Guidelines for the introduction of performance-based building regulations

(Discussion Paper)

Prepared by

The Inter-jurisdictional Regulatory Collaboration Committee

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Preface

The building and construction industry promotes growth and investment internationally.

The Organisation for Economic Co-operation and Development (OECD) has identified urban development as a key ingredient of economic growth. The building industry adds to this growth, internationally, through the provision of physical and social infrastructure; urban development; resource allocation and employment.

The importance of the industry to developing nations can be gauged by the amount of foreign aid allocated to help emerging construction industries. About 20% of World Bank and Asian Development Bank funding goes toward urban housing and infrastructure.

In developed nations, the relationship between the building industry and growth is revealed in a country's Gross Domestic Product. Fundamentally linked to the performance of national economies, it is no wonder the industry is viewed as the "barometer of a national economy".

The output of construction in developing countries is about 5% of GDP; the average is about 8%. These figures may not seem high at first, however, the industry remains one of the most significant contributors in terms of national GDP and employment figures when measured against the contributions of other sectors.

Australia commits more than 25% of its fixed investments to residential and non-residential construction; forming part of the 7% GDP contribution. Equally, construction forms 7% of the USA's GDP, and goes as high as 21% in Japan (this figure, however, includes machinery and equipment).

The industry also impacts on the productivity of other supporting industries. It is estimated that a 10% lift in construction activity (not including residential construction), could lead to a 2.5% gain in developed nations' GDPs. The introduction of performance-based codes is central to improving efficiency. In encouraging innovation and flexibility without strict prescription, performance-based building codes encourage new techniques and practices, leading to expansion and increased efficiency. This promotes investment in the industry, which in turn increases national GDP.

Executive summary

The growing trend around the world to introduce performance-based codes is central to improving efficiency in the construction industry. In encouraging innovation and flexibility without strict prescription, performance-based building codes encourage new techniques and practices, leading to expansion and increased efficiency. This promotes investment in the industry, which in turn increases national GDP.

Introduction of a performance based code without considering the broader context into which they are introduced can create considerable dysfunction both within a country and also have a negative impact on foreign trade. This report has focused upon a number of the key issues that experience has indicated are critical to the successful adoption of a performance based approach to building regulation.

The availability of supporting technology; educational programs; public policy; a support framework; and a implementation process have been identified as critical for a successful implementation. Various options and approaches are explored in this report, along with the experiences of countries who have already completed their transition to the performance approach.

No one organization, or for that matter country, is able to bring to bare sufficient resources to address all of these issues in their totality. Therefore it is clear that there is a need for international cooperation in the development of a common understanding of the performance approach and for the establishment of a collaborative approach to the development of common resources which can be incorporate into individual national regulatory systems.

The establishment of these common elements will greatly facilitate trade between countries through a clearer understanding of the performance that a product or system is able to provide. This report provides the first step in the establishment of such a common understanding through the exposition of the existing approaches and solutions that have been identified by those countries who have collaborated in the development of this report.

IRCC

The Inter- jurisdictional Regulatory Collaboration Committee (IRCC) consists of both corresponding members and active members. This document was drafted by the following active members with input and advice from corresponding members.

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1. Introduction

This document is an overview of the development and implementation of performance-based building regulatory systems.

It comprises the experiences and opinions of an international committee engaged in building regulatory system reform. It does not encompass every issue pertinent to performance systems. Rather, it outlines fundamental components, showcasing the experience of many countries involved in using performance-based systems. It includes feedback and research findings from these countries.

1.1 Mission

The purpose of the Inter-jurisdictional Regulatory Collaboration Committee (IRCC) is to work internationally, producing documents on the development, implementation, and support of construction-related, performance-based regulatory systems.

1.2 Scope

The focus of the IRCC is to identify public policies, regulatory infrastructure, education, and technology issues for implementing and managing these systems.

It is hoped that by doing this, a common understanding of the international regulatory environment can be achieved. The IRCC also aims to promote the global exchange of information, and a more open environment of inter-jurisdictional commerce in building design and construction.

1.3 Background

Regulatory reforms began in many countries in the 1970s and early 1980s. In some countries this was prompted by a growing awareness of the impact of industry and technology on people and their environments.

