Project number: JRB-9906 - 44

Implementation of a Performance-Based Building Code in the United States
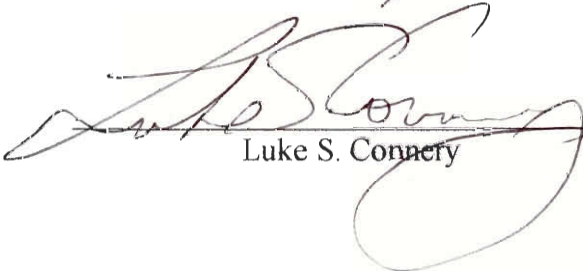
An Interactive Qualifying Project

submitted to the faculty

of the

Worcester Polytechnic Institute

In partial fulfillment of the requirements for the
Degree of Bachelor of Science
by

Jared J. Birmingham

Luke S. Connery

Jason M. Kahan

Approved by:

Prof. Jonathan Barnett

24 October 2001

TABLE OF CONTENTS

ABSTRACT

This study analyzes the feasibility of the implementation of a performance-based building code in the United States, based on the opinions of various stakeholders of the building industry. Interviews with these stakeholders were conducted to discuss prior knowledge of performance systems, and analyze the possibility of implementation. The barriers of the implementation of a performance-based building code, along with solutions, are stated in the analysis to aid stakeholders in the transition process.

EXECUTIVE SUMMARY

Performance-based building codes are now being widely used in many countries around the world. The purpose of this project was to investigate and evaluate the possibilities of a performance-based building code being implemented in the United States. The goal was to generate a list of professionals that would be most affected by a change in the code system. Information was gathered from these stakeholders and evaluated to derive an understanding whether a future for performance-based building codes in the United States is plausible.

In order to gather the necessary information from the stakeholders, informal interviews were conducted. Interviews were done in person, over the phone, and via e-mail. The same template of questions, split into three phases, was used for all of the interviews. Phase one dealt with the sufficiency of the current prescriptive-based building code. Phase two dealt with problems and solutions with a performance-based building code if it were hypothetically implemented. Phase three dealt with a realistic time frame for performance-based building codes to be implemented in the United States. These interviews were designed to reveal the stakeholders' current knowledge of performance-based systems as well as give them a basic understanding of how the code works.

The stakeholder list used for this project contains three of the five major groups that deal with codes in the building community. The Design Group consists of architects and engineers. The Governmental Group consists of code officials and inspectors. The Builder Group consists of contractors and sub-contractors. The interviews were analyzed within these subdivisions as well as on an overall level to determine if opinions varied by profession in the building community.

Many barriers stand in the way of the implementation at this time. There were many solutions offered for these barriers by stakeholders during the interview process. This shows the growing stakeholder interest in performance-based systems. The majority of stakeholders who were interviewed see potential for a performance-based building code, but are also happy with the current prescriptive-based building code. At this point, most stakeholders do not feel that there is need for change, which may greatly inhibit the implementation of a new code.

In conclusion, this project has shown that there are supporters and doubters of a performance-based building code. The fact to remember, though, is that most of the stakeholders interviewed see the potential success of a performance-based building code in the United States. This project recommends that education should be pushed on every level of the building community to inform more people of the benefits of performance-based design systems. This project shows that a performance-based building code may work best with the particular stakeholders that were interviewed if the code is unveiled slowly over a large duration of time, piece by piece.

AUTHORSHIP PAGE

This IQP was entirely a group effort. All three members continuously and equally contributed in the research, data gathering, analysis, and final write-up. The following is an attempt to highlight exactly which areas of this report write-up each individual member worked on the most.

Ch. 1 – Introduction   **Jason Kahan**

Ch. 2 – Literature Review   **Jared Birmingham, Luke Connery, & Jason Kahan**

Ch. 3 – Methodology   **Jared Birmingham**

Ch. 4 – Final Analysis   **Jared Birmingham, Luke Connery, & Jason Kahan**

Ch. 5 – Conclusion   **Luke Connery**

Chapter One

Introduction

1.0 Introduction

Since the first colony of the United States was established, governmental leaders have strived to maintain a safe living environment for all citizens (Sanderson, 1969). Building codes have been evolving through failures since the first code was documented (Fire Protection Handbook, 18th ed.). This fact sometimes makes the code difficult for interpretation. The constant change of codes have encouraged the building business in the United States to implement a set of building codes easily interpreted by all those involved in the industry.

The "burn and learn" philosophy of the prescriptive-based building code, along with lack of knowledge of the enforcement parties, has cost many lives, and even wasted money, but, has supplied building codes in the U.S. with a basis for evolution (Governmental (1), 2000). Within different geographical areas of the United States, there are discrepancies in the code. These discrepancies have caused interpretation problems for the professionals working with the current code (Design (1), 2000).

1.1 Movement Toward Performance-Based System

Interpretation problems with the prescriptive-based building code have led to the exploration of the development of fewer model codes in the United States; a building code that does not vary completely by state, town, or city (Fire Protection Handbook, 18th ed.). Many engineers, architects, insurance agencies, and fabricators have been part of a movement from a prescriptive-based building code to a performance-based building code. Professor David Lucht of Worcester Polytechnic Institute, in Worcester, Massachusetts, congregated members of all facets of the building industry and conversed, in small discussion groups, the positives and negatives of the current prescriptive code and entrance into a performance-based building code.

The first conference held by Lucht was conducted at Worcester Polytechnic Institute in 1991 and was documented and published (Lucht, 1991). As the possibility of the code implementation increased, a second conference was conducted in 1999 and published as a continuation of the first conference. This project is a continuation of the conference's issues that were discussed in order to give more insight to the implementation of performance-based building codes from a stakeholder point of view. It deals with the positives and negatives of how performance design could help strengthen the U.S. building industry. Various stakeholders of the construction world were interviewed in this project to assess how realistic the implementation of a performance-based building code is in the United States.

1.2 Overview

Chapter 2, the "Literature Review", contains information about the current prescriptive-based building code, present day stakeholders, and an introduction to performance-based systems.

The prescriptive-based building code history, Chapter 2.1, provides a background of the code including the evolution through history, the modern prescriptive code, and the code enforcement agencies.

Chapter 2.2, "The Present Day Stakeholders", discusses what and who the pertinent stakeholders of the construction business are. The chapter also gives an identification of the stakeholders and their interaction with building codes.

Chapter 2.3, "The Introduction to Performance-Based Building Codes", gives a background to the performance-based building codes, and how they were formed and have

developed. This chapter also discusses the implementation of the performance-based building codes in other countries.

Chapter 3, "The Methodology", discusses the goals of the project, specifying the research methods, interview methods, interview questions, and analysis of results.

Chapter 4, "Conclusion", is broken up into three sections: Stakeholders in Performance-Based Code, Barriers of Implementation of the Performance-Based Code, and Solutions.

Chapter 4.1, "Stakeholders in Performance-Based Code", shows the advantages of a performance-based building code and shows how each of the stakeholder groups will be benefited by the code. This chapter will also discuss the possible need for change.

Chapter 4.2, "Barriers of Implementation of the Performance-Based Code", discusses the barriers that must be overcome by stakeholder groups during the implementation of a performance-based building code. These barriers are analyzed extensively.

Chapter 4.3, "The Solutions", analyzes the results from the interviews conducted and reports on possible methods to overcome barriers. This section also reports on the feasibility of implementation of performance systems in the United States. Results of this project are compared and contrasted and a final decision is given on what strategies should be taken in order to implement a performance-based building code.

1.3 Closure

      It is the project teams' objective that the project results will be found useful to the construction community interested in a performance-based building code. The data contained in this report will provide useful knowledge concerning the implementation of a performance-based building code in the United States and what each stakeholder group as a whole thinks about the implementation of the codes. Benefits, along with possible problems, are discussed and are intended to be used as an aid to the implementation of a performance-based building code in the United States.

Chapter Two

Literature Review

2.1.0 Evolution of Building Code

Building codes have dated back to before 3000 B.C. Since early man, three important needs have been essential: food, clothing, and shelter. The need for shelter has led to the evolution of buildings, as we know them today. Over the years, thousands of variations of building codes have been adopted and used to ensure safety. Hammurabi, ruler of the Babylonian Empire, implemented the first documented code around 3000 B.C. These codes were very drastic in that they punished the builder and his family by death if his designed structure killed its occupants.

These primitive building codes show that safety is a vital part to humanity. As building designers learned how to design safer structures, the codes inherently began to evolve. Lessons were learned as tragedies occurred, and this "burn and learn" philosophy constantly changed building codes (Governmental (2), 2000). Many tragic fires have caused building codes to be analyzed and changed in order to prevent similar tragedies. Many cities have been plagued by fires that have left them in ruins. The Great fire of London 1666, The Great Chicago fire of 1871, and The Great Boston Fire of 1872 were some of the worlds worst destruction due to fire, leaving each respective city with millions of dollars in damage (Fire Protection Handbook, 18th ed). The United States, like most other countries, has continuously evolved in the area of building codes. George Washington and Thomas Jefferson encouraged the development of building regulations to provide for minimum standards related to public health and safety (Sanderson, 1969).

2.1.1 History of Prescriptive-Based Codes

The first form of a prescriptive-based building code in the United States came as early as 1625, which consisted of rules as to types, locations, and roof coverings of houses. The first formal codes did not come until the second half of the 19th century. The tragedy that caused the enactment of laws for inspection of places of public assembly is not exactly known (Terio, 1987, Deakin, 1990). The United States evolved and still is evolving in codes through, once again, "burn and learn" failures. The first documented regulation passed was in New Orleans in 1856 that gave the inspection duties to the mayor and an appointed surveyor (Sanderson, 1969).

2.1.2 Code Organization History

From the first building code council founded in 1905 by the American Insurance Association, codes have changed greatly according to geography. This first code was called *The Recommended National Building Code*. The *Recommended National Building Code* was used until 1927 when *The Uniform Building Code* was prepared and published by the Pacific Coast Building Officials (Sanderson, 1969).

At this point in time, three major groups of building code officials existed in the United States. These groups consisted of the Southern Standard Building Code Congress, The Building Officials Conference of America, and the International Conference of Building Officials. These three groups of code organizations produced codes for their respective geographical area of the United States. These code societies, over the years, were greatly influenced by organizations that the codes affected. These organizations included worker unions, U.S. government, and industrial/material fabricators amongst others (Fitzgerald, 2000). The main purpose of these code societies was to guarantee human safety.

2.1.3 Building Code Enforcement

Since the first code, there has always been a group that is responsible for ensuring quality and life safety. A United States building code enforcement agency does not exist. Each state or city is responsible for the inspection of each structure that is built within its jurisdiction. The appointment of building code officials is in the hands of administrative agencies of government, such as federal departments and agencies, state fire marshal offices, and other appropriate state agencies and local fire departments, building departments and so on (Fire Protection Handbook, 18th edition). The building code officials are responsible for enforcing the code that their region follows. Some states have a unified building code; the unification usually comes in the form of counties that follow the same code, or large cities that follow a certain code. A non-unified state code provides for interpretation problems for building code officials. A code council makes appropriate changes to the forming national code and it often takes over a year for its implementation (Design (2), 2000).

2.1.4 Building Code Overview

The prescriptive-based building code has been used to prescribe the safety of Americans for over 100 years. The presence of code councils has made it easier for each geographical area of the United States to adopt a code. Building code officials are responsible for the law enforcement of the code, which includes determining if a structure is safe and if it can be built.

2.2.0 Present Day Stakeholders

To accurately define a stakeholder for building codes, research was done on those who would be most affected by the codes in the United States. There are two ways that stakeholders

are mainly affected by the code; time and money. Stakeholders are those spending the time and making the money. An accurate definition for a stakeholder would be any beneficiary, and in this case, anyone who benefits through the use of the building codes (Lucht, 1999).

2.2.1 Identified Stakeholders

There are five major groups that building code stakeholders can be broken into. These five groups deal with every aspect of the building code. Everything from creating the code to owning the building that it defines. The five stakeholder groups are:

1. Design
2. Governmental
3. Builder
4. Supplier
5. Insurance

After initial information gathering and preliminary interviews, the authors found that not all of these groups would be necessary to keep on the list of stakeholders.

2.2.2 Refined Stakeholder List

The Supplier and Insurance Groups could be excluded from the research of this IQP. Although still both stakeholders, they have shown in the past their ability to adapt to the actively changing environments of the building industry. Any changes in the building codes will cause little strain on their industry and have little effect on their role with the code (Lucht, 2001).

The three remaining groups, Design, Builder, and Governmental, are the stakeholders that are focused on in this project. These groups have great influence on the codes and their present day usage. To understand their exact importance, these groups were broken down into the individual occupants and their involvement with the building codes in the U.S.

2.2.3 The Design Group

The Design Group is made up of architects and engineers. Designers are responsible for creating the desired structure on paper. They must create these structures while staying within the boundaries of the building code. Architects are the creators. They utilize creativity to put a customer's desired structure on paper.

Engineers are used in the design process to verify that the architects' designs will be effective when they are constructed (Fitzgerald, 2000). Civil engineers take the blueprints and make the necessary calculations to prove that the structure will meet all of the load demands for the structure. These load demands vary upon the location of the building. Different regions contain different situations that must be considered when designing a building, such as: earthquakes, hurricanes, climate, and the ground under the structure (Governmental (3), 2000).

Some building design teams include fire protection engineers. These engineers check the safety of the structure. A structure doesn't satisfy its goal if there is no safety for the occupants within it. Defining the safety of a building includes everything from designing sprinkler systems and fire extinguishers to implementing sufficient escape routes during a fire emergency (Sullivan, 2000).

The designers have restrictions when creating on paper. Buildings, which they constantly develop for individual owners, are the final product of the design process. They must stay within the boundaries of the building code, while satisfying the needs of the building owner.

2.2.4 The Builder Group

The builder group breaks into two parts; the owners of the building and the builders of the buildings. This stakeholder group needs little knowledge of the building codes (Fitzgerald, 2000). The owners list their demands for the building, while the contractors and subcontractors build from the already code compliant blueprints provided by the designers.

The building owner is the individual or organization that puts up the capital for the creation of any given building project. In the case of a residential homes or commercial building, the owner will make use of the building or make a profit by selling or renting the residence or commercial space. The owner will provide restrictive criteria for the structure to the design group. After the structure is designed, the blueprints are then passed to the second member of the building group, the contractor.

The owners hire contractors to construct the buildings. They take the blueprints, buy the supplies, and turn the drawings into the desired structures. When dealing with blueprints, builders have two things in mind: time and predictability. The predictability of whether the building will meet the code and in turn is able to receive its building code certificate and its certificate of occupancy. Any foreseen time constraints due to the code or other problems will make the difference of whether the contractor will take the job. The contractors take the responsibility to hire subcontractors for service they themselves do not provide. The codes affect the amount of time and money spent on a project. This is due to mandatory designs or materials that designers included to stay within the boundaries of the building code. A finished building must go through the code official's inspections, and be certified that the structure is code compliant (Fitzgerald, 2000).

2.2.5 Governmental Group

The Governmental Group can be broken into two separate stakeholder divisions. The first are the code writers. These people deal with creating, updating, and supplying the code to the public. The second are code officials, who follow the whole building process from the drafting of the blueprint to the construction of the buildings themselves to ensure the structure will be code compliant (Fitzgerald, 2000).

Another stakeholder in the governmental section is the fire prevention inspector, also known as the fire marshal, although this is not true in all states. As with the code officials, the fire prevention inspector, a member of the fire service, also makes sure all buildings follow the building codes in the area of fire safety. Fire prevention inspections are more common among commercial buildings or anywhere where large numbers of people will be spending a lot of time. A few examples of these types of buildings are office buildings, hospitals, schools, and hotels. This is due to the constant emphasis on human safety within a structure (Buchanan, 1994).

The Governmental Group is really the police of the building industry. With the codes as their laws, they make the rules to build by. Through inspections, the Governmental Group ensures these rules are followed.

2.2.6 Modified Stakeholder Careers

The stakeholders have been defined and classified into three groups. These groups and their occupants are listed as the beneficiaries of the building codes. These stakeholders will also be most affected by any changes in the code. A change from a prescriptive-based building code to a performance-based code could be the most immense change these stakeholder groups have ever faced in the building community.

