The participants chosen were those who were:

- working in commercial construction,
- in a supervisory position on the jobsite,
- all working within the same geographic area,
- working on a project with reinforced concrete components,
- working on a project with a total construction cost exceeding $1 million,
- all working within one building code enforcement agency’s jurisdiction, and
• directly involved with the concrete reinforcing building inspection process.

Building Inspectors

The participants targeted were those that:

• inspect reinforced concrete components,

• inspect commercial construction projects, and

• are employed by a government building codes enforcement agency.

Description of Sample Area Chosen

This study was localized to the city limits of Gainesville, Florida. The city is located in the north central part of the state and has an estimated population of 110,000 as of September 1, 2002 (City of Gainesville, Florida 2002). According to a phone conversation with the local building official, the estimated new commercial construction projects active in Gainesville, Florida as of September 24, 2002 is less that fifty (50).

Estimation of Sample Size

The intention of this study was to survey each person involved in the concrete reinforcing inspection process for each commercial job within the Gainesville, Florida city limits. Due to the time involved in personally introducing the questionnaire to each participant, twenty-three (23) interviews were completed and accepted according to the sample group criteria before the study data collection time ended.

Resulting Sample Size:

\[
\frac{23 \text{ responses}}{\leq 50 \text{ approximate commercial jobs}} \geq 46\% \text{ sample}
\]
Limitations

This research was conducted to show the current perceptions of construction supervisors regarding the quality of the concrete reinforcing inspection process in an effort to determine a possible approach for improving building safety and the usable life of buildings. An attempt was made to receive the building inspectors’ responses to the same questionnaire (see Appendix A). Unfortunately, no responses had been received before the cutoff deadline stipulated. There are four limitations that apply to this study:

1) Limited range of sample – The population surveyed in this study was localized to the Gainesville, Florida city area.

2) Subjectivity of topic – Data obtained in this study came from the opinions of site supervisors whose workmanship is what is being inspected.

3) Central tendency bias – Respondents may tend to avoid the extremes of a scale, which may limit the desire for the perfect inspection performance rating.

4) Time limitation – The data collection time was limited to August 21, 2002 – September 5, 2002.

Survey Methodology

A total of thirty-one (31) possible candidates were interviewed in person to determine whether they were qualified to be included in the sample group. The reason for personally introducing the questionnaire was four fold:

1) to obtain a higher acceptance rate,

2) to insure that the target person received the survey,

3) to answer any questions regarding the mechanics of the survey, and

4) to insure consistency of administering the questionnaire.

The interviews were conducted between August 21, 2002 and September 5, 2002. Each employee holding a supervisory level position who was directly involved in the concrete reinforcing inspection process was asked whether they would be willing to complete a
questionnaire at a time convenient to them. The participants were typically general contractor superintendents or assistant superintendents. On the larger jobs surveyed ($14-50 million), field engineers and assistant superintendents were predominantly more involved in the building inspection process. The names of the participants and the companies they work for were held anonymous in this research due to a localized population. A list of job position, current project size and estimated annual company volume of the participants can be seen in Appendix B. To introduce the survey to the targeted participant, the jobsite superintendent of each project was approached using a standard dialogue to get the required preliminary information:

“Hello, my name is Mark Powers and I am a graduate student at the M.E. Rinker School of Building Construction. I am currently working on my master’s research and am researching building inspectors’ performance relating to reinforced concrete inspection. May I speak with the person directly involved in handling that process and ask them a few questions?”

When in contact with the appropriate person, it was stated:

“Your experience regarding the concrete inspection process is a valued resource and your opinions would be beneficial to my research.”

They were further asked,

“Would you be willing to complete a survey that I have designed as a part of my research to try and get an idea of how well building inspectors perform reinforced concrete inspection?”