In other cases, reforms aimed to minimise government regulation and reduce bureaucracy. Other reforms focused on streamlining the regulatory system and advocated exchanges of information, technology, and products. Over time, various aspects of these, and other factors, became common themes in global regulatory reform efforts.

Several countries investigated the possibilities of performance- or objective-based building regulations.[i] [ii] [iii] [iv] [v] [vi] [vii] [viii] For instance, the International Council for Building Research Studies and Documentation (CIB), at the request of the National Research Council, Canada (NRCC), commissioned a Task Group (TG11) to review the development of performance-based regulations internationally, and to identify the common features of such regulations (codes).[ix]

The taskforce concluded that there was a need for better understanding of the regulations, especially the different frameworks within which the performance-based building regulations were being used.

As many countries had discovered - and others just beginning to experience - there was a need to identify and address public policy, regulatory infrastructure, education, and technology issues relating to managing the regulations.

For some, the immense scope of these issues became clear during the First International Conference on Performance-Based Codes and Fire Safety Design Methods.[x]

At this conference, various cultural, legal, technical, and practical issues were raised. There was informal discussion among delegates from Australia, Canada, and the United States. This led to the idea of forming a collaborative on global building reforms, which would promote the exchange of information, and foster more open commerce in building design and construction.

The inter-jurisdictional group was formed in late 1996, after several teleconferences were held between representatives of the Australian Building Codes Board (ABCB); the International Conference of Building Officials (ICBO); the National Research Council, Canada (NRCC), and the Society of Fire Protection Engineers (SFPE).

Delegates discussed the aims of such a group, whether the CIB should head it, and who would be the participants. A planning meeting was held in Australia on March 5, 1997.

There, the benefits of such an inter-jurisdiction collaborative effort were identified as being to:

- provide a forum promoting a common understanding of, and a framework for, performance-based building regulatory system development;
- provide guidance and support materials for countries which develop, implement, and support performance-based regulatory systems;

promote the pooling of resources, on an international scale, to aid research and development of commonly-needed components of a performance-based regulatory system;

- provide an economic benefit to countries embarking on performance-based regulation development, by providing guidance and support materials, thus minimising potential duplication;
- provide a forum for those with experience in building regulatory system

reform, from both the technical and regulatory perspectives, to foster exchange of ideas and the development of "Best Current Practice" documents;

- create a potential medium for inter-jurisdictional trade. (It was recognised that the lack of regulatory harmonisation can impact upon the ability of jurisdictions to adopt Standards and to import or export products, systems, and skills.); and
- encourage investment in construction-related technology and innovation.

It was agreed that participation and collaboration with any country or organisation (government or private) that had an interest in the above points would be welcome.

However, in order to complete a work report within one year, it was decided to:

- limit the size of the initial working group; and
- operate the collaborative as an independent forum (ie: not under the umbrella of any existing organisation).

As a result, initial participation included the four progenitors: the ABCB, ICBO, NRCC, and SFPE. Invitations were extended to organisations in Japan, Finland, New Zealand, and the United Kingdom. The collaborative was named the Inter-jurisdictional Regulatory Collaboration Committee (IRCC). (Other organisations that expressed an interest were to be welcomed).

The first working meeting of the IRCC was convened in Los Angeles, California, USA, on May 22-23, 1997.

Present were people from the ABCB, ICBO, Ministry of Construction (MOC, Japan), NRCC, and SFPE. Discussions focussed on the issues involved in introducing performance-based regulation.

A target was set for a draft for an issues-based paper, to be presented at the Second International Conference on Performance-Based Codes and Fire-Safety Design Methods at Maui, Hawaii, USA, on May 4-9, 1998.

The IRCC agreed that this document should provide an overview of the broader performance-based regulatory system issues, including:

- technology requirements;
- education issues;
- public policy issues (including communication, risk, legislative, and liability issues);
- support framework issues (including qualifications and availability of professionals and enforcement issues); and
- process management issues (related to development, implementation, and

continued use).

The IRCC decided that a number of sub-areas that might also need to be addressed. This exercise resulted in a detailed outline, which the IRCC would need to address before the May 1998 deadline.