2.3.0 Introduction to Performance-Based Building Codes

There have been objective- or performance-based regulations in various countries around the world for more than the past ten years. Beginning with the British and Japanese in the mid-1980s, and through the Warren Centre Report from Australia in the late 1980s, there has recently been an international movement toward decreasing prescriptive constraints and maximizing design flexibility in building codes. At this point, the most recent countries to move toward a performance-based system, Sweden and the United States, can still be viewed as performance pioneers (Meacham, 1996).

2.3.1 Performance Overview

The concepts of performance-based regulations and of engineered approaches to building fire safety have existed for several years. There has been minimal change from the initial outlooks of early fire safety engineering approaches of the early 1970s (Meacham, 1998). Currently, with the availability of many more engineering tools and the evolution of performance-based building regulations in many countries, there has been an international increase in interest in performance-based fire safety design.

2.3.2 Design Process

At the start of the design process, the goals in a performance-based design are extremely flexible and provide for an almost unlimited amount of options. As the design process moves toward completion, functional objectives must become more defined for the unique design at hand. Although these goals begin to highlight the direction of the project, they are not specific enough to base the entire design on. Performance requirements begin to constrain the design as the design moves on into the next level. These requirements become permanent and completely agreed upon as the performance design moves toward a final design for the project. This final phase is referred to as setting the performance criteria for the project. These are the final guidelines constraining the project scope.

2.3.3 Performance-Based Design Description

The performance-based building code allows for flexibility in all levels of building construction and upkeep. The intent of the performance-based building code is to allow for the construction and action of a building using flexible engineered solutions. The code extends its restrictive power through meeting the requirements mentioned above. The code operates strictly on agreed upon fire safety goals, loss objectives, and design objectives. As opposed to the current building codes used in the United States, a performance-based building code would provide a new solution to the problem of designing in the evolving realm of the building industry.

Currently in the U.S., when there is a situation within the design of a new project that falls outside the boundaries of the prescriptive-based code, the stakeholders involved often feel over-constrained with their design options. A performance-based building code allows for

alternate approaches to be taken in the design task and therefore provides more room for the design team to work. Performance-based design envelops the design process with revolutionary design freedom. The performance-based mindset is based in allowing so-called "engineered solutions" to handle any situation that the design team confronts that the code does not or cannot prescribe. Making another citation to prescriptive-based codes, instead of going through the process of manipulating design restrictions, any given designer merely designs based on meeting the functional objectives of the performance-based building code. Under this system, designers always have the ability to engineer new solutions to each unique situation of a design. The main problem that seems to be answered here is that each new building in today's society is indeed a unique case. Performance-based building codes take this fact into account and provide the design team with engineered solution freedom from the start.

2.3.4.0 International Performance-Based Code Development: Past 20 Years

The following gives a brief overview of the voyage of performance systems through the past 20 years on an international scale.

2.3.4.1 Introduction

As with any defining system, there have been subtle changes in building codes over the past 20 years reflecting the needs of society. This next section will take a look at changes towards a performance-based system overseas over the past 20 years. In 1996, Brian J. Meacham released "The Evolution of Performance-Based Codes..." dealing with the evolution of the performance-based empire and how it is beginning to fit in well with many countries in today's code business. Some of the following have been adapted from this reading.

2.3.4.2 The United Kingdom

Beginning with the Fire of London in 1666, regulations were set forth to help limit the spread of fire between buildings and prevent a similar loss from occurring. During the years that followed, changes were made to the code to reflect the lessons learned from fatal fires, changes in building technology, and the like. By 1976, though, these regulations had grown to a total of 307 pages, which were "very prescriptive and understood mainly by lawyers" (Meacham, 1996).

In an attempt to increase flexibility in design, and produce a more intelligent system, a reform of the building regulations was undertaken in the late 1970s and the early 1980s. The result was completely dramatic. In 1985, the publication of the Building Regulations reduced the total page number of the building code from 307 pages to about 23 pages, while still covering the requirements for Structure, Fire, Site Preparation, Resistance to Moisture, Toxic Substances, Resistance to the Passage of Sound, Ventilation, Hygiene, Drainage and Waste Disposal, Heat Producing Appliances, Stairways, Lamps and Guards, Conservation of Fuel and Power, and Facilities for Disabled Peoples.

This was made possible, in short, by using functional, or performance, wording, instead of prescriptive requirements. Terms such as "adequate resistance" and "reasonable under the circumstances" are open to broad interpretation, and often depend upon the user's specific design objectives and the purposes for which a particular structure is intended. As such, the objectives might well be construed to be "in the eye of the beholder" (Meacham, 1996).

This radical change in regulatory language led engineers to, for the first time ever, engineer "acceptable solutions" for the objectives. Although engineered solutions now seemed the proper and most modern tool to take advantage of, few employed design service members seemed comfortable enough to use them. This led design teams during this time period to rely

on the older prescriptive method of coding, which was arrived at through the "Approved Documents" section of the British Building Code. The fire safety engineering community recognized this conflict within the code and set out to remedy the problem. In British terms, a code of practice was implemented in the early 1990s to do exactly this.

The British Building Code, revised to fit performance regulations in 1985, was reformatted again in 1991. One of the key additions to the 1991 draft was the reference to the use of Approved Documents, or alternative methods, based on fire safety engineering principles in meeting the objectives of the regulations. Even with this change, many within the design community remained reluctant to use their performance tools. This hesitation was based mainly in a lack of guidance, both for the fire safety engineers and for those who reviewed the design plans. To address this issue, a design team was contracted to develop a draft code of practice for the application of fire safety engineering principles to building fire safety design.

The British Standards Institute released *The Application of Fire Safety Engineering Principles to Fire Safety in Buildings* as a British Standard Draft for Development. From published reports on the draft version, it appears that the document is a comprehensive, well-structured, and well-documented source for providing guidance in the engineering and evaluation of building fire safety design (Meacham, 1996).

2.3.4.3 Japan

The regulatory system was similar in Japan during this time period. Since 1950, Japan had been using a highly restrictive, highly prescriptive building code system called the Building Standards Law. Although these regulations seemed to be doing the job in a relatively acceptable fashion, by the mid-1980s, the Japanese government also felt that they "incurred the undue

increase of construction costs and restraint to building designs" (Meacham, 1996). Some of the drawbacks that were identified included inefficient and/or overlapping fire safety measures, limited flexibility in architectural design, difficulty in gaining approval to apply newly developed fire safety technologies, difficulty in understanding the actual level of fire safety, and a sense of general discouragement against improving the level of fire safety.

Recognizing this situation, the Building Research Institute of the Ministry of Construction embarked on a planned five-year research project beginning in 1982 to develop a performance-based design system that could be used as an alternate to the Building Standards Law. The intent of this action was quite simple: develop a performance-based system that could provide an appropriate level of safety through engineered solutions that are comparable to the Building Safety Law (Meacham, 1996).

Japan commenced to develop a system named "The Total Fire Safety Design System of Buildings" (Meacham, 1996). This system was composed of five sub-systems. These five primary sub-systems are clear (i.e. Prevention of Fire Outbreak and Spread). Under each of these sub-systems, "prediction methods" are supplied, which allow for numerical answers supplied to each of the objectives of the sub-system. The prediction methods are "approved methods" for calculating criteria (i.e. equations, correlations, or models), and the "concepts of testing methods" provide acceptable means of verification.

Although the system has its shortcomings, it has nevertheless resulted in a significant increase in the number of applications submitted to the Ministry of Construction for equivalencies to the Building Standards Law. Japan has remained rather stagnant since this change in the 1980s, although there have been changes made to the code as a whole based on past experience with new technology within Japan's performance-based system.

2.3.4.4.0 New Zealand

New Zealand took an interest toward performance-based design in the late 1980s and early 1990s. Their 1992 code, the *New Zealand Building Code*, was a revolutionary performance system that considered Outbreak of Fire, Means of Escape, Spread of Fire, and Structural Stability During Fire, as specific issues that must be addressed during the design of a building. Like the British regulations, New Zealand incorporated an appendix of "Acceptable Solutions". The three levels of performance building design talked about earlier in this report (objectives, functional requirements, and performance requirements) are significantly addressed in this 1992 New Zealand version. To note, a performance-based approach is ***required*** for some aspects of buildings with fire loads exceeding 1500 MJ/m^2 (Buchanan, 1994).

2.3.4.4.1 *New Zealand Building Code*: Example

Objective

C2.1 The objective of this provision is to:

(a) Safeguard people from injury or illness from a fire while escaping to a safe place, and

(b) Facilitate fire rescue operations

Functional Requirement

C2.2 Buildings shall be provided with escape routes which:

(a) Give people adequate time to reach a safe place without being overcome by the effects of fire, and

(b) Give fire service (FD) personnel adequate time to undertake rescue operations

Performance Requirement

C2.3.1 The number of open paths available to each person escaping to an exit way or final exit shall be appropriate to:

   (a) The travel distance,

   (b) The number of occupants,

   (c) The fire hazard, and

   (d) The fire safety systems installed in the fire cell

(Meacham, 1996)

2.3.4.4.2 *New Zealand*: Closure

New Zealand can be viewed currently in the world as one of the most developed performance-based design countries. Unlike the United States, New Zealand's code is a national one dictated from its government. Although many "speed bumps" have been encountered since its implementation, the Centre for Advanced Engineering at the University of Canterbury helps with its "guidance" publications. The *Fire Engineering Design Guide*, produced by above, helped to guide the stakeholders of this country through the turbulence of the new national building code.

2.3.5 Other Performance-Based Shifts

Many countries have leaned toward performance-based design implemented under their building design systems over the past 20 years. We have named the preceding countries based on their relevance in decisive criteria for the performance-based shift. Performance-based design is indeed a phenomenon that is aimed for by many countries because of its ability to hold so

much flexibility in such a limited amount of actual text. In conjunction with this, many countries also see an overall diminishing cost of construction due to design teams having to deal less with the courts of their respective countries. Performance-based design, at one level or another, can indeed help the building industry of any country. The following is a list of other nations that have either converted completely to a performance-based building system or have somehow incorporated performance systems into their current building system (which are mostly prescriptive-based).

- The United Kingdom
- Japan
- The United States of America
- Canada
- New Zealand
- Australia
- Sweden
- Denmark
- Finland
- Iceland
- Norway

2.3.6.0 Performance-Based Code Development – USA

In the U.S., The National Fire Protection Research Foundation (NFPRF) undertook the National Fire Risk Assessment Project in 1986. The goal of this project was to develop "an objective, comprehensive, generally applicable, and widely recognized fire risk assessment methodology for products that go into buildings" (Meacham, 1996). This was a collaborative effort between the National Institute of Standards and Technology (NIST), the NFPA Fire Analysis & Research Division, and the private consulting firm of Benjamin/Clark Associates. This conjunction ended up producing what was finally named FRAMEworks. FRAMEworks combines a quantitative method (fire modeling) to evaluate specific products in specific fire scenarios with a statistical method of relating fire deaths to the specific scenarios in order to

establish a death rate baseline for the scenarios. The impact of new products to the fire-engineering field can be referenced to these baseline statistics.

2.3.6.1 SFPE Involvement

To also note, the SFPE, at this time, realized that fire protection engineers and fire officials needed fire science tools that could be readily used in the office. This led to the development and publication of the SFPE Handbook of Fire Protection Engineering, a resource document consisting of fundamentals of fire science and engineering. Since its publication in 1988, the Handbook became a cornerstone in the application of engineered approaches to fire safety problems. For many, the Handbook was also a key reference document in the support of performance-based fire safety design (Meacham, 1996).

2.3.6.2 Conference on Firesafety Design in the 21st Century - WPI

In 1991, the Conference on Firesafety Design in the 21st Century was held at Worcester Polytechnic Institute in Worcester, MA. This played a role in the motivation of performance-based firesafety design methods and codes in the United States similar to the Warren Centre Project in Australia just two years earlier. The conference was a 3-day collaboration of all types of stakeholders within the building and safety industries. In addition to the presentation of some twenty-nine conference papers, the participants broke down into working groups for more detailed discussion of important issues.

The participants identified a number of important goals, barriers, and strategies for firesafety design in the 21st century. A United States national goal was formulated that "by the year 2000, the first generation of an entirely new concept in performance-based building codes

be made available to engineers, architects, and authorities having jurisdiction... in a credible and useful form" (Lucht, 1991). At the end of this conference, barriers based on a change to performance-based design were listed, and strategies to overcome these barriers were presented. This conference was a landmark for the further development of performance-based design in the United States in the 21st century.

2.3.6.3 U.S. Building Code Organizations

Unlike the countries the group has discussed so far, the United States does not have a single, nationalized building code. Within the U.S., there are three basic model prescriptive-based building codes. The three codes are the BOCA National Building Code, the Southern Building Code, and the Uniform Building Code. These three organizations each provide a written code, with which each state models their building codes from. Although not an official code organization, the NFPA also has contributions to U.S. building codes through its unique tabulations of electrical, fire alarm, and life safety codes. These NFPA codes can all be brought into whichever platform each individual state chooses to follow. The Life Safety Code put forth by the NFPA is used by more states overall than any of the building codes distributed by the three building code organizations in the U.S.

Although the U.S. lacks a national building code, there is an organization that contains delegates from each of the three code organizations. The ICC (International Code Council) aims toward providing the United States with a national building code. After five years of code drafting, coupled with proposed changes submitted in the current 2001 Code Development Cycle, the ICC is publishing the 2001 Edition of the *ICC Performance Code for Buildings and Facilities* (ICCPC). This document represents the culmination of several interim drafts released

in August 1998, August 1999, and a Final Draft dated August 2000. The 2001 edition of the ICCPC is expected to be available at the end of December 2001, and will include the approved revisions from the 2001 Code Development Cycle, which saw a myriad of proposals from interested and affected parties (www.intlcode.org).

2.3.6.4 Future for Performance-Based Codes

Although there is no national code in the United States, whether it be prescriptive or performance-based, "performance" oriented wording does indeed exist in the U.S. All of the current building codes in the U.S. do allow some sort of performance action. It is often termed as the allowance for "equivalent methods and materials". The NFPA has also taken steps toward a performance-oriented system in the U.S. Several of NFPA's standards, such as NFPA 72, The National Fire Alarm Code, contain wording and design methodologies that are performance-oriented (Meacham, 1996).

NFPA's Building Code Technical Correlating Committee has released its Report on Proposals (ROP), which includes the second draft of NFPA 5000, Building Code – the first building code to be developed using an open consensus process, accredited by the American National Standards Institute (ANSI) (www.nfpa.org). When finalized, the NFPA Building Code will round out the only full set of integrated codes for the built environment. NFPA and its partners, including the International Association of Plumbing and Mechanical Officials (IAPMO) and the Western Fire Chiefs Association (WFCA), are developing the set.

NFPA's building code was first released in preliminary draft form in August of 2000 for public review and input. At that time, a total of more than 1,400 proposals were received from interested groups and individuals, including the Building Code Technical Committees. Today's

release of the Report on Proposals gives all interested parties another opportunity to provide

input on the building code (www.nfpa.org).

Chapter Three

Methodology

3.0 Project Direction

The idea of this IQP came through Professor Robert Fitzgerald, who had discussed a possible need for a change in building codes in the United States (Fitzgerald, 2000). Some initial research led this IQP to two previous projects that were conducted in New Zealand on the conversion from a prescriptive-based building code to a performance-based building code (IQP, 1991, IQP, 1993). Further research into performance-based codes showed that they were now all over the world and that there has been interest in these codes shown in the United States. The New Zealand projects discovered that there were many barriers that prevented a smooth transition of the two systems. This is where the basis of this project has its roots. The purpose of this Interactive Qualifying Project is to research and identify problems and barriers that would prevent a smooth transition from prescriptive to a performance-based system in the United States. In doing this, we are going to discover if a change of this magnitude is plausible at this time.

A milestone chart was utilized for this project to keep the work pace on schedule. The chart consisted of project tasks and the dates that they are to be completed by. The project group began by attaining background information of prescriptive and performance-based building codes.