Favorable responses resulted in setting a time best suited to the participant for administration of the questionnaire.
The Participants who responded favorably totaled twenty-eight (28). Of these twenty-three (23) fit the sample group criteria. Once all the questionnaires were received, the data collected was tested using the heterogeneity chi-squared and chi-squared statistical tools. The heterogeneity test was used to indicate whether the various responses were consistent with one another. The questions asked required the respondents to indicate their agreement or disagreement with a series of statements. A 5-point Likert scale ranging from “1” for complete disagreement to “5” for complete agreement was used. A “6” was recorded when the participant had no opinion or lacked the knowledge to express an informed opinion. Due to the variable range of data, the chi-squared test was chosen because it tests categorical responses and predictors. To test the hypothesis and the consistency of the various samples, the observed value chosen for both the chi-squared and chi-squared heterogeneity tests was the cumulative frequency that a choice of “5” occurred for each question. In turn, the expected value was the total possibility that a number “5” could occur. The alpha level for both of these tests was set at 0.005. Each hypothesis has a descriptive analysis of the data to best explain the responses and relevance to the study. Along with this analysis bar charts were generated to visually represent the data.
CHAPTER 4
ANALYSIS OF RESULTS

Survey Results

The construction industry experience of the twenty-three (23) respondents to the questionnaire varied from 1.5 to 53 years with an average of 21.6 years (Figure 4-1). Although the average industry experience was substantial, the heterogeneity chi-squared test was performed to determine whether the responses were consistent with one another. The heterogeneity chi-squared test results are shown in Table 4-1. The end result was obtained by comparing the total pooled heterogeneity chi-squared result (5.9) with the critical value of (18.5) which was found in the Chi-Squared Distribution at the set confidence interval of 99.5% with 6 degrees of freedom. Results less than the critical value indicate that the responses are consistent with one another.
value (18.5) occur within the set confidence interval. As shown in Table 4-1, the result (5.9) is less than the critical value (18.5), so with a 99.5% level of confidence, the various samples were not significantly different and all of the data can be accepted.

Table 4-1. Heterogeneity Chi-Squared Test for Response Data

<table>
<thead>
<tr>
<th>Question #</th>
<th>Observed (O)</th>
<th>Expected (E)</th>
<th>Σ(O-E)^2/E</th>
<th>Degrees of Freedom</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17</td>
<td>23</td>
<td>1.6</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>23</td>
<td>9.8</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
<td>23</td>
<td>11.1</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>23</td>
<td>12.6</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>23</td>
<td>11.1</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>23</td>
<td>9.8</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>23</td>
<td>21.0</td>
<td>1</td>
</tr>
<tr>
<td>Pooled X^2</td>
<td>54</td>
<td>161</td>
<td>71.1</td>
<td>1</td>
</tr>
<tr>
<td>Total X^2 of samples</td>
<td></td>
<td></td>
<td>77.0</td>
<td>7</td>
</tr>
<tr>
<td>Heterogeneity X^2 (Total Pooled)</td>
<td></td>
<td></td>
<td>5.9</td>
<td>6</td>
</tr>
</tbody>
</table>

Note: Critical Value=18.5 at 6 Degrees of Freedom with an Alpha Level of 0.005

Hypothesis 1 (Question # 1)

The null and alternative hypotheses are as follows:

1) H₀: Field supervisors agree that building inspectors refer to the contract documents to decide if the reinforcement is correct.

1) H₁: Field supervisors do not agree that building inspectors refer to the contract documents to decide if the reinforcement is correct.

The chi-squared test results for Hypothesis 1 are shown in Table 4-2. The end result was obtained by comparing the chi-squared result (1.6) with the critical value of (7.88) which was found in the Chi-Squared Distribution at the set confidence interval of 99.5% with one degree of freedom. Results less than the critical value (7.88) occur within the set confidence interval. In Table 4-2, the result (1.6) is less than the critical value (7.88), so with a 99.5% level of confidence the null hypothesis can be accepted.
Table 4-2. Chi-Squared Test for Hypothesis #1 Response Data

<table>
<thead>
<tr>
<th>Question #</th>
<th>Observed (O)</th>
<th>Expected (E)</th>
<th>O-E</th>
<th>(O-E)^2</th>
<th>Σ(O-E)^2/E</th>
<th>D.F.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17</td>
<td>23</td>
<td>-6</td>
<td>36</td>
<td>1.6</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: Critical Value=7.88 at 1 Degree of Freedom with an Alpha Level of 0.005

Hypothesis 2 (Question #2)

The null and alternative hypotheses are as follows:

2) H_0: Field supervisors agree that building inspectors reference the Florida Building Code to decide if the contract plans follow the code.