Participation was invited from Finland (Technical Research Centre of Finland, VTT); New Zealand (Building Industry Authority, BIA), and the United Kingdom. Representatives from each of these organisations indicated interest.

Various other organisations such as the National Fire Protection Association (NFPA) and the CIB, were told of the IRCC and informed that their participation would be welcome. (Although the UK and Finland indicated interest, representatives were unable to actively participate until late in the process. Thus, this document lacks detail on European national regulatory systems. It is anticipated that future editions will address these systems in more detail).

In the meetings that followed (Canada, August; Japan, November; and Australia, February), the IRCC drafted and modified this document: *Guidelines for the introduction of performance-based building regulations*. In this document you will find that in some areas - such as technology - that the focus has been on fire safety: a key component of a performance-based building regulations. In future editions, other relevant technology will also be addressed.

Similarly, although the areas of education, public policy, and support framework provide an overview of key issues, the range covered will be expanded in future editions. The process management section will grow with time as more jurisdictions implement performance-based regulatory systems.

2. Technology

2.1 Background: analysis and design technology

A performance-based regulatory system is based on the premise that performance can be identified, measured and/or calculated.

This requires that performance criteria be qualitative or quantitative. It must serve as the basis for design and evaluation, and suitable technology should exist to implement and evaluate it. If technology requirements are lacking, deficiencies need to be identified and addressed through technological development, education, regulatory, or other policy measures.

Before identifying the technological requirements of a performance-based regulatory system, a common framework must be established. The fundamental issues of "What is performance?" and "What does a performance-based system mean?" must be resolved.

Performance and performance-based regulations

The term "performance-based regulation" may be open to interpretation if not well defined in a specific regulatory policy.

For Example:

At the United States Environmental Protection Agency, (EPA), a regulation calling for the reduction in emissions of a hazardous pollutant by a certain percentage per year, is considered a *performance-based regulation*

However, a reduction of a pollutant through the use of the Best Available Control Technology (BACT) is referred to as a *technology-based regulation*. Furthermore, a regulation that requires a population to be protected from a pollutant with an adequate margin of safety is considered a *risk-based regulation*.

To date, the EPA-type distinctions between performance-based, technology-based, and risk-based regulations have not been made within the building and fire-regulatory communities. The term "performance-based regulations" has been all encompassing. This lack of distinction is not necessarily bad. However, concepts of technology- and risk-based regulation are considered in the context of performance.

With this in mind, a performance-based building requirement or fire regulation may have "performance criteria" identified and expressed in technological terms, risk terms, and/or performance terms.

Technological criteria may be considered in scientific or engineering terms. It can be expressed in terms such as temperatures, distances, and concentrations.

Likewise, risk criteria may range from qualitative criteria such as "an acceptable level of safety" to quantitative criteria based on probabilistic analyses, such as the likelihood of a significant ground motion in a 100-year period.

Performance-based criteria may be interpreted as a percentage deflection under a given load, or interpreted as the ability of the regulated item to perform as expected when measured against the technological- or risk-based criteria.

In summary, the term "performance" needs to be well defined and accepted within the building regulatory environment. Performance criteria - be they performance-, technology-, or risk-based, need to be well defined, developed in a consistent manner, and widely accepted.

Performance-based regulatory system structure

A prescriptive-based building regulatory system is a collection of codes and Standards that describe how buildings should be designed, built, protected and maintained with regard to the health, safety and amenity of the public.

For the most part, documents specify what is required for health, safety and amenity, and how these requirements are to be met. The current system is focused on providing a minimum level of safety, (minimum level of regulation).

A performance-based building regulatory system, by contrast, has three separate components: the code, Acceptable Solutions, and evaluation and design tools.

<u>The code</u>:

Through societal goals, functional objectives and performance requirements the code reflects society's expectations of the level of health, safety, welfare, and amenity provided in buildings. (For Example: acceptable access, egress, ventilation, fire protection, structural stability, use, function, electrical services, sanitary services, etc.).

<u>Acceptable Solutions</u>:

Through documents adopted by reference, these solutions describe acceptable methods for complying with the code. (For Example: Deemed-to-Satisfy prescriptive solutions and performance-based engineering Standards, practices and guides).