3.1 Background Research

The background research was a vital part to putting together a good project proposal. The proposal was due on October 18, 2000. To begin the project research, the group went to the Worcester Polytechnic Institute library where the project group observed and borrowed several sources (as listed under References) on performance-based building codes, research methods,

interview styles, and the previous performance-based code projects done in New Zealand (IQP, 1991, IQP, 1993).

Another aspect of the background research was to identify the people that would be most affected by this code conversion. These "stakeholders" were the main focus of this IQP. To identify them, the project group met with the head of the Fire Protection Engineering Department at WPI, Professor David A. Lucht. Professor Lucht is currently involved with performance-based building codes in the United States. He has hosted two conferences at WPI in 1991 and 1999 to educate and get feedback from stakeholders in the U.S. (Lucht, 1999). In a meeting with Professor Lucht, the group went through his list of attendants to his conference, and derived a similar list of stakeholders to interview for the project. The stakeholder list consisted of five groups:

- Builder
- Governmental
- Designer
- Supply
- Insurance

Due to the Supply and Insurance Groups' ability to adapt, the project group felt they were not a necessity to the project and removed them from the interview lists. The conclusions reached in this project are based heavily on information gathered during the interviews of these stakeholders.

Before the completion of the proposal, the project group wanted to see what type of responses it would get from interviewees on the subject. Preliminary interviews were added into the milestone chart, and they were completed before any other interviews.

3.2 Preliminary Interviews

During the preliminary interview process, three things were kept in mind. The project group wanted to see if the information gathered would allow for completion of the project. During this preliminary timetable, it was documented which of the stakeholders had the best grasp of the subject matter. Lastly, the group wanted to develop a set list of interview questions that all stakeholders could be asked, allowing the group to extract relevant data, but also keeping interviews as short and comfortable as possible.

For the preliminary interviews, two members were chosen from each of the three stakeholder groups. From the results of these interviews, answers to all three of the preliminary questions were answered. The project group was able to gather more than enough information from the interviews for a comfortable ability to complete an accurate and thorough project on the proposed problem statement. The project group was able to develop a list of interview questions that allowed for quick, impersonal interviews those stakeholders with or without any knowledge of performance-based systems were able to answer. The finalized interview questions (see Appendix A) were split into three phases:

- Phase 1. Prescriptive vs. Performance (Safety Issues)
- Phase 2. Hypothetical Performance Implementation (Barriers and Solutions)
- Phase 3. Interviewee Opinions (Likelihood & Time for Implementation)

With the completion of the preliminary interviews, the proposal quickly began to take shape. With the problem statement already completed, the group moved to the Introduction, which gives a brief history of performance-based building codes. Next came the Methodology, which is based on the milestone chart. This gave a global view of the project and steps that were planned to take to complete it. Going back to initial research, the group developed the Literature Review. This section gave all the information on the IQP that was gathered over the course of

the in-depth research completed for this project. The group completed the proposal and submitted it to Professor Barnett. With the proposal done, the next milestone was to complete the interviews.

3.3 Interviews

Interview techniques were discussed with Professor David A. Lucht, as well as researched in the WPI library. The number of interviews was set to thirty, ten in each stakeholder group for the project. We felt this would give us enough feedback to accurately answer the given problem statement.

The project group began to develop a list of interviewees through Internet research of local companies and code officials. We were able to finish the list by meeting Professor Jonathan R. Barnett, who provided a list of names that he had attained throughout his professional career. With the list of interviewees complete, the group began making phone calls and setting up interview dates.

An interview itinerary was developed to follow, so that all information was all gathered in the same way. The itinerary went as follows:

1. Set interview date
2. Arrive at interview on time
3. Begin with brief overview of this project and the WPI project curriculum
4. If interviewee has no knowledge of topic, briefly update them
5. Complete interview, keeping strictly to developed questions.
6. Group meeting, interview write-up done and discussed
7. Repeated for all interviews.

Personal interviews were best for getting the data, but certain circumstances, such as location and time restraints, led the group to do a few interviews over the phone, and a couple interviews were done by the interviewee answering questions over e-mail.

3.4 Interview Analysis

The results and conclusions of this project were all extracted from the completed interviews. The analysis process took much longer than expected due to the extensive amount of information gathered.

The main focus of the project group, when going through the interview write-ups, was the barriers that the stakeholders felt would mostly likely keep performance-based building codes from being implemented in the United States. The group also kept focus on the proposed solutions that interviews offered, which dealt with ideas that would personally help them in the case of a code change. The group compared the gathered results in two ways. The first, interviewees' answers were compared and contrasted within the same stakeholder group. The second way, the group compared the general consensus from stakeholder groups to one another.

All of the gathered data was organized for use in the results section of the project. With all of the data gathered, charts were developed to further show the outcome of the interview questions.

3.5 Write-Up Process

This IQP breaks into 5 major parts:

1. Introduction
2. Literary Review
3. Methodology
4. Results and Analysis
5. Conclusion

Referring back to the project proposal, additions were added to the Introduction, Literary Review and Methodology. The extensive information gathered from the interview process allowed for more detail in these parts. The interview data was tallied on an Excel spreadsheet to be displayed graphically in the analysis section. By looking over the data and analysis charts, conclusions were developed for the projects proposed goals. This project was read over by several students and checked with Prof. Barnett before being revised, edited, and finalized for submission.

Chapter Four

Final Analysis

4.1.0 Impact of Transition on Stakeholder Groups

The interview process has shown that an impact due to the transition to a performance-based system is apparent. The change from the current prescriptive-based building code will be difficult for all facets of the building community. Each stakeholder group will undergo an adjustment that will be shown in the proceeding sections.

4.1.1 Design Group Changes

A performance-based building code will allow architects and engineers in the Design Group to be creative in designing structures. With no specific codes inhibiting them, a designer's flexibility is maximized using performance-based design. "Larger and more dynamic buildings become possible under a performance-based system," (Design (3), 2000).

With the increase of possibilities for the Design Group, there will also be an increase in liability. The design team is responsible for meeting the safety and performance goals for various structures. This increase in liability means the communication throughout the design team and code officials must be improved. All unique designs and solutions under a performance-based building code must be thoroughly inspected to ensure their effectiveness (Design (4), 2001). The increase of liability and responsibility of the Design Group will surely lead to an increase in salary.

4.1.2 Governmental Group Changes

Changes within the Governmental Group are foreseen to be minimal by the interviewees. The change under a performance-based building code provides that they will need to prove that the safety goals and performance goals have been met. Once again, the responses show that new implementation of a performance-based building code will increase the level of liability put onto the shoulders of these stakeholders.

Code officials will have to play a larger role in the design procedures throughout the entire process of erecting a structure. Officials and inspectors will have to prove blueprints and buildings meet performance specifications through engineering methods. The official's job will become more technical because specifications will no longer dictate each possibility during a building project.

4.1.3 Builder Group Changes

The response of the Builder Group implies that they will be the least affected in the code transition. Costs will increase due to dynamic buildings being fabricated, but a performance-based system will allow for material costs to lower. New effective materials and technologies will be permitted for use as long as performance criteria are met. These same materials and technologies were either denied by the previous code or in the long process of being accepted (Builder (1), 2001, Governmental (4), 2001). In many cases, these capable materials are much cheaper than those specified under the prescriptive code. Cost ranges may vary for builders, but their duties will remain to be building the designed structure placed before them.

4.2.0 Barriers

Change is the best driving force behind creating chaos and disorder. As with any change in the fundamentals of a working system, the transition from a prescriptive-based building code to a performance system provides excellent conditions for problems to arise. These problems are categorized here as barriers to the conversion to a performance system here in the United States. One must keep in mind that these barriers are all directly related to change. There are groups of people currently working with this issue forming ideas toward making the transition to a performance system a bit smoother.

4.2.1 Design Group Responsibilities

With the transition to a performance-based system, change manifests itself into the responsibilities of the listed stakeholder groups. The Design Group of the industry is one of the hardest impacted areas of the conversion. Designers, engineers, and architects will be called upon to use their engineering skill at a much higher level during the fabrication of plans for building (Design (5), 2000).

4.2.2 Loopholes

As the current prescriptive-based building code evolved over the years, the people who worked with it on a daily basis became acquainted with its ins and outs (Design (6), 2000, Governmental (5), 2000). The current code used here in the U.S. provides an accurate description of safe building practices if, and only if, the design team interprets it correctly. With the entrance of a performance-based code, interpretation will also play a large role. One of the largest problems seen overseas with the implementation of performance systems is the fact that

the code is almost never exactly perfect with initial implementation (Meacham, 1996). As the new code is used more and more, will loopholes begin to form within its structure? It is a problem with perception: will the design industry be able to interpret the code in its intended sense? Complementing both problems, who will be in charge of paroling this new system so these previous two problems can be curbed?

4.2.3 Fear of Change

Many of the interviewees expressed a very indifferent attitude toward the idea of a performance-based code. The idea that "change is good" seems to be a bit less than a popular one. Within all three of the stakeholder groups focused on in this project, the vast majority expressed concern about having to change their most fundamental practices. All of the subjects offered that the people they work with, including themselves, have become nicely acquainted with the code as it stands (Design (7), Builder (2), Governmental (6), 2000). The interviews unanimously showed that most of the stakeholders feel that the prescriptive code is sufficient for what its intended to do.

They express themselves through the phrase, "if it's not broken, why fix it?" (Design (8), 2000, Sullivan, 2000). This stands solidly as a barrier in the conversion to a performance system.

4.2.4 Code Dispersion

Presently in the United States, the code industry is constantly augmenting the code system. "The new BOCA code came out in 1997, and it was two years before it started becoming enforced" (Design (9), 2000). There currently exists no clear route to supply each of

the members of the registered building industry with a hard copy of the newly published code. These members are expected to seek this knowledge themselves and supply themselves with this knowledge.

4.2.5 Code Unification

A large portion of the interviewees believed that code unification could play a huge role in the implementation of a performance-based building code. If in some way, the U.S. could form a national code alliance either before or during the conversion, perhaps the building enterprise would feel a bit more comforted. Although the three standard code alliances, (SBCC, BOCA, UBC) are implemented for use in each region of the U.S. for a reason, performance-based systems may provide the new level of freedom the industry needs for unification of the code. The difficulty of the government enforcing a uniform building code presents itself as another barrier halting the conversion process.

4.2.6 Grandfather Clause

A smaller concern lies is the minds of some of the interviewees. "What will happen to the designs or buildings that are already contracted out or are under construction?" (Builder (3), 2000). The industry must come up with a decision on how to deal with this "grandfather clause" situation. Although this problem could arise, most of the subjects have no problem understanding that this could readily be taken care of.

4.2.7 Liability

Moving back to the discussion that went with the barriers arising in the design portion of the industry, there will be an increased emphasis put on the use of the performance code. Liability becomes the concern here. Currently, when a failure occurs, the blame falls on the design team that stamped and approved the architectural plans. With the entire industry producing newly engineered solutions, where will the fault lie if there is a failure of some sort?

4.2.8 Cost of Conversion

With some of the barriers discussed above, the question of funding comes strongly into play. With members of the building industry becoming torn in new directions of their careers, there is much money needed to help aid this transition. The code supply questions discussed above are directly related to this barrier. Other education costs may arise also. Will people have to pay for their own night classes related to educating themselves about this new way of thinking? Compensation may be necessary in many areas of the industry to help combat the increasing cost of increasing the ability to change.

4.2.9 Safety

Safety becomes a large concern in the transition also. Stakeholders in this project felt that through the acquaintance with the present codes that most stakeholders have, safety has started to finally become optimized. Once again, whenever one deals with codes, interpretation is key. Will a new performance-based building code instantly become manifested in the classically based United States building industry? The following figure shows the *interviewed stakeholders'* opinions on which code meets safety best.

Performance Vs. Prescriptive - Safety
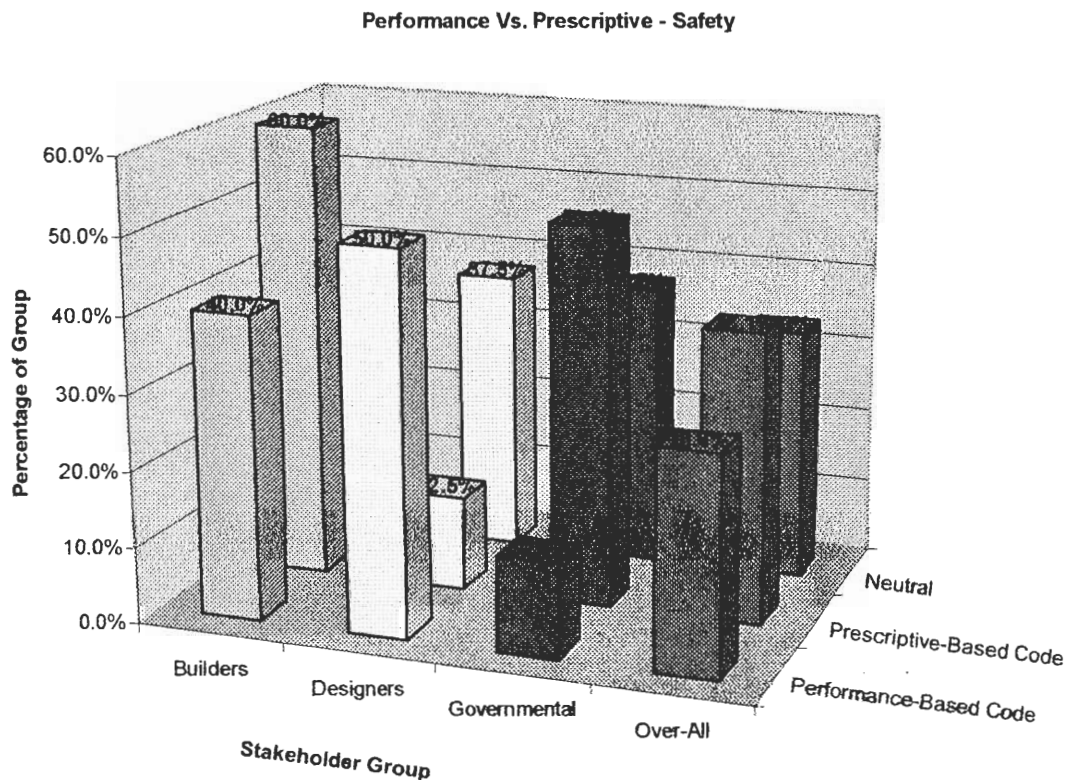
The subjects seemed fairly confident in the ability for a performance system to dictate safety, although it still is a strong concern. The bottom line of any code is to provide its users with a level of safety that meets the level that society deems fit (Governmental (7), 2000). The prescription of safety to society is a very broad subject, not exactly defined in any code (Design (10), 2000). Although through the facets of safety, no building code allows people to be killed, but people do die in code complying buildings. The point here is that it is very hard to quantify "safety" (Governmental (8), 2000). Once again, can the U.S. adapt to a new level of interpretation, especially when the realm of building safety comes into question?

4.2.10 Qualification

Beyond the idea of adaptation lies the barrier of under-qualification. Are the stakeholders that have been bred to deal with the aspects of the current U.S. code going to be able to handle adaptation necessities for movement into a performance system? This is a question that perhaps the motivators of the conversion may want to ask themselves. One must keep in mind the fact that with the presence of hesitation toward the performance conversion in the minds of even a small percentage of the building industry, friction toward change arises. Will this inhibition within the conversion allow stakeholders to be able to get a full grasp of the performance mindset, or will they struggle under the new set of conditions?

4.2.11 Legislature

Perhaps on the top of the building industry in the midst of this adaptation, legislative bodies may begin to battle issues they have never seen before (Sullivan, 2000). Already noted and at the top of the list of problems, liability and insurance are major themes of the governmental aspect of the conversion. Insurance companies and lawyers may begin to work themselves into the daily careers of most stakeholders during and after this transition. Will legislature begin to play more of a key role in the upkeep of the performance code? This questions ties directly in to the discussion of a national United States building code, especially a performance dominated one. As one interview subject pointed out, "…internationally, legislature has been a huge part of the conversion and the aftermath of the conversion through its rulings and ability to mold the industry" (Governmental (9), 2000).

4.2.12 Closure

Clearly shown, there are many uncertainties in the minds of the given set of present-day United States stakeholders. Presiding themes include education, time, and patience throughout the entire building industry, affecting potential clients and their respective businesses. In one way or another, these barriers will have to be dealt with before conversion to a performance-based system.