2) H_1: Field supervisors do not agree that building inspectors reference the Florida Building Code to decide if the contract plans follow the code.

The chi-squared test results for Hypothesis 2 are shown in Table 4-3. The end result was obtained by comparing the chi-squared result (9.8) with the critical value of (7.88) which was found in the Chi-Squared Distribution at the set confidence interval of 99.5% with one degree of freedom. Results greater than the critical value (7.88) do not occur within the set confidence interval and are rejected. In Table 4-3, the result (9.8) is greater than the critical value (7.88), so with a 99.5% level of confidence the null hypothesis was rejected and the alternative hypothesis (H_1) can be accepted.

Table 4-3. Chi-Squared Test for Hypothesis #2 Response Data

<table>
<thead>
<tr>
<th>Question #</th>
<th>Observed (O)</th>
<th>Expected (E)</th>
<th>O-E</th>
<th>(O-E)^2</th>
<th>Σ(O-E)^2/E</th>
<th>D.F.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>8</td>
<td>23</td>
<td>-15</td>
<td>225</td>
<td>9.8</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: Critical Value=7.88 at 1 Degree of Freedom with an Alpha Level of 0.005

Hypothesis 3 (Questions # 3-7)

The null and alternative hypotheses are as follows:

3) H_0: Field supervisors agree that building inspectors thoroughly inspect reinforcing for concrete and yield results consistent with those of other building inspectors.
3) H$_1$: Field supervisors do not agree that building inspectors thoroughly inspect reinforcing for concrete and yield results consistent with those of other inspectors.

The chi-squared test results for Hypothesis 3 are shown in Table 4-4. The end result was obtained by comparing the chi-squared result (65.7) with the critical value of (16.7) which was found in the Chi-Squared Distribution at the set confidence interval of 99.5% with five degrees of freedom. Results greater than the critical value (16.7) do not occur within the set confidence interval and are rejected. In Table 4-4, the result (65.7) is greater than the critical value (16.7), so with a 99.5% level of confidence the null hypothesis was rejected and the alternative hypothesis (H$_1$) can be accepted. It is important to note that hypothesis #3 was formulated by combining questions #3-7 to achieve a quality rating of the inspection process. To attain a consistent 99.5% level of confidence, each individual question’s chi-squared result was referenced to the corresponding one degree of freedom critical value (7.88). Each individual question’s result is greater than the critical value (7.88) ensuring that each question could be separately rejected.

Table 4-4. Chi-Squared Test for Hypothesis #3 Response Data

<table>
<thead>
<tr>
<th>Question #</th>
<th>Observed (O)</th>
<th>Expected (E)</th>
<th>O-E</th>
<th>(O-E)$^2$</th>
<th>Σ(O-E)$^2$/E</th>
<th>D.F.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>7</td>
<td>23</td>
<td>-16</td>
<td>256</td>
<td>11.1</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>23</td>
<td>-17</td>
<td>289</td>
<td>12.6</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>23</td>
<td>-16</td>
<td>256</td>
<td>11.1</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>23</td>
<td>-15</td>
<td>225</td>
<td>9.8</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>23</td>
<td>-22</td>
<td>484</td>
<td>21.0</td>
<td>1</td>
</tr>
<tr>
<td>Sum</td>
<td></td>
<td></td>
<td></td>
<td>Σ(O-E)$^2$/E</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Critical Value=16.7 at 5 Degrees of Freedom with an Alpha Level of 0.005
Discussion of Results

1) \( H_0 \): Field supervisors agree that building inspectors refer to the contract documents to decide if the reinforcement is correct.