Embodied within the code or the Acceptable Solutions are criteria against which design solutions will be evaluated, (this varies from country to country.).

<u>Evaluation and design tools</u>:

These provide acceptable methods for assisting in the development, review and verification of designs in which performance-based Acceptable Solutions are used. (It is assumed that Deemed-to-Satisfy solutions will not require further evaluation or verification at the design phase).

Within the code, performance is most often addressed in broad terms - acceptable, adequate, appropriate - and is inherently associated with societal risks, costs, and benefits.

Unlike a prescriptive-based system, a performance-based system can incorporate multiple levels of performance and risk. Within Acceptable Solutions and evaluation and design tools, performance becomes more narrowly defined.

For Example:

In a Deemed-to-Satisfy solution, specific measurements may be given. In a performance-based solution, an engineering method or engineering tool, acceptance/design criteria will be specified and used. It is often related to available technology (eg: design tools, evaluation tools, systems, materials, etc.). Again, multiple levels of performance and risk are achievable.

In summary, a performance-based regulatory system requires three components: the code, Acceptable Solutions, and evaluation and design tools. Although all of these components do not need to be fully complete for the system to work - the Acceptable Solutions and evaluation and design tools will be constantly developing - the fundamental structure needs to be in place. Within the code, multiple levels of performance must be possible.

Measuring, calculating, and estimating performance

Just as performance can be defined in many ways, so it can be measured, calculated, and estimated in several ways.
Traditionally, the performance of building- and fire-safety systems is measured against the specific criteria of Standards and tests. These criteria are wide-ranging, from specified live and dead loads for structural analysis, to resistance to fire from a given time-temperature relationship, to a total width of exit opening (ie: total width of door opening) based on the population in a building.

These criteria are usually based on scientific and engineering briefs, and adopted as industry- and profession-based Standards and practices.

Uniformity of criteria provides for consistency between testing laboratories. This, in turn, leads to a "confidence level" regarding the performance of a material, component, or system.

However, because the criteria of current codes and Standards are based on providing a minimum level of safety at a single level of performance, and testing is based on providing repeatability, it is likely that neither the criteria nor the test methods will be appropriate for direct application in a performance-based system.

(At a minimum, criteria and test methods will require expansion and modification. That is, the more varying characteristics, the more appropriate test and calculation methods will be needed to evaluate materials, components, and systems.) In addition, there is often a gap between current regulations and the building performance expected.

<u>For Example:</u>

When an earthquake in Northridge, California, occurred many of the newer buildings had been constructed to the code-required "life-safety" level. That is, the structure could, and did, sustain considerable damage as long as the occupants evacuated safely.

After the event, seismic engineers agreed that the buildings performed as designed. The public, however, who lost homes and businesses, did not understand why code-complying buildings were not useable after the quake.

In this case, what the code provided as a minimum level of performance was not what the public expected. With regard to fire safety, requirements are specified by fire-resistance ratings and maximum travel distances. However, a fire-rated assembly is tested against a specific time-temperature relationship, and it cannot be assumed that the assembly will perform the same under different time-temperature relationships.

With regard to travel distances, the time it takes to achieve safe egress, will depend on: the materials burning; the rate of heat release and fire growth; ceiling height; the point at which occupants are notified, and the point at which they decide to evacuate.

In this case, however, most prescriptive codes do not consider the fire or the ceiling height, and some do not require early-fire detection and occupant-notification systems. (In addition, when early-fire detection and occupant-notification systems are provided, the fire and the other safety systems are usually not considered.)

In summary, key issues in a performance-based system include how performance is defined and how criteria are established.

Based on these items, mechanisms for measuring, predicting, calculating, and estimating various levels of performance need to be identified and developed. This may require new test methods, equipment, and Standards, as well as ways of calculating risk-based performance. Means should be established within the system to ensure the acceptability of performance measurements and estimates as part of design solutions, (Acceptable Solutions).

Performance-based design

A performance-based regulatory system means that a performance-based design can be accomplished.

The Society of Fire Protection Engineers (SFPE) is attempting to determine what performance-based fire-safety design is, and what is required for such a design to be realised in the United States.