4.3.0 Solutions

The preceding section was a report on the problems arising within a hypothetical transition from a prescriptive-based building code to a performance system. The following section will highlight this project team's effort, in conjunction with the opinions of the interview group, to undo what these barriers have presented as problems.

4.3.1 Education

Under-education is the stem of all of the problems with the implementation of a performance-based building code. All areas of the construction community agree that this vast change will require continued education (Governmental (10), 2000). A majority of the stakeholders in the three groups have some previous knowledge of performance-based systems. The following chart shows the percentages of each *interviewed group* that had any kind of knowledge about performance-based building codes.

Stakeholders With Previous Awarness of Performance-Based Codes
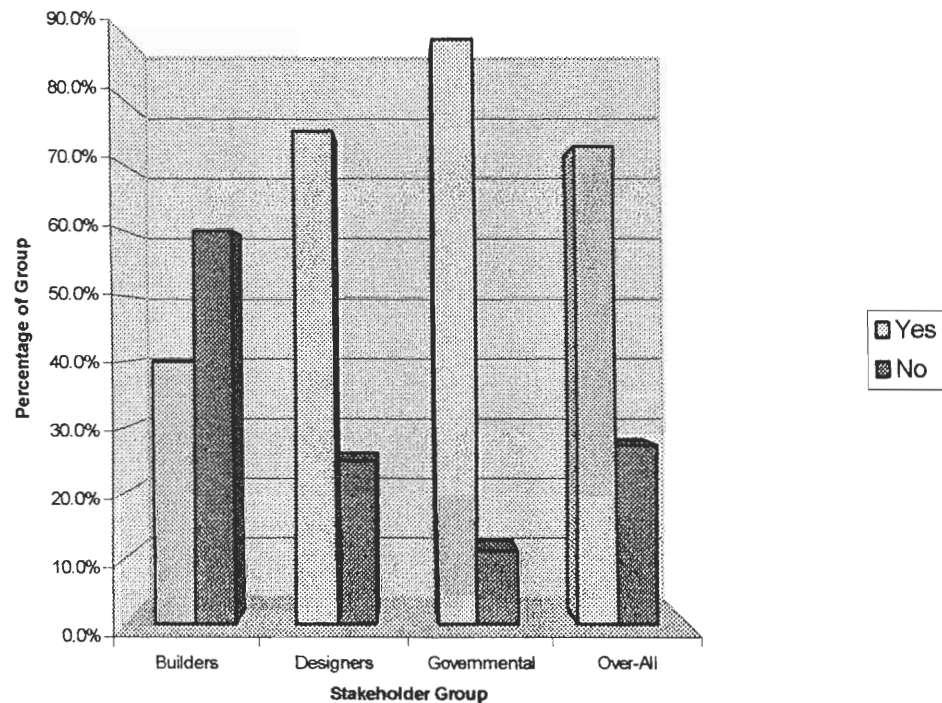
The building code officials will have to be more knowledgeable. They will have to determine if the performance requirements are met (Design (11), 2000). This increased need for knowledge will require the building code officials to be licensed engineers, or to become re-educated. The emphasis on the design teams will cause a more detailed peer review system, and all design teams must be educated in the correct way to go about this peer review system (Design (12), 2000). Education is the essential part in the implementation of a performance-based system.

In order for fire marshals, building code officials, and all other governmental parts of the construction world to accept a performance based building code, they must realize how they can benefit from the code. The governmental groups must see what the code has to offer and decide whether a change is necessary. A public campaign is necessary to show that the change of code

will benefit all Americans, and "removes them from behind the eight ball," with all other countries in the construction world (Governmental (11), 2001).

4.3.2 Time

It is obvious that the complete transition from a prescriptive to a performance-based building code will not happen overnight, like in other countries such as New Zealand (IQP, 1993). Because the United States government does not rule over the code used in each state, the federal government cannot demand the usage of any nationalized system. Each state, if not even at a smaller level, must choose to make the transition. The key to a smooth transition is time (Governmental (12), 2000). The following figure displays the time period that the *interviewed stakeholder groups* expect this transition to be possible.

Realistic Time Until Conversion
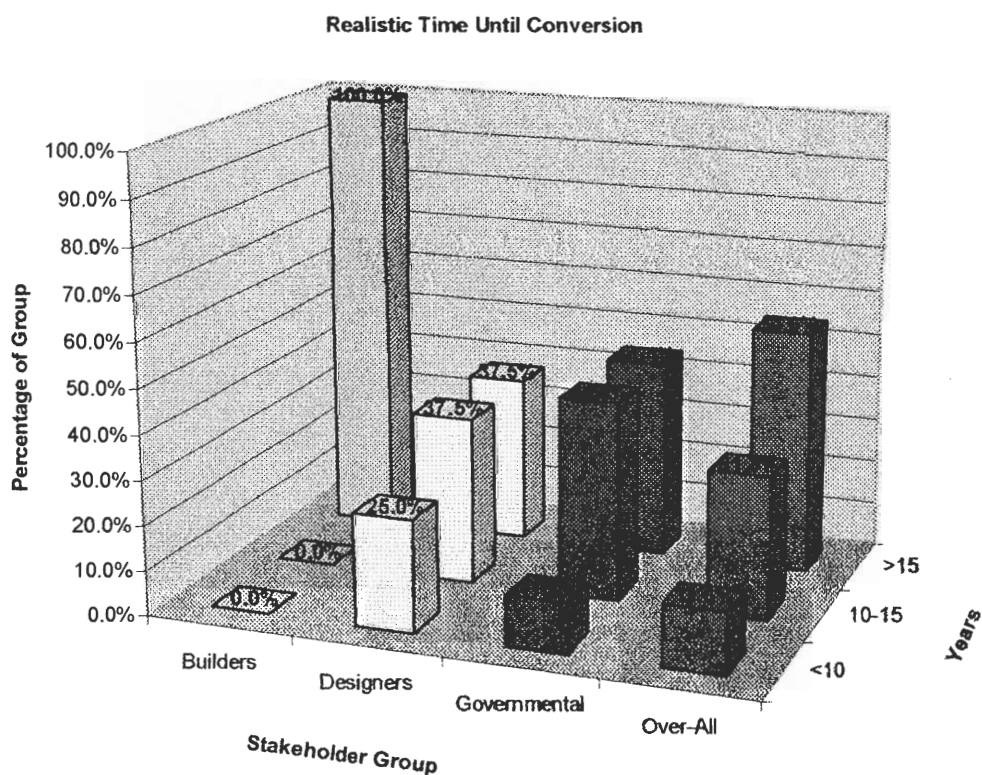
A performance-based building code will be extremely flexible and will evolve as the prescriptive codes did over time. Each state must accept the code, begin to implement the code, and use the code. As the code is used, problems will occur and the problem areas can be adjusted.

4.3.3 Acceptable Solutions

A performance-based building code gives goals that can be met using the knowledge of the designer. If these goals cannot be met using this method, each section of the performance-based building code will have an appendix. These appendices are a series of "acceptable solutions". These solutions may be the previous prescriptive-based building code, being referenced within the performance system where some sort of "benchmark" could be used. This has proven to be successful in the country of Japan (Meacham, 1996). "Acceptable solutions", as mentioned previously in this report, incorporate some prescriptive listings, or some other "benchmark", as a backup in case the designer has problems meeting the performance code.

4.3.4 Create Need For Change

The construction world has not yet accepted a full performance-based conversion because of a fear for change (Builder (3), 2000). The figure below shows that the *interviewed stakeholders* feel there is desire for change in the building world.

Need For Change In Building Code
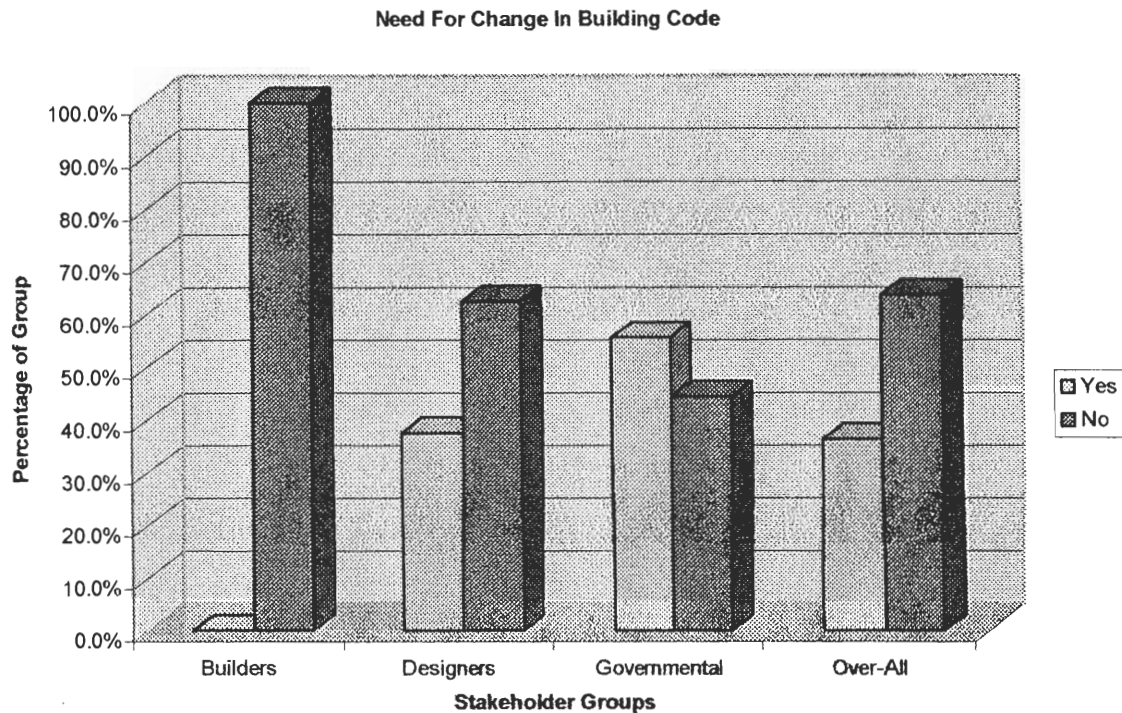
There must be a reason for the change, and this reason must be brought to the attention of all facets of the construction community. Safety problems have existed with variations of the prescriptive-based building code ever since it was established. It is unknown if the prescriptive code prescribes safety efficiently; safety is too much of an intangible topic. A performance-based building code lets the design engineer prescribe the safety of the building, and a series of peer reviews lets other stakeholders decide if the plan is satisfactory. This will save money and is intended to increase the level of safety in structures (Design (13), 2001).

4.3.5 Solutions For Grandfather Barrier

The implementation of a performance-based building code must occur over a number of years. Many buildings will be on the drawing board during the beginning steps of implementation, and older buildings that were built with the prescriptive codes must be inspected differently than newer buildings (Governmental (13), 2000). Dates must be set giving a

grandfather clause to which code must be met. Any buildings that are being constructed or are older and already built will be taken care of by legal means as to which code they must meet.

4.3.6 Fire Service Involvement

The implementation of performance-based building codes in New Zealand brought about a new freedom for the design engineers of the area. Although intended as a positive change within the building industry, New Zealand had a slow start with the transition to a performance system (MQP, 1993). Through their daily contributions to the previous building code system in New Zealand, the fire service of New Zealand became increasingly important to the adaptation of that entire country's building division to the new performance system (MQP, 1993). Perhaps this same trend could be taken into consideration here in the United States although fire departments in the U.S. provide mostly for orthodox needs of a fire service.

4.3.7 Peer Groups

In New Zealand, the implementation of performance-based building codes produced a series of checks and balances in the construction process. Each territory, which is similar to a county in the U.S., was assigned between three and five territorial assistants (TAs). These TAs are the equivalent to a building code official, except they are more educated and familiar with the code. The TAs have many interactive meetings with design teams to make the construction process easier

In this system, each building code official will need to become certified to understand and be able to interpret the performance-based building code (MQP, 1993). This certification

will help liability problems. The certification will be similar to the professional engineer's test, and will be required by all building code officials.

4.3.8 Closure

The change from a prescriptive-based building code to a performance-based building code in the United States is extremely fearful for many participants of the building community. The need for change is present in the fact that the United States is not up to date with other countries given a construction mindset. With a performance-based building code come options, freedom, and dollars saved. The fear of change by many of interviewees shows that the implementation may take time. To complement the previous statement, many of the interviewees realized also that a performance-based building code could indeed benefit them.

There are many ways to go about applying a smooth transition for the code that will be appealing to the building community. The most important step is education of the building stakeholders. In many cases, when an interviewee had no idea what a performance-based building code was, they were against it. When a small amount of background information was given to them, it began to grow on them. This small information given to the interviewee clearly showed that education is a must for people to accept any sort of performance-based system. If people do not know anything about a particular topic, they will not support it. With education and understanding of the possibilities of a performance system implemented here in the United States, people on all ends of the building empire will see the benefits that the code has to offer.

Chapter Five

Conclusions

A conversion to a performance-based system here in the United States is a tremendous undertaking. The change will affect the daily lives of every stakeholder, involved or not involved with the transition. These people play a large role in the initiation of change, the propagation of change, and in the upkeep of the duties necessary to embed the change into the fundamental processes of their everyday careers. The opinions of the stakeholders in the United States, although at a slightly personal level as opposed to an industry level, have been presented in this IQP.

As it has been stated, the daily duties of the stakeholders will be affected by the possible change to a performance-based system. Stakeholders will be called upon to do completely different jobs. The question lies in exactly where these changes will be. As this report is concluding, one can begin to visualize the problems with a drastic change to a performance-based code in the United States. Assuming that there will be an eventual move into the performance-based arena, the gradual implementation approach should work best. Once again, there is a question here also. How slow does this "slow leak" need to be?

There are two main themes that were presented in this project; *"What were the problems with the conversion to a performance-based system?"* and *"How can they be fixed?"* The intent of the project was to be able to present each interviewee with a hypothetical situation, which placed them in the time and place of the conversion from a prescriptive-based building code to a performance-based building code. The interview process then proceeded to query each interviewee and ascertain their opinions and reactions to this hypothetical transition. Many scenarios were presented to each interviewee so that they could get a maximized grasp on the subject matter. For example, in some cases, international performance-conversion action was discussed to provide a bit of contrast for a lesser knowledgeable interviewee. This interview

process allowed the project group to extract extremely valuable information from a homogeneous pool of data. With this data collection provided at the end of this project, an analysis was created and published.

Analysis of the interviews gave the project group the answers it set out to find. The majority of candidates interviewed had a good grasp of performance systems. Many of the interviewees talked a bit about performance-based systems and then found themselves slightly off track of this project's topic.

The next section for analysis in this project dealt with prescriptive-based building codes. Although the building industry is constantly changing and evolving through time, the data supplied in this project shows that the large majority of the stakeholders do not want a complete overhaul in the way they operate day to day; at least not in a way comparable to what has been happening internationally. The interviewees expressed a complete familiarity with their respective prescriptive-based building code as it stands in their states. When asked if they felt a need for change to a performance-based code in the United States, most weren't enthusiastic about it. One of the biggest arguments is whether or not there is any need for a change to a performance system. The responses of the interviewees show that providing the American public with substantiating reasons for this hypothetical conversion would help empower the idea of change.

As was touched on previously, the stakeholders are indeed comfortable with the building code as it stands currently. The stakeholders have grown acquainted with their current building code. When asked if they were comfortable with the current code operating as it does on a prescriptive-based level, the interview subjects almost unanimously agreed that indeed they were. This question was used as leverage to ask if the current code does its job well. Even

though most of the building industry has had interpretation problems with the prescriptive code, most had pro-prescriptive reactions. One major lesson that the project group learned as a result of this project is that codes currently in use are indeed left mostly up to interpretation. Any given stakeholder, whether or not they are in one of the three categories analyzed in this project, must be able to interpret the building code in the way it was meant to work. With that, this project group's opinion lies with the idea that no matter what kind of building code is in use, its user must learn through experience how to provide maximum safety for the people that are affected by the code.