Accepting this hypothesis suggests that building inspectors are perceived by field supervisors as orienting themselves to the contract documents in regards to what is being inspected. The inspectors are then using the design information in the field as a basis for the overall general placement criteria. The hypothesis response distribution is shown in Figure 4-2.

![Figure 4-2. Response Distribution for Hypothesis #1](image)

2) \( H_1 \): Field supervisors do not agree that building inspectors reference the Florida Building Code to decide if the contract plans follow code.

The statistical analysis leads to rejection of the null hypothesis and acceptance of the alternative hypothesis. However, a limitation of this hypothesis must be noted. Field supervisors may not physically see building inspectors cross-reference the Florida
Building Code with the contract plans. However, the inspector may be able to inherently reference the contract plans with knowledge of the code gained from the experience and education needed for inspection certification. The hypothesis response distribution is shown in Figure 4-3.

Figure 4-3. Response Distribution for Hypothesis #2

3) $H_1$: Field supervisors do not agree that building inspectors thoroughly inspect reinforcing for concrete and yield results consistent with those of other building inspectors.

Questions 3 through 7 in the survey questionnaire were used to form the accepted alternative hypothesis. A frequency-of-response bar chart for each question was generated and is shown in Figure 4-4. Accepting the alternate hypothesis suggests there is a need for more consistent, all-inclusive reinforcing placement inspections.
Figure 4-4. Response Distribution for Hypothesis #3 by Question

(A). Distribution of Responses for Question #3;

(B). Distribution of Responses for Question #4;

(C). Distribution of Responses for Question #5;
(D). Distribution of Responses for Question #6;

(E). Distribution of Responses for Question #7.

Figure 4-4. Continued
CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

Conclusions

In conclusion, the placement of reinforcing in concrete is crucial to the useful life and safety of buildings that use reinforced concrete components as their primary load bearing structure. To insure that the placement of reinforcement is correct, building inspectors are charged with competently administering the building codes. If building inspectors have not gained the experience and technical knowledge required for thorough inspections, the workmanship and design of these structures are left only to those with a monetary vested interest. With a drive for extra monetary gain, corners can be cut and the codes and contract documents may not be followed. This research combined with future studies aimed at improving other key parties’ contributions to the concrete reinforcement design, installation, and inspection process may further benefit the commercial construction industry. If every key party were in synch with one another, the need for concrete reinforcement rework along with its associated costs would decrease while maintaining building safety and useable life projections.

Some suggestions for improvement include:

- devoting some of the continuing education hours needed for recertification of inspectors to coursework involving concrete reinforcing placement methods and designs,
- developing and implementing a specific inspection checklist,
- increasing the time devoted to each inspection, and
enacting field experience requirements similar to those for currently followed by on-the-job training minimums journeyman apprenticeship programs.

According to the 2002 Florida Statutes, building inspectors are required to take a total of fourteen (14) hours of approved continuing education coursework every two (2) years. A list of courses approved by the Building Code Administrators and Inspectors Board that address the topics of foundations, concrete, and concrete reinforcing has been included in Appendix C. The coursework is not limited to only those offered by the state, and the Florida Building Commission allows alternative educational training with the Building Code Administrators and Inspectors Board’s approval. This flexibility may in the future allow for a program created for specific training regarding reinforced concrete inspection to be a viable option in allowing an avenue for current building inspectors to become more proficient at concrete reinforcing placement inspection while fulfilling a recertification requirement. Such a training program could cover common field installation techniques including necessary field adjustments, problems associated with reinforcing misplacement as well as acceptable inspection techniques.

In order to reduce the variation of inspection results, the implementation of an inspection checklist may be beneficial. The checklist could be a comprehensive, step-by-step procedure that rates the rebar placement and workmanship. A checklist for each type of reinforced concrete component could be part of a data base in which the inspector retrieves the template dependent upon what is to be inspected: strip footing, wall, beam, elevated slab, etc. When the checklist is complete, it can be used as part of the documentation process with a copy given to the field supervisor and the original kept for the building inspectors’ records.
A possible explanation of deficient inspections may be the result of a lack of time devoted to the inspection. If building inspectors are overburdened with work, they may be rushing inspections to cover the workload. The average inspection workload of a building inspector to accomplish complete inspections should be ascertained and set as a limit not to be exceeded. If the number of new construction projects exceeds the capacity of a codes enforcement agency to handle safely, extra help should be employed to lessen the work burden.