One of the largest issues when dealing with building codes is the issue of safety. Safety is a very dynamic concept. As reflected throughout all of the interviews, very strongly, is that in the opinion of the interviewees, one cannot quantify safety. Safety is always a qualitative concept. A few interviewees mentioned the fact that one of the reasons why the code, as it currently stands, is so thick and over-constraining, is directly because of its safety-mindedness (Builder (4), 2000, Design (14), 2001). The current prescriptive-based building code may try to over-quantify safety. Keeping this in mind, when asked to compare safety defined through a prescriptive-based system versus safety defined under a performance-based system, many of the interviewees finally began to see how the industry could benefit from performance-based codes. Once again, the issue of safety is not by any means a simple one. As a plea for the U.S. prescriptive-based system, one may argue that because it has indeed evolved through decades, it is a safer system. But, on the other hand, as an argument for a new performance-based system, through the use of acceptable solutions and a sort of "prescriptive-based backbone" to quantify safety, performance-based codes may indeed have a place in the American building industry.

There is much discussion about the conversion to a performance-based system here in the United States. There are also many questions that need answers before even rudimentary steps can be taken toward this monolithic goal. The interview group was asked one final question before each interview was over. Each interviewee was asked to place the conversion to some sort of performance-based system in the U.S. in a time scale based on his or her current understanding of the issues involved. This question dumbfounded almost all of the interview participants

In conclusion, the idea of a performance-based system has definitely reached the minds of stakeholders in today's United States. Some initially think that a conversion is a great idea for the U.S. Others doubt the plausible use of a performance system from the start. Of the doubters, though, it seems that only a fraction of them completely shun performance-based codes. The remaining majority sees possibilities for performance-based design systems. Moving back to the implementation of a performance-based system in the United States with reference to when it will happen, the majority of the stakeholders interviewed answered with a time frame unconnected to the current one; within a time frame of perhaps 20 years from now. With this fact, taken along with all of the others extracted from the minds of today's building industry workers, performance-based codes have a definite future in the United States.

REFERENCES

1. Anchor, R. D., Malhotra, H. L., & Purkiss, J. A. (Eds.). (1986). Proceedings of the International Conference on Design of Structures Against Fire. Birmingham, UK: Aston University.

2. Anderson, Carl. Interview by Luke Connery. 14 February 2001.

3. Anderson, Mark. Interview by Jared Birmingham. 12 February 2001.
    Anderson, M. E., Cox, A., Irelan, P. & Woehnker, T. (1993). Intermediate Qualifying Project. The Societal Impact of the New Zealand Performance-Based Building Code. New Zealand. Advisor Prof. Jonathan Barnett. Worcester Polytechnic Institute.

4. Alarie, Ronald S. Interview by Jared Birmingham, Luke Connery, and Jason Kahan. 14 November 2000.

5. Bent, Erik. (ed.). (1989). International Conference on Fires in Buildings. Toronto, Canada: Park Plaza Hotel.

6. Berg, Bruce L. (1998). Qualitative Research Methods for Social Sciences. (3rd Ed.). Needham Heights, MA: Allyn & Bacon.

7. Buchanan, A.H. (1994). Fire Engineering Design Guide. University of Canterbury, Christchurch, New Zealand: Centre for Advanced Engineering.

8. Case Studies of the 3rd International Conference on Performance-Based Codes and Fire Safety Design Methods Vol. 1. (2000). Lund, Sweden: Lund University.

9. Case Studies of the 3rd International Conference on Performance-Based Codes and Fire Safety Design Methods Vol. 2. (2000). Lund, Sweden: Lund University.

10. Colangelo, Mathew. Interviewed Luke Connery and Jason Kahan. 29 November 2000.

11. Cox, Saara. Interview by Luke Connery. 12 February 2001.

12. Custer, Richard L. & Meacham, B. (1997). Introduction to Performance-Based Fire Safety. Boston, Ma: Society of Fire Protection Engineers.

13. Dipert, Richard. Interview by Jason Kahan. 20 February 2001.

14. Fitzgerald, Robert. Interview by Luke Connery and Jason Kahan. 20 September 2000.

15. Gordon, Raymond L. (1975). Interviewing: Strategy, Techniques and Tactics. Homewood, IL: The Dorsey Press.

16.   Harvey, Francis. Interview by Jason Kahan. 28 January 2001.

17.   Hoertdoerfer, Manfred. Interview by Luke Connery. 10 February 2001.

18.   Hubbard, D. Jr., Pastore, T. (1997). Interactive Qualifying Project., New Zealand Regulations, Five Years Later. New Zealand. Advisor Prof. Jonathan Barnett. Worcester Polytechnic Institute.

19.   ICBO Code Central. From October 2000 to February 2001. [Online]. http://www.icbo.org/.

20.   Interim Report of the ICC Performance Building Code Committee. (1999). New Orleans, Louisiana: Hyatt Regency New Orleans.

21.   Lautenberger,Christopher. Interview by Jared Birmingham. 25 March 2001.

22.   Lavik, John R. Interview by Jared Birmingham. 21 February 2001.

23.   Lucht, David A. (1991). Strategies for Shaping the Future, A Report on the Conference on Fire Safety Design in the 21st Century. Worcester, Ma: Worcester Polytechnic Institute.

24.   Lucht, David A. (1999). Proceedings of the 2nd Conference on Fire Safety Design in the 21st Century. Worcester, Ma: Worcester Polytechnic Institute.

25.   Malhotra, H. (1982). Design of Fire Resisting Structures. London, UK: Surrey University Press.

26.   Marrino, Angela. Interview by Jason Kahan. 9 February 2001.

27.   Meacham, Brian J. (1998). The Evolution of Performance-Based Codes and Fire Safety Design Methods. Bethesda, MD: Society of Fire Protection Engineers.

28.   Meacham, Brian J. (1998). Concepts of a Performance-Based Building Regulatory System for the United States. Bethesda, MD: Society of Fire Protection Engineers.

29.   Meacham, Brian J. (1998). Assessment of the Technological Requirements for the Realization of Performance-Based Fire Safety Design in the United States. Bethesda, MD: Society of Fire Protection Engineers.

30.   The National Committee on Structural Engineering. (1989). Fire Engineering for Building Structures and Safety. Australia: Institution of Engineers.

31. National Fire Protection Association. (2000). The SFPE Engineering Guide to Performance-Based Fire Protection Analysis and Design of Buildings. Quincy, MA: National Fire Protection Association.

32. National Fire Protection Association Online. From October to December 2000, [Online]. http://www.nfpa.org.

33. National Institution of Standards and Technology. From October to December 2000, [Online]. http://www.nist.com.

34. O'Sullivan, Daniel. Interview by Luke Connery and Jason Kahan. 14 December 2000.

35. Patterson, James. (1993). Simplified Design For Building Fire Safety. New York: John Wiley and Sons.

36. Pehrson, Richard. Interview by Jason Kahan. 13 February 2001.

37. Proceedings of the 3rd International Conference on Performance-Based Codes and Fire Safety Design Methods. (2000). Lund, Sweden: Lund University.

38. Prueher, Christopher. Interview by Jared Birmingham. 25 March 2001.

39. Purkiss, J.A. (1996). Fire Safety Engineering, Design of Structures. Oxford: Butterworth Heinemann.

40. Ransom, W. H. (1981). Building Failures. New York: E. & F. N. Spon

41. Senacel, William. Interview by Jared Birmingham, Luke Connery and Jason Kahan. 14 January 2001.

42. Smith, E. & Harmathy, T. (1979). Design of Buildings for Fire Safety. Philadelphia, PA: American Society For Testing and Materials Special Technical Publication.

43. Snell, Charles. Interview by Jared Birmingham, Luke Connery, and Jason Kahan. 30 November 2000.

44. Snell, Christopher. Interview by Jared Birmingham, Luke Connery, and Jason Kahan. 30 November 2000.

45. Society of Fire Protection Engineers. From October to December 2000, [Online]. http://www.sfpe.org.

47. Society of Fire Protection Engineers. Handbook, 18th edition.

46.   Stollard, P. & Johnston, L. (1994). Design Against Fire, An Introduction to Fire Safety Engineering Design. London, UK: Chapman and Hall.

47.   Sullivan, Paul. Interview by Jared Birmingham, Luke Connery, and Jason Kahan. 4 October 2000.

48.   Vanney, Robert F. Interview by Jared Birmingham. 21 February 2001.

49.   Wojcik, Michael. Interview by Luke Connery. 16 February 2001.

APPENDIX A: INTERVIEW FORMAT

Phase I

Preliminary information session. – *Inform/derive already known info of the interviewee.*

1. What is a performance-based building code in your opinion? – *To understand where our interviewee stands in the realm of performance-based knowledge.*

2. Prescriptive-based building code, is it sufficient for what it intends to do? – *Preliminary opinion of prescriptive-based codes. Will be used for leverage in later analysis.*

3. What problems do you have with the prescriptive-based building code? – *Opinion of prescriptive-based building code problems.*

4. Does the prescriptive-based building code prescribe the "safety" of a building sufficiently? – *Opinion on "safety" issues that seem to be an up-and-coming topic for our project.*

5. At this point, is there a need for change to a performance-based building code? – *Interviewee's opinion on "where we stand". It's a compare/contrast tool.*

6. Do you see any positives with a newly implemented performance-based code? – *Self-explaining.*

7. Do you see any negatives with a newly implemented performance-based code? – *Self-explaining*

Phase II

Assuming a performance-based code will be entirely implemented in the U.S. relatively soon (next 6 months). – *This reference is to give the interviewee a point of view as to from what time from he should be speaking out of. This is purely based on the fact that there, currently, is no "written-in-stone" date for the implementation of a performance-based code in the U.S.*

1. What barriers do you see stemming from the implementation of a performance-based code? – *Self-explaining*

2. Routes to overcome barriers. – *Self-explaining.*

3. Going back to Phase I, Question 4. Could a performance-based code clarify any of the "safety" issues not covered by the prescriptive-based code? – *Compare/contrast.*

4. "Safety" – "Performance v. Prescriptive" – *Opinion on "safety" minimum for each of the two codes.*

Phase III

General ranking questions – Please rate, -Not at all, -Partially, -Completely

– These two questions are merely to get the overall feeling of the interviewee.

1. Is there a need for change to a performance-based code in the U.S.?
2. Do you feel that the change from a prescriptive-based code to a performance-based code will happen within the next ten years?

APPENDIX B: LIST OF INTERVIEWEES
(listed in no particular order)

Builders:

1. Mathew Colangelo
   J. Colangelo and Sons.
   General Contractor
   West Boylston, Ma

2. Steven Gentillucci
   Project Manager/ Superintendent
   Consigli Construction
   Milford, Ma

3. Jeffery Martin
   Project Manager
   Consigli Construction
   Milford, Ma

4. Blair Tasker
   Kiewit Construction
   Project Manager/ Business administrator
   Omaha, Ne

5. Matthew Munzing
   Project Manager
   Shawmut Construction
   Everett, Ma

6. James Beach
   Project Manager/ Superintendent
   Kiewit Construction
   Omaha, Ne

Designers:

1. Saara Cox
   Architect
   Irwin Aregent Ass.
   Framingham, MA

2. Francis Harvey
   Architect
   Francis Harvey Ass.
   Worcester, MA

3. Manfred Hoertdoerfer
   Director of Engineering
   Goodman Engineering Co.
   Shrewsbury, MA

4. Christopher Lautenberger
   Fire Protection Engineer
   ARUP
   San Francisco, CA

5. John R. Lavik
   Architect
   Vanney Ass.
   Saint Paul, MN

6. Christopher Prueher
   Fire Protection Engineer
   Schirmer Engineering
   Los Angeles, CA

7. Paul Sullivan
   Engineering Consultant
   R.W. Sullivan, Inc.

8. Robert F. Vanney
   Architect
   Vanney Ass.
   Saint Paul, MN

9. Charles Snell
   Architect
   New England Design
   Worcester, MA

10. Christopher Snell
    Architect
    New England Design
    Worcester, MA

Governmental:

1. Ronald S. Alarie
   Building Inspector
   Department of Building Inspection
   Shrewsbury, MA

2. Mark Anderson
   Building Inspector
   Fire Department Inspectional Services
   Boston, MA

3. Carl Anderson
   Fire Protection Engineer
   Tacoma Fire Department
   Tacoma, WA

4. Richard Dipert
   Chief Fire Protection Engineer
   State Fire Marshall Office
   Raleigh, NC

5. Robert F. Fitzgerald
   Civil & Fire protection engineer
   Professor WPI
   Worcester, MA

6. Angela Marrino
   Senior Fire Protection Engineer
   State of Colorado
   Colorado Springs, CO

7. Daniel O'Sullivan
   Building Inspector
   City of Springfield
   Springfield, MA

8. Richard Pehrson
   Senior Fire Protection Engineer
   City of Saint Paul
   Saint Paul, MN

9. Michael Wojcick
   Building Plan Examiner
   Boston Fire Department
   Boston, MA

APPENDIX C: INTERVIEWEE TRANSCRIPTS

(In no particular order)

Phase I (Interviewee 1)

1. What is a performance-based building code in your opinion? *Has some prior knowledge.*

2. Prescriptive-based building code, is it sufficient for what it intends to do? *Yes, works fine*

3. What problems do you have with the prescriptive-based building code? *Restricts design of building.*

4. Does the prescriptive-based building code prescribe the "safety" of a building sufficiently? *Yes, provides the minimum amount of safety required for a building. That's what the code is intended to do.*

5. At this point, is there a need for change to a performance-based building code? *No, the current code is working fine.*

6. Do you see any positives with a newly implemented performance-based code? *Yes, may be able to provide new systems that are currently unable to be approved under the prescriptive code.*

7. Do you see any negatives with a newly implemented performance-based code? *Education of all it's constituents.*

Phase II

Assuming a performance-based code will be entirely implemented in the U.S. relatively soon (next 6 months).

1. What barriers do you see stemming from the implementation of a performance-based code? *People will not have the knowledge of the code completely figured out, it may cause delays in the building process.*

2. Routes to overcome barriers. *Education, money*

3. Going back to Phase I, Question 4. Could a performance-based code clarify any of the "safety" issues not covered by the prescriptive-based code? *No, prescriptive code has covered all aspects of safety.*

4. "Safety" – "Performance v. Prescriptive". Which code wins? *Prescriptive.*

Phase III

General ranking questions – Please rate, -Not at all, -Partially, -Completely

1. Is there a need for change to a performance-based code in the U.S.? *Not at all*

2. Do you feel that the change from a prescriptive-based code to a performance-based code will happen within the next ten years? *Not at all*

Phase I (Interviewee 2)

1. What is a performance-based building code in your opinion? *Performance based building code is a code that has no guidelines, but is universal.*

3. Prescriptive-based building code, is it sufficient for what it intends to do? *It does a good job. People have learned over the years of how to make the code work. Quality of the code comes with history.*

4. What problems do you have with the prescriptive-based building code? *Who defines the level of safety? Also the makers of the code are officials and not designers. They are pressured into making decisions by groups like unions and industries.*

5. Does the prescriptive-based building code prescribe the "safety" of a building sufficiently? *Yes, but who defines the level of safety.*

6. At this point, is there a need for change to a performance-based building code? *Not sure of what problems the code will solve. It would be good to have a universal code, and use better products in the building products if they are accepted by the code.*

7. Do you see any positives with a newly implemented performance-based code? *Will bring three different codes together and unite them.*

8. Do you see any negatives with a newly implemented performance-based code? *Practical enforcement. Who will enforce the code? Code officials? They will not be educated enough. Most code officials were either police officers or firemen who do not know anything about the design process.*

Phase II

Assuming a performance-based code will be entirely implemented in the U.S. relatively soon (next 6 months).

1. What barriers do you see stemming from the implementation of a performance-based code? *The public may be a factor in the implementation. They will not want to pay one cent more for a building or a house, and won't realize that money may be saved in the future. In the town of Marion, the public voted away the town code that they followed. The public has a lot of power.*

2. Routes to overcome barriers. *No way to overcome these problems. Has worked with codes for over 60 years and doesn't see anything changing. Large amounts of money and time need to be spent.*

3. Going back to Phase I, Question 4. Could a performance-based code clarify any of the "safety" issues not covered by the prescriptive-based code? *No*

4. "Safety" – "Performance v. Prescriptive". Which code wins? *Prescriptive has been around for years and is doing the job.*

Phase III

General ranking questions – Please rate, -Not at all, -Partially, -Completely

1. Is there a need for change to a performance-based code in the U.S.? *Partially*

2. Do you feel that the change from a prescriptive-based code to a performance-based code will happen within the next ten years? Not at all

Phase I (Interviewee 3)

1. What is a performance-based building code in your opinion? *Has somewhat of knowledge of what the performance-based code is supposed to be. Has heard about it overseas.*

2. Prescriptive-based building code, is it sufficient for what it intends to do? *Yes, the national prescriptive-based code has been modified nicely for MA.*

3. What problems do you have with the prescriptive-based building code? *Really has no problem with it. Has used it, is used to it.*

4. Does the prescriptive-based building code prescribe the "safety" of a building sufficiently? *Yes, absolutely.*

5. At this point, is there a need for change to a performance-based building code? *Always a need for change. Made special interest in a unified code throughout the U.S.*

6. Do you see any positives with a newly implemented performance-based code? *Infinite positives... especially with unification.*

7. Do you see any negatives with a newly implemented performance-based code? *There would probably be negatives initially. It would take time to iron out the flaws.*

Phase II

Assuming a performance-based code will be entirely implemented in the U.S. relatively soon (next 6 months).

1. What barriers do you see stemming from the implementation of a performance-based code? *Design process of a building that was currently under construction (grandfather clause?).*

2. Routes to overcome barriers. *Time, education, flexibility.*

3. Going back to Phase I, Question 4. Could a performance-based code clarify any of the "safety" issues not covered by the prescriptive-based code? *Couldn't tell us, doesn't know how the performance-based would stand in the U.S.*

4. "Safety" – "Performance v. Prescriptive". Which code wins? *Once again, no basis for comparison. He is happy with the prescriptive.*

Phase III

General ranking questions – Please rate, -Not at all, -Partially, -Completely

1. Is there a need for change to a performance-based code in the U.S.? *Partially.*

2. Do you feel that the change from a prescriptive-based code to a performance-based code will happen within the next ten years? *Not at all*

Phase I (Interviewee 4)

1. What is a performance-based building code in your opinion? *Little prior knowledge of performance based code.*

2. Prescriptive-based building code, is it sufficient for what it intends to do? *They are overly sufficient. They overly categorize every aspect of building. Sometimes to constraining.*

3. What problems do you have with the prescriptive-based building code? *Too constraining at some points of the code.*

4. Does the prescriptive-based building code prescribe the "safety" of a building sufficiently? *The codes have evolved over the years and have proven their safety level.*

5. At this point, is there a need for change to a performance-based building code? *No, the current codes work well. They could evolve more and maybe become a bit less strict, but stay prescriptive.*

6. Do you see any positives with a newly implemented performance-based code? *No, we can't tell…just asking for more problems.*

7. Do you see any negatives with a newly implemented performance-based code? *Need education. A new BOCA code was implemented in '97 and in took over 2 years for people to even become aware of it. There will be a change in the face of the code business and the key players as they stand now will not want the change and currently, these people have the power. Fire marshals won't allow it due to new issues in safety.*

Phase II

Assuming a performance-based code will be entirely implemented in the U.S. relatively soon (next 6 months).

1. What barriers do you see stemming from the implementation of a performance-based code? *See question 7.*

2. Routes to overcome barriers. *If there had to be routes to overcome these barriers, education and time would be the only things you could do.*

3. Going back to Phase I, Question 4. Could a performance-based code clarify any of the "safety" issues not covered by the prescriptive-based code? *The only thing a performance-based code would do is cloud up the issues that already exist.*

4. "Safety" – "Performance v. Prescriptive" *Prescriptive.*

Phase III

General ranking questions – Please rate, -Not at all, -Partially, -Completely

1. Is there a need for change to a performance-based code in the U.S.? – *Not at all*

2. Do you feel that the change from a prescriptive-based code to a performance-based code will happen within the next ten years? *No at all.*

Phase I (Interviewee 5)

1. What is a performance-based building code in your opinion? *A PB building code is one in which compliance is achieved by using calculation procedures to show that the candidate designs meet previously established performance criteria when unwanted fire, quantified through a design fire curve, occurs in the space.*

2. Prescriptive-based building code, is it sufficient for what it intends to do? *Yes and no. PB codes are adequate for most of buildings being designed today. There is no reason to use PB design for an everyday office building. Generally, prescriptive codes are inadequate only for unique buildings. An example is that under BOCA96 (on which the Massachusetts State Building Code is based), the Patriots' new stadium under construction in Foxboro would be considered a high rise and must meet all the requirements of high rise buildings. However, it is obviously is not the intent of BOCA for a stadium to meet all the high rise requirements.*

3. What problems do you have with the prescriptive-based building code? *Answer to the first part is at: http://www.wpi.edu/~clauten/fp570/termpaper/termpaper.html. Answer to the second part is no, under prescriptive codes the safety factor is not explicitly known. However, under PB codes, a safety factor must be explicitly included which brings up another issue—what is an appropriate safety factor?*

4. Does the prescriptive-based building code prescribe the "safety" of a building sufficiently? *At this time it does.*

5. At this point, is there a need for change to a performance-based building code? *Doesn't see any reason to go to PB codes at this point in time. If an owner really wants a PB design to be done, he can talk to the AHJ and they will most likely allow a PB design to be done in lieu of a prescriptive design. That's how Arup currently does PB design. Of course there are positives associated with PB codes, primarily that savings can be realized due to more efficient designs that wouldn't be allowed under the current codes without going through the equivalencies.*

6. Do you see any positives with a newly implemented performance-based code? *See question 2.*

.

7. Do you see any negatives with a newly implemented performance-based code? *In addition to what's already cited in the term paper cited above, there are many other problems with PB codes. Design fire selection is a huge problem, in fact it is one of the focuses of the ICEFPD conference June 11-15 in San Francisco this year.*

Phase II

Assuming a performance-based code will be entirely implemented in the U.S. relatively soon (next 6 months).

1. What barriers do you see stemming from the implementation of a performance-based code? *Lack of validated design tools, lack of competent users of design tools, problems with design fire selection, inability to predict occupant behavior.*

2. Routes to overcome barriers. R*equire a certification program for users of design tools, development of guidelines for which tools can be used under. Provide more funding from government/industry/academia to support development of modern predictive tools (both "fire" and occupant movement).*

3. Going back to Phase I, Question 4. Could a performance-based code clarify any of the "safety" issues not covered by the prescriptive-based code? N*ot particularly bothered by the fact that the safety factor in prescriptive codes isn't explicitly known. Insurance companies will much rather insure a building that meets a prescriptive building code where the safety factor is unknown rather than one that was justified using zone fire models and a low safety factor.*

4. "Safety" – "Performance v. Prescriptive. Which code wins? *It's "apples and oranges"... You can design a building with PB techniques and a high safety factor that is "less safe" than one that "barely" meets the prescriptive code.*

Phase III

General ranking questions – Please rate, -Not at all, -Partially, -Completely

2. Is there a need for change to a performance-based code in the U.S.? *No*

3. Do you feel that the change from a prescriptive-based code to a performance-based code will happen within the next ten years? *Yes*

Phase I (Interviewee 6)

1. What is a performance-based building code in your opinion? *Little knowledge on performance based code.*

2. Prescriptive-based building code, is it sufficient for what it intends to do? *Yes, not much experience, but she has been learning how to "make it work" since she's started to become an architect.*

3. What problems do you have with the prescriptive-based building code? *There are always problems with printed material such as a code, maybe too restrictive.*

4. Does the prescriptive-based building code prescribe the "safety" of a building sufficiently? *Yes, people aren't necessarily dying because of the code… this is a good sign.*

5. At this point, is there a need for change to a performance-based building code? *No, why change something that you can learn to work with.*

6. Do you see any positives with a newly implemented performance-based code? *More flexibility*

7. Do you see any negatives with a newly implemented performance-based code? *Too lenient.*

Phase II

Assuming a performance-based code will be entirely implemented in the U.S. relatively soon (next 6 months).

1. What barriers do you see stemming from the implementation of a performance-based code? *The grandfather problem.*

2. Routes to overcome barriers. *Set dates, legally take care of the over lappings.*

3. Going back to Phase I, Question 4. Could a performance-based code clarify any of the "safety" issues not covered by the prescriptive-based code? *It will always be the same. Safety is always an important issue and will be task #1 for the performance based as well as it is with the prescriptive.*

4. "Safety" – "Performance v. Prescriptive. Which code wins? *Tie*

Phase III

General ranking questions – Please rate, -Not at all, -Partially, -Completely

5. Is there a need for change to a performance-based code in the U.S.? *Partially*

6. Do you feel that the change from a prescriptive-based code to a performance-based code will happen within the next ten years? *Partially*

Phase I (Interviewee 7)

1. What is a performance-based building code in your opinion? *A performance-based code to be one in which the end result is specified, but the means to achieve that goal are not 'prescribed'.*

2. Prescriptive-based building code, is it sufficient for what it intends to do? *The real advantage of a prescriptive code is in administration. It is relatively easy for the parties concerned (building inspectors, architects, contractors and owners) to know what needs to be done to create a safe building, and evaluate whether it has, indeed, been accomplished.*

3. What problems do you have with the prescriptive-based building code? Does the prescriptive-based building code prescribe the "safety" of a building sufficiently? *Prescriptive building codes occasionally creates unnecessary burdens on architects and owners while not always eliminating all safety hazards. In some cases, prescriptive codes may stifle creativity by requiring one solution to a safety problem where some alternative solutions could produce equal or superior safety and perhaps greater aesthetic quality.*

4. At this point, is there a need for change to a performance-based building code? . *There is no great need to change to performance-based codes. It would be nice if there was some mechanism available for a performance-based alternative to prescriptive requirements.*

5. Do you see any positives with a newly implemented performance-based code? *Flexibility in design.*

6. Do you see any negatives with a newly implemented performance-based code? *Enforcement.*

Phase II

Assuming a performance-based code will be entirely implemented in the U.S. relatively soon (next 6 months)

1. What barriers do you see stemming from the implementation of a performance-based code? *Enforcement of performance-based codes is the real challenge. It is, by its very nature, much more difficult (and probably much more expensive) to evaluate whether a safety goal has been met.*

2. Routes to overcome barriers? *The design professionals may be the key to implementing performancebased codes. They are already responsible for building life-safety. Training professionals better in life/safety and then making them more responsible for actual safety rather than just "meeting the letter of the code" could overcome this barrier.*

3. Going back to Phase I, Question 4. Could a performance-based code clarify any of the "safety" issues not covered by the prescriptive-based code? *It would be difficult to write a performance-based code to cover safety issues better than prescriptive codes.*

4. "Safety" – "Performance v. Prescriptive" Which code wins? S*afety would probably be equivalent either way.*

Phase III

General ranking questions – Please rate, -Not at all, -Partially, -Completely

1. Is there a need for change to a performance-based code in the U.S.? *Not at all*

2. Do you feel that the change from a prescriptive-based code to a performance-based code will happen within the next ten years? *Not at all*

Phase I (Interviewee 8)

1. What is a performance-based building code in your opinion? *A way to design a building where objectives are set and goals are to be met. These goals can be met using alternative methods.*

2. Prescriptive-based building code, is it sufficient for what it intends to do? *The ICC 2000 Performance based building code manual is not complete. It has alternative methods, these methods are the prescriptive code. The prescriptive code sets societies goals for safety for every facet of a building. It does a good job but is "down and dirty."*

3. What problems do you have with the prescriptive-based building code? *Undetermined level of safety. If the code is followed, the code tends to work. Some cases of the code tend to be excessive and useless. Intent of provision.*

4. Does the prescriptive-based building code prescribe the "safety" of a building sufficiently? *If followed and maintained it does a good job. It does a good job preventing massive tragedies in large building or industries, but does not do a good job on family residences.*

5. At this point, is there a need for change to a performance-based building code? *No, no need for a change, but a need for an option and alternative method. The code has no framework in design.*

6. Do you see any positives with a newly implemented performance-based code? *Yes, gives structure to the entire building process. The designers and engineers make allowable strength and safety decisions instead of people that are not involved in design. Gives framework.*

7. Do you see any negatives with a newly implemented performance-based code? *Most designer's, engineer's, and code officials think that they are ready for the change, but in reality they are not educated enough and are not ready. They overestimate their abilities.*

Phase II

Assuming a performance-based code will be entirely implemented in the U.S. relatively soon (next 6 months).

1. What barriers do you see stemming from the implementation of a performance-based code? *Not possible in the U.S. Each state determines the code that they want to use, so the government does not have the power to force any state to abide by any code.*

2. Routes to overcome barriers. *Change in code enforcement.*

3. Going back to Phase I, Question 4. Could a performance-based code clarify any of the "safety" issues not covered by the prescriptive-based code? *Yes it could, it will state it's intention and it must be met.*

4. "Safety" – "Performance v. Prescriptive". Which code wins? *Prescriptive, has done the job for years.*

Phase III

General ranking questions – Please rate, -Not at all, -Partially, -Completely

1. Is there a need for change to a performance-based code in the U.S.? *Partially.*

2. Do you feel that the change from a prescriptive-based code to a performance-based code will happen within the next ten years? *Not at all*

Phase I (Interviewee 9)

1. What is a performance-based building code in your opinion? *Codes that look at standards and goals and look for alternate methods for completion including design methods, materials, and all other components of the building process.*

2. Prescriptive-based building code, is it sufficient for what it intends to do? *Yes, The code does what it intends to do, keep people safe at a minimum standard.*

3. What problems do you have with the prescriptive-based building code? *The code is sometimes too restrictive, or non applicable. In her job, they are faced with the problem of communities being constructed and designed to be similar to country "old time," neighborhoods. The city of Colorado Springs is looking for neighborhoods that are close to the town center. This design calls for very narrow streets making it hard for fire truck access. This problem is causing the new structures to have more sprinklers and more easily obtained egress. The prescriptive code cannot handle this problem.*

4. Does the prescriptive-based building code prescribe the "safety" of a building sufficiently? *Yes, it does a good job with the cookbook it prescribes for building that are applicable.*

5. At this point, is there a need for change to a performance-based building code? *Yes, definitely. Colorado Springs as shown above is trying to revamp, and put life into the neighborhoods, and are building lofts that are very close to each other and very close to the road. These lofts call for many performance based goals that need to be met. She has been told to incorporate performance based codes by January 2002, to solve the problem.*

6. Do you see any positives with a newly implemented performance-based code? *More flexibility in design and many cost benefits potentially in the future. Money should be saved in alternate methods instead of following the prescriptive code that calls for materials and systems that are not applicable and necessary.*

7. Do you see any negatives with a newly implemented performance-based code? *Resources, manpower in her workplace, time and education. Designers, builders, and everyone else will fear change and not support the code. Who will be liable for the increased emphasis in design. More involved meetings with code officials and designers.*

Phase II

Assuming a performance-based code will be entirely implemented in the U.S. relatively soon (next 6 months).

1. What barriers do you see stemming from the implementation of a performance-based code? *Resistance to change and a comfort factor that has been built over the years by the prescriptive code. Also training and education.*

2. Routes to overcome barriers. *Education, training.*

3. Going back to Phase I, Question 4. Could a performance-based code clarify any of the "safety" issues not covered by the prescriptive-based code? *Yes, individual plus specific cases that cannot be solved by the prescriptive code.*

4. "Safety" – "Performance v. Prescriptive". Which code wins? *Prescriptive, past events. Safety through experience. Performance makes guesses and assumptions, who is to determine whether these guesses and assumptions are correct?*

Phase III

General ranking questions – Please rate, -Not at all, -Partially, -Completely

1. Is there a need for change to a performance-based code in the U.S.? *Partially.*

2. Do you feel that the change from a prescriptive-based code to a performance-based code will happen within the next ten years? *Partially*

Phase I (Interviewee 10)

1. What is a performance-based building code in your opinion? *Grasps the general concepts, doesn't consider it a heavy contender for implementation.*

2. Prescriptive-based building code, is it sufficient for what it intends to do? *Yes, but much is based on interpretation and if the interpreter understands the code well, then there are good decisions made, if the opposite is true, then maybe there are more mistakes.*

3. What problems do you have with the prescriptive-based building code? *Prescriptive-based doesn't give leeway for common sense changes that sometimes need to be made.*

4. Does the prescriptive-based building code prescribe the "safety" of a building sufficiently? *Safety is fine through prescriptive-based as long as there is a competent team effort*

5. At this point, is there a need for change to a performance-based building code? *Change is not needed. Currently, he receives from his designers, a grocery list of everything he needs to use for each project.*

6. Do you see any positives/negatives with a newly implemented performance-based code? *With performance-based, more emphasis is placed on the engineers and the architects. This leads to the contractors needing to know as much about the codes as the engineers and the architects do. Once again, there may be a problem through perception of the performance-based code.*

Phase II

Assuming a performance-based code will be entirely implemented in the U.S. relatively soon (next 6 months).