The state of Florida’s minimum field experience required for becoming a building inspector is one year of construction, building code inspection or plans review experience, with the exception of a person currently holding a standard certificate as issued by the Building Code Administrators and Inspectors Board and completing the required training program hours. In the required field experience training, the adoption of a modified journeyman apprenticeship programs’ on-the-job training hour requirement could be made. Journeyman apprenticeship programs ensure a wide variety of work experiences for apprentices by requiring minimum hours of on-the-job training. One example is the National Center for Construction Education and Research’s Carpentry Apprenticeship Program that encompasses the following categories of work experience including: foundations, walls, floors, framing, roofs, exterior mill work, interior wall coverage, stairs and others. For building inspectors, the categories covered could include all of the areas they will be inspecting. Each category would also require a minimum number of on-the-job training hours that must be documented before a building inspector can become certified. This would not only benefit the inspection of concrete reinforcing, but inspection process as a whole.
Recommendations for Future Studies

Further studies should gather data from other municipalities for comparison since this study was limited to one jurisdiction. There are many parties involved throughout the design and construction process that have a direct responsibility for creating a safe building. This study focused only on one of these parties and they should in no way take the complete burden. Research should be done to assess the other parties’ expertise related to reinforced concrete components to determine whether any improvements can be made within their disciplines. In addition, other studies should include questions relating to the availability of building inspectors and then compare those results to the quality of the inspection.
APPENDIX A
PROTOCOL AND ADMINISTERED SURVEY
Protocol Title: Survey of Concrete Reinforcing Inspection Process

Please read this consent document carefully before you decide to participate in this study.

Purpose of the research study:
The purpose of this study is to examine current building official expertise and consistency in relation to concrete reinforcing inspection of commercial construction projects which are over one million dollars in total cost.

What you will be asked to do in the study:
Fill out a seven question survey about reinforced concrete inspection.

Time required:
10 minutes

Risks and Benefits:
The survey has the potential of showing a need for a more educated and consistent inspection force that may, if trained, increase the longevity and safety of buildings. There are no risks because your name and company (agency) will not be used.

Compensation:
None.

Confidentiality:
Your identity will be kept confidential to the extent provided by law. Your information will be assigned a code number. The consent form connecting your name to the number will be kept in a locked file in my faculty supervisor's office. When the study is completed and the data have been analyzed, the form will be destroyed. Your name will not be used in any report.

Voluntary participation:
Your participation in this study is completely voluntary. There is no penalty for not participating.

Right to withdraw from the study:
You have the right to withdraw from the study at anytime without consequence.

Whom to contact if you have questions about the study:
Mark Powers: Grad. Student at ME Rinker School of Building Construction, 1238 N.W. 55th Terrace, Gainesville, Fl 32605, phone: (352)374-2203, E-mail: buzzard9876@hotmail.com

Dr. Raymond Issa: , ME Rinker School of Building Construction 101 Fine Arts Building C PO Box 115703 Gainesville, Fl 32611-5703, 392-5965, raymond-issa@ufl.edu

Whom to contact about your rights as a research participant in the study:
UFIRB Office, Box 112250, University of Florida, Gainesville, FL 32611-2250; ph 392-0433.

Agreement:
I have read the procedure described above. I voluntarily agree to participate in the procedure and I have received a copy of this description.

Participant: ____________________________ Date: ______________

Principal Investigator: ____________________________ Date: ______________
Survey of Concrete Reinforcing Inspection, a Commercial Construction Superintendent’s View

Job Title: 

Years of Experience: 

Type(s) of Construction: 

Estimated Annual Volume: 

Average Project Size: 

Instructions: In the following section, please circle the number which indicates the extent to which you agree with the following statements. A score of “1” denotes a low level of occurrence, while a score of “5” denotes a high level of occurrence.