1. What barriers do you see stemming from the implementation of a performance-based code? *Building officials and crew need to way up to speed. Most building officials are ex-electricians, etc. Not in a position to pick up enough of this new knowledge. You need to get everyone a copy of the new code. What about projects that may overlap into the transition period, are they "grand fathered" to keep prescriptive or not?*

2. Routes to overcome barriers. *Transition could be overcome, time and money. Back up the performance with some prescriptive.*

3. Going back to Phase I, Question 4. Could a performance-based code clarify any of the "safety" issues not covered by the prescriptive-based code? *No differential... both will deal the same.*

4. "Safety" – "Performance v. Prescriptive". Which code wins? *Probably prescriptive.*

Phase III

General ranking questions – Please rate, -Not at all, -Partially, -Completely

1. Is there a need for change to a performance-based code in the U.S.? *Partially*

2. Do you feel that the change from a prescriptive-based code to a performance-based code will happen within the next ten years? *Not at all*

Phase I (Interviewee 11)

1. What is a performance-based building code in your opinion? *Not exactly sure.*

2. Prescriptive-based building code, is it sufficient for what it intends to do? *Yes, sometimes prescribes unnecessary safety features.*

3. What problems do you have with the prescriptive-based building code? *May add additional costs due to unneeded specifications.*

4. Does the prescriptive-based building code prescribe the "safety" of a building sufficiently? *Yes, sometimes over prescribes the safety.*

5. At this point, is there a need for change to a performance-based building code? *No, prescriptive code has been affective for over a century.*

6. Do you see any positives with a newly implemented performance-based code? *Yes, but it may cause more negatives than positives.*

7. Do you see any negatives with a newly implemented performance-based code? *Lack of knowledge in field will lead to several problems with building process. Time, Money, Materials.*

Phase II

Assuming a performance-based code will be entirely implemented in the U.S. relatively soon (next 6 months).

1. What barriers do you see stemming from the implementation of a performance-based code? *The code officials will not be able to deal with the magnitude of the change. See question 7*

2. Routes to overcome barriers. *Education, appeals to construction industry.*

3. Going back to Phase I, Question 4. Could a performance-based code clarify any of the "safety" issues not covered by the prescriptive-based code? *Yes, on the Charles River Crossing, the piles that were driven for the deep earth foundation were not in any code. They were specially designed for safety reasons.*

4. "Safety" – "Performance v. Prescriptive". Which code wins? *Prescriptive, currently does it's job, in the future performance may be better for the expanding industry.*

Phase III

General ranking questions – Please rate, -Not at all, -Partially, -Completely

1. Is there a need for change to a performance-based code in the U.S.? *Not at all*

2. Do you feel that the change from a prescriptive-based code to a performance-based code will happen within the next ten years? *Not at all*

Phase I (Interviewee 12)

1. What is a performance-based building code in your opinion? *Basically gives a goal for a structure in which building structure and fire code follow. Life safety issues do not follow a cookbook (BOCA, ICC, NFPA5000), but meet a goal.*

2. Prescriptive-based building code, is it sufficient for what it intends to do? *Yes, the prescriptive codes are only known for their failures, not successes. Most failures in the prescriptive code, (life losses) are attributed to egress problems where the system was not maintained. Buildings that follow the prescriptive codes are not responsible for massive deaths, they do their job.*

3. What problems do you have with the prescriptive-based building code? *Codes are based on a burn and learn philosophy and have been this way for the past 150 years. Fires like the "Chicago Fire," opened eyes and people realized that something was wrong with the code. Problems are only discovered when tragedies occur.*

4. Does the prescriptive-based building code prescribe the "safety" of a building sufficiently? *The prescriptive does a great job in the prevention of large conflagrations, but lacks sufficient coverage in areas like kinder dry forest fires and house to house fires. Overall does a good job.*

5. At this point, is there a need for change to a performance-based building code? *No, no need for a change. Prescriptive code is doing the job that is supposed to. The performance code is only useful for about 2 percent of building constructed. Why have a drastic change is only 2 percent of buildings will use the code. Also the performance based building codes are offered as an alternative to the prescriptive codes in many areas.*

6. Do you see any positives with a newly implemented performance-based code? *Very useful for out wire buildings with unique features. Buildings can benefit from intense designs.*

7. Do you see any negatives with a newly implemented performance-based code? *Many problems with the "stakeholders" conforming to the new codes. Education is a problem. Not enough Fire protection Engineer's in the government positions, because they do not get paid well. Fire officials with no technical background cannot review plans.*

Phase II

Assuming a performance-based code will be entirely implemented in the U.S. relatively soon (next 6 months).

1. What barriers do you see stemming from the implementation of a performance-based code? *Not enough FPE's and "stakeholders" will not conform.*

2. Routes to overcome barriers. Education, more federal funding.

3. Going back to Phase I, Question 4. Could a performance-based code clarify any of the "safety" issues not covered by the prescriptive-based code? *No, the prescriptive code only fails when the system is not maintained. The intent of prescriptive codes are quantified better. Who is to say if a performance design is safe?*

4. "Safety" – "Performance v. Prescriptive". Which code wins? *Prescriptive.*

Phase III

General ranking questions – Please rate, -Not at all, -Partially, -Completely

1. Is there a need for change to a performance-based code in the U.S.? *Not at all.*

2. Do you feel that the change from a prescriptive-based code to a performance-based code will happen within the next ten years? *Not at all.*

Phase I (Interviewee 13)

1. What is a performance-based building code in your opinion? *Has a vast and deep understanding of how a performance-based code should be run and how they are run internationally. -> Definitely does NOT require a briefing of performance-based.*

2. Prescriptive-based building code, is it sufficient for what it intends to do? *Over the grand scale of how building codes have been used in the U.S., they work very well. The question you have to ask yourself revolves around the fact that nothing you implement can be perfect; for example, people are always going to die as a direct result of the code interpretation. It's merely a matter of reducing these numbers through consistency and code enforcement. One can never tell the variables involved in the life of a code-defined structure.*

3. What problems do you have with the prescriptive-based building code? *Sometimes the code can't cover all areas of a project. How do you know what the requirements need to be for a specific building? How long will it take for the fire dept. to get there? There are many examples of independence in structures that merely can't be defined by a "cookbook" code.*

4. Does the prescriptive-based building code prescribe the "safety" of a building sufficiently? *Is the speed limit safe? Safety is not measurable. One can only use good judgment in determining the safety of a building.*

5. At this point, is there a need for change to a performance-based building code? *Performance-based is money and competition driven… maybe there is a need for change for the money aspect of the ordeal. His opinion is that the U.S. is just watching everyone else in the world and see how they handle the conversion and living under the performance-based code. Will it work? Competency? Capability?*

6. Do you see any positives with a newly implemented performance-based code? *If implemented properly, the performance-based building code allows for much new flexibility. It also fixes the problems that structures cross on the independent level.*

7. Do you see any negatives with a newly implemented performance-based code? *Money during the conversion. Will the stakeholders be able to handle the conversion and implementation from a competency perspective? There, instantly, becomes a huge capability for a huge margin of error on the part of the stakeholders.*

Phase II

Assuming a performance-based code will be entirely implemented in the U.S. relatively soon (next 6 months).

1. What barriers do you see stemming from the implementation of a performance-based code? *Fitting the performance-based code into a legislative body. This code brings with it many new issues that have never been seen in the U.S. building industry. Who's going to be for the performance-based? Who's going to be pitted against it?*

2. Routes to overcome barriers. *As a precedent, the fire service has been the collaborative effort that has been able to educate most of the stakeholders in this conversion. Perhaps they will be critical when it comes to the conversion.*

3. Going back to Phase I, Question 4. Could a performance-based code clarify any of the "safety" issues not covered by the prescriptive-based code? *Things will remain the same based on the discussion on safety in the earlier question.*

4. "Safety" – "Performance v. Prescriptive". Which code wins? *Neutral*

Phase III

General ranking questions – Please rate, -Not at all, -Partially, -Completely

1. Is there a need for change to a performance-based code in the U.S.? Partial

2. Do you feel that the change from a prescriptive-based code to a performance-based code will happen within the next ten years? *Completely.*

Phase I (Interviewee 14)

1. What is a performance-based building code in your opinion? *Has much knowledge of the performance-based concept. Deals with prescriptive codes day in and day out... and has also worked with a performance-based design.*

2. Prescriptive-based building code, is it sufficient for what it intends to do? *Yes, completely. The code is an evolutionary article as it stands now. It changes with the needs of the people of the time. He has no problems with it.*

3. What problems do you have with the prescriptive-based building code? *None. See above.*

4. Does the prescriptive-based building code prescribe the "safety" of a building sufficiently? *Falling back on the evolutionary aspect of the prescriptive, safety is high priority over time. The safety aspect of the prescriptive-based building code evolves over time also reflecting only the best facets of safety design.*

5. At this point, is there a need for change to a performance-based building code? *No. there is to much new work that comes with a conversion to performance-based.*

6. Do you see any positives with a newly implemented performance-based code? *Flexibility, money saving capabilities.*

7. Do you see any negatives with a newly implemented performance-based code? *Poor education. Poor qualification of designers, architects, and engineers.*

Phase II

Assuming a performance-based code will be entirely implemented in the U.S. relatively soon (next 6 months).

1. What barriers do you see stemming from the implementation of a performance-based code? *No real barriers, his job becomes much easier. This is with the mindset of today's stakeholder positions; not really reflecting any new responsibility of any stakeholder positions... especially his. Once again, the ability of engineers and architects to take on new levels of liability may be a problem.*

2. Routes to overcome barriers. *Time... education.*

3. Going back to Phase I, Question 4. Could a performance-based code clarify any of the "safety" issues not covered by the prescriptive-based code? *See next question.*

4. "Safety" – "Performance v. Prescriptive". Which code wins? *Safety is covered through the evolutionary aspect of codes, whether they be prescriptive or performance...a poor safety level will never be tolerated in the U.S. So, in this sense, the two codes should be able to cover the safety issues of building relatively similarly.*

Phase III

General ranking questions – Please rate, -Not at all, -Partially, -Completely

1. Is there a need for change to a performance-based code in the U.S.? *Partially*

2. Do you feel that the change from a prescriptive-based code to a performance-based code will happen within the next ten years? *Not at all*

Phase I (Interviewee 15)

1. What is a performance-based building code in your opinion? *Had a very good understanding of performance goals, and is up to date partial use of them in the US today.*

2. Prescriptive-based building code, is it sufficient for what it intends to do? *Yes, they provide a good regulation for building.*

3. What problems do you have with the prescriptive-based building code? *He's encountered problems with large structures such as arenas and stadiums. Also it is a very slow process getting new technology certified into the prescriptive codes.*

4. Does the prescriptive-based building code prescribe the "safety" of a building sufficiently? *The codes are safe and have evolved over to provide that safety, but it is uncertain of the exact safety level that they provide. (lack safety goals).*

5. At this point, is there a need for change to a performance-based building code? *He feels its time we step up to keep up with the rest of the world.*

6. Do you see any positives with a newly implemented performance-based code? *Sees many positives with a newly implemented performance based code, most exclusively dealing with structures that can't be built under current codes.*

7. Do you see any negatives with a newly implemented performance-based code? *Sees problems with code enforcement for the new codes.*

Phase II

Assuming a performance-based code will be entirely implemented in the U.S. relatively soon (next 6 months).

1. What barriers do you see stemming from the implementation of a performance-based code? *Major barriers include the acceptance of the codes, and the training of designers and engineers. He feels that the partial use of performance based codes without proper education and understanding of them, could lead to a major problem when full implementation is in question.*

3. Routes to overcome barriers. *Education and training are biggest issues. NFPA has releases a "Design Guide" for Performance based codes and is in the process of starting 2 week seminars for designers.*

4. Going back to Phase I, Question 4. Could a performance-based code clarify any of the "safety" issues not covered by the prescriptive-based code? *They could definitely clarify safety issues better, due to set performance goals for safety that must be met. (problem may arise when setting these safety goals)*

5. "Safety" – "Performance v. Prescriptive". Which code wins? *Performance codes are better equipped to deal with safety issues because they are building specific, where as prescriptive codes are safer for some buildings than others.*

Phase III

General ranking questions – Please rate, -Not at all, -Partially, -Completely

1. Is there a need for change to a performance-based code in the U.S.? *Partially*

2. Do you feel that the change from a prescriptive-based code to a performance-based code will happen within the next ten years? *Partially*

Phase I (Interviewee 16)

1. What is a performance-based building code in your opinion? *Heard of the code, but does not exactly know what it is about.*

2. Prescriptive-based building code, is it sufficient for what it intends to do? *Yes, gives clear concise plans that are easy to follow, step by step.*

3. What problems do you have with the prescriptive-based building code? *From experiences, no problems exist.*

4. Does the prescriptive-based building code prescribe the "safety" of a building sufficiently? *Yes, even sometimes over prescribes the safety.*

5. At this point, is there a need for change to a performance-based building code? *No, the prescriptive code has worked fine for years.*

6. Do you see any positives with a newly implemented performance-based code? *No, no need to change what works.*

7. Do you see any negatives with a newly implemented performance-based code? *May cause a lot of confusion due to lack of knowledge throughout the entire construction process.*

Phase II

Assuming a performance-based code will be entirely implemented in the U.S. relatively soon (next 6 months).

1. What barriers do you see stemming from the implementation of a performance-based code? *Design teams will take longer to get their job done, project managers will not be able to bid jobs due to different scheduling tasks.*

2. Routes to overcome barriers. *Education, the inspectors will have to be more qualified.*

3. Going back to Phase I, Question 4. Could a performance-based code clarify any of the "safety" issues not covered by the prescriptive-based code? *No, seems that performance would leave the safety would be left to engineers on each job, and past lessons learned from history will not be used.*

4. "Safety" – "Performance v. Prescriptive". Which code wins? *Prescriptive*

Phase III

General ranking questions – Please rate, -Not at all, -Partially, -Completely

1. Is there a need for change to a performance-based code in the U.S.? *Not at all*

2. Do you feel that the change from a prescriptive-based code to a performance-based code will happen within the next ten years? *Not at all*

Phase I (Interviewee 17)

1. What is a performance-based building code in your opinion? *Performance based codes provide an engineer the flexibility to design building features based on the knowledge of how fire behaves. This behavior can be simulated through fundamental and analytical tools, or through computer modeling. The engineer can design safety and egress features based on the hazards present - addressing specific needs of a unique situation - rather than following a set of generic, prescribed rules, which may underestimate the level of protection actually needed.*

2. Prescriptive-based building code, is it sufficient for what it intends to do? *A prescriptive building code is much like a set of rules and laws that a building design must follow in order for that building to meet the minimum safety requirements deemed necessary. All a prescriptive code states is the minimum requirements enforceable by law. So following the intention of designing minimally safe buildings, the prescriptive code is sufficient.*

3. What problems do you have with the prescriptive-based building code? *You can have a building designed following exactly what the code requires but may not protect the occupants in a building. A building can be designed to be safe from a life-safety point of view or a property protection point of view. Therefore, specific measures can be taken to protect a building without inclusion of automatic sprinklers. For instance, for a given situation it may be allowed to protect the building with fireproofing on structural elements or include some other counter-measures to avoid installing sprinklers. In this case the building may be considered safe since it meets the requirements of the code, but may not be safe from a life-safety perspective since there are no sprinklers to protect the occupants.*

4. Does the prescriptive-based building code prescribe the "safety" of a building sufficiently? *Minimum allowable safety.*

5. At this point, is there a need for change to a performance-based building code? *There is definitely a need for performance-based design. The U.S. has a terrible track record for fire deaths each year. However, the timing is key. We are not ready for such a system. Right now there are about 3 major building codes for different areas of the country. We are trying to get national building and fire codes approved but there are so many politics involved.*

6. Do you see any positives with a newly implemented performance-based code? *See question 3.*

7. Do you see any negatives with a newly implemented performance-based code? *We have to take things one step at a time and figure out a way to educate building officials, AHJ's, engineers, etc. how to design and approve performance based systems.*

Phase II

Assuming a performance-based code will be entirely implemented in the U.S. relatively soon (next 6 months).