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Always</th>
<th>Do Not Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Local Building inspectors refer to the contract documents to decide if the reinforcement is correct.</td>
<td>1 2 3 4 5 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Local Building inspectors reference the Florida Building Code to decide if the contract plans follow the code.</td>
<td>1 2 3 4 5 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Local Building inspectors do a thorough inspection of the entire area to be inspected.</td>
<td>1 2 3 4 5 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. While inspecting the rebar placement, local Building inspectors actually measure rebar lap length, rebar spacing and the proposed concrete coverage depth.</td>
<td>1 2 3 4 5 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Local Building inspectors are knowledgeable about reinforced concrete inspection.</td>
<td>1 2 3 4 5 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Different Building inspectors on the same job yield consistent interpretations of the contract documents regarding the rebar placement with one another.</td>
<td>1 2 3 4 5 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Inspection occurs during the actual placement of concrete.</td>
<td>1 2 3 4 5 6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Survey of Concrete Reinforcing Inspection, a Building Inspector’s View**

**Job Title:**

**Years of Experience:**

**Type(s) of Construction:**

**Instructions:** In the following section, please circle the number which indicates the extent to which you agree with the following statements. A score of “1” denotes a low level of occurrence, while a score of “5” denotes a high level of occurrence.

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Always</th>
<th>Do Not Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I refer to the contract documents to decide if the reinforcement is correct.</td>
<td>1 2 3 4 5 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. I reference the Florida Building Code to decide if the contract plans follow the code.</td>
<td>1 2 3 4 5 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. I do a thorough inspection of the entire area to be inspected.</td>
<td>1 2 3 4 5 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. While inspecting the rebar placement, I actually measure rebar lap, rebar depth and proposed concrete coverage.</td>
<td>1 2 3 4 5 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. I am knowledgeable about reinforced concrete inspection.</td>
<td>1 2 3 4 5 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Different building inspectors on the same job yield consistent interpretations of the contract documents regarding the rebar placement with one another.</td>
<td>1 2 3 4 5 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Inspection occurs during the actual placement of concrete.</td>
<td>1 2 3 4 5 6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# APPENDIX B
## DEMOGRAPHICS

<table>
<thead>
<tr>
<th>Participant Number</th>
<th>Position</th>
<th>Years in Industry</th>
<th>Estimated Company Annual Volume (in Millions)</th>
<th>Project Size (in Millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Assistant Superintendent</td>
<td>2</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>Superintendent</td>
<td>21</td>
<td>110</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>Superintendent</td>
<td>8</td>
<td>110</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Assistant Superintendent</td>
<td>10</td>
<td>110</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>Superintendent</td>
<td>26</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Assistant Superintendent</td>
<td>4</td>
<td>50</td>
<td>10</td>
</tr>
<tr>
<td>7</td>
<td>Superintendent</td>
<td>18</td>
<td>600</td>
<td>50</td>
</tr>
<tr>
<td>8</td>
<td>Superintendent</td>
<td>25</td>
<td>200</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>Superintendent</td>
<td>28</td>
<td>200</td>
<td>7</td>
</tr>
<tr>
<td>10</td>
<td>Labor Foreman</td>
<td>1.5</td>
<td>50</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Assistant Superintendent</td>
<td>30</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>Superintendent</td>
<td>24</td>
<td>150</td>
<td>20</td>
</tr>
<tr>
<td>13</td>
<td>Superintendent</td>
<td>32</td>
<td>20</td>
<td>3</td>
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<tr>
<td>14</td>
<td>Superintendent</td>
<td>15</td>
<td>80</td>
<td>16</td>
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<tr>
<td>Participant Number</td>
<td>Position</td>
<td>Years in Industry</td>
<td>Estimated Company Annual Volume (in Millions)</td>
<td>Project Size (in Millions)</td>
</tr>
<tr>
<td>-------------------</td>
<td>----------------</td>
<td>------------------</td>
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<tr>
<td>15</td>
<td>Project Engineer</td>
<td>25</td>
<td>100</td>
<td>10</td>
</tr>
<tr>
<td>16</td>
<td>Assistant Superintendent</td>
<td>8</td>
<td>60</td>
<td>13</td>
</tr>
<tr>
<td>17</td>
<td>Superintendent</td>
<td>40</td>
<td>70</td>
<td>14</td>
</tr>
<tr>
<td>18</td>
<td>Superintendent</td>
<td>38</td>
<td>60</td>
<td>4</td>
</tr>
<tr>
<td>19</td>
<td>Superintendent</td>
<td>53</td>
<td>70</td>
<td>3</td>
</tr>
<tr>
<td>20</td>
<td>Superintendent</td>
<td>24</td>
<td>60</td>
<td>2</td>
</tr>
<tr>
<td>21</td>
<td>Superintendent</td>
<td>22</td>
<td>60</td>
<td>18</td>
</tr>
<tr>
<td>22</td>
<td>Superintendent</td>
<td>40</td>
<td>60</td>
<td>15</td>
</tr>
<tr>
<td>23</td>
<td>Assistant Superintendent</td>
<td>3</td>
<td>60</td>
<td>8</td>
</tr>
</tbody>
</table>

Total                                282

Average project size                $13 Million
APPENDIX C
APPROVED CONTINUING EDUCATION COURSE LIST

BUILDING CODE ADMINISTRATORS & INSPECTORS BOARD
CONTINUING EDUCATION SPONSOR AND COURSE LIST
(Abbreviated)

Course Sponsor: Santa Rosa County Building Dept
Contact: Rhonda Royals
Sponsor No.: 0001245
Date Approved: April 21, 1995
Course: Concrete Transportation and Placement
Length: 1 hour
Course Number: BCAI 0002463
Date Approved: June 16, 1995

Course Sponsor: Seminole County Building and Fire Protection Division
Contact: Paul Watson
Sponsor No.: 0001251
Date Approved: September 23, 1995
Course: Concrete Inspection & Testing.
Length: 4 hours
Course Number: BCAI 0002649
Date Approved: March 8, 1996

Course Sponsor: The South Florida Building Officials Council
Contact: James Rodgers
Sponsor No.: 0001258
Date Approved: December 16, 1996
Course: #4: The S.F.B.C. – Reinforced & Gypsum Concrete
Chapter 25 & 26
Length: 1 hour
Course Number: 0005359
Date Approved: January 22, 1997

Course Sponsor: Building Officials & Inspectors Association of Broward County
Contact: William G. Dumbaugh
Sponsor No.: 0000865
Date Approved: May 2, 1994
Course: Soils and Foundations
Length: 1 hour
Course Number: BCAI 0002041
Date Approved: January 23, 1998

Course Sponsor: Southern Building Code Congress International Inc.
Contact: Lindsey Carter
Sponsor No.: 0000991
Date Approved: September 22, 1994
Course: Concrete and Masonry Construction and Inspection
Length: 7 hours
Course Number: BCAI 0002097
Date Approved: September 22, 1994

(Source: Department of Business and Professional Regulation 2001)
REFERENCES


Florida Statute, Chapter 468, Part XII, Building Code Administrators and Inspectors.


BIOGRAPHICAL SKETCH

Mark Powers was born in Shell Lake, Wisconsin, and moved to Gainesville, Florida, in 1991. He has been involved in construction since he was seven years old while working with family in the industry. After graduating high school he attended Santa Fe Community College to complete an Associate of Arts in Building Construction. He was then accepted to the M.E. Rinker School of Building Construction at the University of Florida, where he received his Bachelor of Science in Building Construction. While receiving the undergraduate degree, he continued to work in the commercial construction industry. Working for a local general contractor, he continued his education by completing the Associated Builders and Contractors Inc.’s apprenticeship program to become a state of Florida recognized journeyman carpenter. He also completed his Master of Science in Building Construction degree at the University of Florida in December of 2002.