1. What barriers do you see stemming from the implementation of a performance-based code? *The obvious barrier is ensuring that engineers designing fire protection features using performance-based approaches are educated properly and are using industry-approved tools. In many cases it may be cheaper to install fire protection features designed in a performance based manner than a prescriptive code approach. Therefore, unless proper licensing is attained (something similar to a professional engineering stamp) you could have any designer out there creating a system that excludes sprinklers and puts a performance based stamp on it just to save some money on installation costs.*

2. Routes to overcome barriers. *See above – something similar to P.E. licensing perhaps? Believes that in Australia only "engineers" are able to design performance systems. This would prevent any sprinkler contractor or equivalent from designing a system using tools they are not familiar with.*

3. Going back to Phase I, Question 4. Could a performance-based code clarify any of the "safety" issues not covered by the prescriptive-based code? *A performance based code would clarify safety issues not addressed by prescriptive codes because each building and each system would be addressed individually. Fire protection features would be designed catering to the needs and goals of the stakeholders involved and the unique building features.*

4. "Safety" – "Performance v. Prescriptive. Which code wins? *In some aspects the performance code is better and in some aspects the prescriptive code is better. Feels buildings should be designed as a mix of performance and prescriptive. Performance approaches should be used when designing life-safety and fire protection features that require extra evaluation and consideration and prescriptive codes should be used when defining egress features such as stairwell characteristics and building features such as construction type.*

Phase III

General ranking questions – Please rate, -Not at all, -Partially, -Completely

1. Is there a need for change to a performance-based code in the U.S.? *Partially*
2. Do you feel that the change from a prescriptive-based code to a performance-based code will happen within the next ten years? *Partially*

Phase I (Interviewee 18)

1. What is a performance-based building code in your opinion? *Never heard of the performance based building code.*

2. Prescriptive-based building code, is it sufficient for what it intends to do? *Yes, in some cases it gives him problems on some projects, but overall it is sufficient.*

3. What problems do you have with the prescriptive-based building code? *The code sometimes will call for added detail that does not seem necessary. Sometimes code is too specific.*

4. Does the prescriptive-based building code prescribe the "safety" of a building sufficiently? *Yes, no problems so far in short experience in the field.*

5. At this point, is there a need for change to a performance-based building code? *No, the prescriptive code is sometimes too specific, but it does what it intends to do.*

6. Do you see any positives with a newly implemented performance-based code? *"It doesn't seem like it would change my job at all," but it seems to be beneficial to the designers.*

7. Do you see any negatives with a newly implemented performance-based code? *May make the process of design/build, fast-track system move slower.*

Phase II

Assuming a performance-based code will be entirely implemented in the U.S. relatively soon (next 6 months).

1. What barriers do you see stemming from the implementation of a performance-based code? *Slow building process, no one would know exactly what they were doing.*

2. Routes to overcome barriers. *Money, education*

3. Going back to Phase I, Question 4. Could a performance-based code clarify any of the "safety" issues not covered by the prescriptive-based code? *Possibly could help with building that need a specific design, or have unique features.*

4. "Safety" – "Performance v. Prescriptive". Which code wins? *Prescriptive, been around for awhile, proven to work sufficiently.*

Phase III

General ranking questions – Please rate, -Not at all, -Partially, -Completely

1. Is there a need for change to a performance-based code in the U.S.? *Not at all*

2. Do you feel that the change from a prescriptive-based code to a performance-based code will happen within the next ten years? *Not at all*

Phase I (Interviewee 19)

1. What is a performance-based building code in your opinion? *Little prior knowledge to the codes.*

2. Prescriptive-based building code, is it sufficient for what it intends to do? *They were sufficiently its current means, but didn't adapt to new building products on the market.*

3. What problems do you have with the prescriptive-based building code? *Just with the new products.*

4. Does the prescriptive-based building code prescribe the "safety" of a building sufficiently? *Prescriptive prescribed safety very well.*

5. At this point, is there a need for change to a performance-based building code? *No, if codes are able to adapt to new technology.*

6. Do you see any positives with a newly implemented performance-based code? *The theory of performance-based code sounds great.*

7. Do you see any negatives with a newly implemented performance-based code? *Doesn't think conversion will go very well. Believed converging in stages would the only way to do, but may take a very long time.*

Phase II

Assuming a performance-based code will be entirely implemented in the U.S. relatively soon (next 6 months).

1. What barriers do you see stemming from the implementation of a performance-based code? *Education.*

2. Routes to overcome barriers. *The only way the change could be made, was if the government stated "this is how it going to be", if the government were to do so, than they also must be willing to pay for the education process as well.*

3. Going back to Phase I, Question 4. Could a performance-based code clarify any of the "safety" issues not covered by the prescriptive-based code? *Both codes will most likely have their flaws, (similar clarification)*

4. "Safety" – "Performance v. Prescriptive. Which code wins? *See above.*

Phase III

General ranking questions – Please rate, -Not at all, -Partially, -Completely

1. Is there a need for change to a performance-based code in the U.S.? *No*

2. Do you feel that the change from a prescriptive-based code to a performance-based code will happen within the next ten years? *No*

Phase I (Interviewee 20)

1. What is a performance-based building code in your opinion?

    A code that describes the intended results to be accomplished and does not list the specific means to achieve those intentions. It states the required results and not the required means. The design professional arrives at the solutions and the code official evaluates if it meets the intent of the code.

2. Prescriptive-based building code, is it sufficient for what it intends to do?

    Mostly, it sets specific standards and requirements for health, welfare and safety which are to be uniformly applied throughout its' jurisdiction.

3. What problems do you have with the prescriptive-based building code? Does the prescriptive-based building code prescribe the "safety" of a building sufficiently?

    It does not allow for a variety of acceptable solutions. It takes the creativity away from the design professionals. Limits the design professional's ability to arrive at a solution based on their professional expertise, judge and experience. The prescriptive code sufficiently protects the safety of the public as it relates to life threatening safety issues, i.e. – require widths, locations and quantity of exit doors. However, it does not assure all aspects of the building will be safe and prevent injure, i.e. – Hand or guardrails are only requires at the edge of a platform or landing if the change in level is greater than 30". While a person may not died from a fall from this height they still may be serious injured.

4. At this point, is there a need for change to a performance-based building code? *Yes, this would allow the design professionals to use their expertise to design projects.*

5. Do you see any positives with a newly implemented performance-based code? *One positive to the prescriptive code is the design professional and the code official could work together to arrive at a solution.*

6. Do you see any negatives with a newly implemented performance-based code? *The code official may not have the education or experience to properly evaluate the professional's design solutions. The code review process will require more time for "evaluation vs. checking" for compliance. The code official could over rule the designer "professional" judge or registration responsibilities creating a moral, legal and ethical problem. The code official could try to apply arbitrary and capricious requires to the design.*

Phase II

Assuming a performance-based code will be entirely implemented in the U.S. relatively soon (next 6 months)

1. What barriers do you see stemming from the implementation of a performance-based code? *Additional time required by the code official of design evaluation. Additional professional liability for the design professional. Additional insurance costs. The change in traditional roles of design professionals and code officials may be resisted by each player.*

2. Routes to overcome barriers? *Breakdown traditional adversarial roles between design professionals and code officials. Establish teamwork mentality between design professionals and code officials. Have joint conferences/seminars with code officials, design professionals and insurance experts.*

3. Going back to Phase I, Question 4. Could a performance-based code clarify any of the "safety" issues not covered by the prescriptive-based code? *Yes, the design professionals could add safety measures based on their professional experience, judgment and liability.*

4. "Safety" – "Performance v. Prescriptive" Which code wins? *Performance code with some recognized standards to establish some common ground between the code official and the design professional..*

Phase III

General ranking questions – Please rate, -Not at all, -Partially, -Completely

1. Is there a need for change to a performance-based code in the U.S.?
   Partially.

2. Do you feel that the change from a prescriptive-based code to a performance-based code will happen within the next ten years
Partially.

Phase I (Interviewee 21)

1. What is a performance-based building code in your opinion? *Had little prior knowledge of performance-based, but as soon as he understood the general concept, he was much more attentive.*

2. Prescriptive-based building code, is it sufficient for what it intends to do? *Yes, definitely. It is cumbersome though. Some times it gets a bit too detailed and that can lead to less-effectiveness.*

3. What problems do you have with the prescriptive-based building code? *There are too many variations and its too scattered.*

4. Does the prescriptive-based building code prescribe the "safety" of a building sufficiently? *Definitely, completely, absolutely... if people die, then I get in trouble. So, people don't die.*

5. At this point, is there a need for change to a performance-based building code? *No, god idea though.*

6. Do you see any positives with a newly implemented performance-based code? *Flexibility, good.*

7. Do you see any negatives with a newly implemented performance-based code? *Loopholes and liability, bad.*

Phase II

Assuming a performance-based code will be entirely implemented in the U.S. relatively soon (next 6 months).

1. What barriers do you see stemming from the implementation of a performance-based code? *Time for education and what about transition period projects, grandfather?*

2. Routes to overcome barriers. *Time and education.*

3. Going back to Phase I, Question 4. Could a performance-based code clarify any of the "safety" issues not covered by the prescriptive-based code? *The only thing you could do to make performance-based codes even at the same level when it comes down to safety issues is to use the acceptable solutions to document the criteria for safety.*

4. "Safety" – "Performance v. Prescriptive". Which code wins? *Performance, must come up with break down of code for certain purposes (i.e. not everything can be a performance goal)*

Phase III

General ranking questions – Please rate, -Not at all, -Partially, -Completely

1. Is there a need for change to a performance-based code in the U.S.? *Not at all*

2. Do you feel that the change from a prescriptive-based code to a performance-based code will happen within the next ten years? *Not at all*

Phase I (Interviewee 22)

1. What is a performance-based building code in your opinion? *Has experience of using forms of the performance code. Uses variances and acceptable solutions in his consulting work.*

2. Prescriptive-based building code, is it sufficient for what it intends to do? *For the most part the prescriptive code is sufficient. Only 5% of buildings require performance codes applications.*

3. What problems do you have with the prescriptive-based building code? *One code is unable to cover everything an architect will design; more flexibility is needed.*

4. Does the prescriptive-based building code prescribe the "safety" of a building sufficiently? *Prescriptive code provides the minimum safety requirements for a building.*

5. At this point, is there a need for change to a performance-based building code? *There's no immediate need for change, but the building world is evolving and the codes will also need to evolve to keep up with industry.*

6. Do you see any positives with a newly implemented performance-based code? *Yes, at this point variances are the only way to provide this type of service. Variances are very time consuming and a performance code would prevent the now needed judicial hearing.*

7. Do you see any negatives with a newly implemented performance-based code? *Performance codes are meet through computer modeling, and performance analysis. Insurance companies may not see these as acceptable ways to prove a buildings safety, and decline coverage.*

Phase II

Assuming a performance-based code will be entirely implemented in the U.S. relatively soon (next 6 months).

1. What barriers do you see stemming from the implementation of a performance-based code? *See question 7.*

2. Routes to overcome barriers. *Education is key, it will also take time for the code process to be adapted.*

3. Going back to Phase I, Question 4. Could a performance-based code clarify any of the "safety" issues not covered by the prescriptive-based code? *Yes, but it has been apparent in the past that a "jerk," reaction will be needed to initiate a change of this magnitude. This could be caused by a safety tragedy under the current prescriptive code.*

4. "Safety" – "Performance v. Prescriptive". Which code wins? *Both codes could contribute to a safety of a building. Different situation could benefit from a combination of both codes.*

Phase III

General ranking questions – Please rate, -Not at all, -Partially, -Completely

1. Is there a need for change to a performance-based code in the U.S.? *Partially*

2. Do you feel that the change from a prescriptive-based code to a performance-based code will happen within the next ten years? *Partially*

Phase I (Interviewee 23)

1. What is a performance-based building code in your opinion? *Has talked to Prof. Barnett on the issues and has a fairly good idea of the concept of the performance-based goals.*

2. Prescriptive-based building code, is it sufficient for what it intends to do? *Yes. When the code through as much checking as they do, the code as it stands works well for them.*

3. What problems do you have with the prescriptive-based building code? *Not many at all, it mostly works fine for us. Maybe a little bit ore flexible in materials and techniques.*

4. Does the prescriptive-based building code prescribe the "safety" of a building sufficiently? *The code has evolved with the times and is safe to the extent of good interpretation.*

5. At this point, is there a need for change to a performance-based building code? *No, won't happen; unions will stop it and won't stand for it. Government will never step all over labor workers.*

6. Do you see any positives with a newly implemented performance-based code? *Good idea, difficult. If it were to be implemented, the commercial realm won't be affected much, checking upon checking currently goes on for liability reasons, but the lesser levels will be hesitant about the acceptance*

7. Do you see any negatives with a newly implemented performance-based code? *Included in above.*

Phase II

Assuming a performance-based code will be entirely implemented in the U.S. relatively soon (next 6 months).

1. What barriers do you see stemming from the implementation of a performance-based code? *Performance-based puts much of the liability on the engineers and designers and architects, takes the code officials out of the picture. Inspectors have responsibility but not liable like the engineers or architects. Unions out there will prevent changes form being made in the U.S.*

2. Routes to overcome barriers. *See above. House Builders most affected. Could work, publicity through education. People willing to pay a bit more if their house is going to be safer.*

3. Going back to Phase I, Question 4. Could a performance-based code clarify any of the "safety" issues not covered by the prescriptive-based code? *Performance-based may deal with safety fairly well and much better than prescriptive-based.*

4. "Safety" – "Performance v. Prescriptive". Which code wins? *See above.*

Phase III

General ranking questions – Please rate, -Not at all, -Partially, -Completely

1. Is there a need for change to a performance-based code in the U.S.? *Partially*

2. Do you feel that the change from a prescriptive-based code to a performance-based code will happen within the next ten years? *No at all*

Phase I (Interviewee 24)

1. What is a performance-based building code in your opinion? *Little prior knowledge of performance based code.*

2. Prescriptive-based building code, is it sufficient for what it intends to do? *Never had any problems with them.*

3. What problems do you have with the prescriptive-based building code? *No problems, but building process is slow and getting slower.*

4. Does the prescriptive-based building code prescribe the "safety" of a building sufficiently? *Safety is a large part of the prescriptive code; it is very sufficient.*

5. At this point, is there a need for change to a performance-based building code? *There are no real problems with the current code, no need to change it. Always needs updating.*

6. Do you see any positives with a newly implemented performance-based code? *Can only really tell y experience.*

7. Do you see any negatives with a newly implemented performance-based code? *Lack of experience by everyone dealing with them.*

Phase II

Assuming a performance-based code will be entirely implemented in the U.S. relatively soon (next 6 months).

1. What barriers do you see stemming from the implementation of a performance-based code? *Confusion, a lot bugs that will only be overcome over time.*

2. Routes to overcome barriers. *Time is the biggest thing, education will be needed to get the new code started.*

3. Going back to Phase I, Question 4. Could a performance-based code clarify any of the "safety" issues not covered by the prescriptive-based code? *Prescriptive is very clear, performance codes could lead to many different levels of safety depending on different designers.*

4. "Safety" – "Performance v. Prescriptive" *Prescriptive.*

Phase III

General ranking questions – Please rate, -Not at all, -Partially, -Completely

1. Is there a need for change to a performance-based code in the U.S.? – *Not at all*

2. Do you feel that the change from a prescriptive-based code to a performance-based code will happen within the next ten years? *No at all.*