Support for the project was provided by a grant from the National Institute of Standards and Technology, Building and Fire Research Laboratory, (NIST, BFRL).[xi]

The project found that performance-based design is merely engineering a solution to meet specific levels of performance, in terms of performance levels (or objectives) and performance criteria.

In structural engineering, for example, performance levels are often defined by how damage to a structure can be limited, taking into account an objective measurement of its estimated function and performance.[xii]

This concept has guided structural engineers for years, in determining buildings' dead-, live-, and wind loads. The concept has expanded into the realm of design against unacceptable loss due to earthquake loadings as well.

In fact, the Structural Engineers Association of California (SEAOC) Vision 2000 project - initiated to provide engineers with a framework for performance-based engineering of buildings against earthquake loads - has defined performance-based engineering as "selection of design criteria, appropriate structural systems, layout, proportioning, and detailing for a structure and its nonstructural components and contents and the assurance of construction quality control such that at specified levels of ground motion and with defined levels of reliability, the structure will not be damaged beyond certain limit states."
In this definition, one sees aspects of both deterministic and probabilistic analysis and design entering into the process. This is common in several of the design methods reviewed.

In summary, performance-based design means designing to specifiable and quantifiable levels of performance. As performance criteria may be deterministic or probabilistic, design methods must be developed for both deterministic or probabilistic approaches.

2.2 Fire-safety engineering technology

In this section, discussion will focus on technology requirements for fire-safety engineering, including fire-safety design, analysis and design tools; test methods; test data, and design and acceptance criteria.

Performance-based fire- safety design

Performance-based fire-safety design is a process of engineering a fire-safety solution to meet a specific level of performance.

In some jurisdictions, this concept is an acceptable means of undertaking fire-safety analysis and design in the United States.

However, only a few engineers working in the building and fire communities have experience in performance-based approaches to fire-safety design. In addition, there are discrepancies in the terminology and definitions used by different codes and organisations.

The first step towards identifying what is meant by performance-based fire-safety analysis and design was to research the topic. As a starting point, the following definition of performance-based fire-safety engineering was adopted:[xiii]

"An engineering approach to fire-protection design must be based on:

- agreed fire-safety goals, loss objectives, and design objectives;
- deterministic and probabilistic evaluation of fire initiation, growth, and development;
- the physical and chemical properties of fire and fire effluents; and
- quantitative assessment of the effectiveness of design alternatives against loss objectives and performance objectives."

Given this definition, research into the evolution of performance-based codes and performance-based fire-safety analysis and design approaches was completed. This research resulted in the identification of more than a dozen performance-based fire-safety analysis and design approaches under development, or in use around the world, including:

- FiRECAM (NRC, Canada) - computer model[xiv]
- FRAMEworks (NFPRF, USA) - computer model[xv]
- Building Fire Safety Evaluation Method (Fitzgerald, WPI, USA) - framework document[xvi]
- Fire Engineering Guidelines (FCRC and VUT, Australia) - framework document[xvii]
- The Application of Fire Performance Concepts to Design Objectives (ISO, International)[xviii]
- Draft for Development on the Application of Fire Safety Engineering Principles to Building Fire Safety Design (BSI, UK) - framework document[xix]
- Performance Requirements for Fire Safety and Technical Guide for Verification by Calculation, (Nordic Committee on Building Regulations, NKB, Fire Safety Committee) - framework document[xx]
- Fire-Induced Vulnerability Evaluation (FIVE) Methodology (EPRI, USA) - computer model and framework document[xxi]

- Fire Engineering Design Guide (University of Canterbury, New Zealand) - framework document[xxii]
- Total Fire Safety Design System for Buildings (MOC, Japan) - equivalent method for compliance with the Building Standards Law[xxiii]
- Fire Safety Evaluation System (NFPA, USA) - equivalent method for compliance with the Life Safety Code®[xxiv]

This paper includes a brief history and discussion of performance-based regulatory documents. (Other approaches - such as the Swiss SIA 81 found in various Eurocodes - fall under the category of performance-based or verification approaches).

Despite the extensive list of international design approaches, there is still no single, generally accepted framework for undertaking a performance-based approach to building fire-safety analysis and design (although the ISO effort will likely result in a widely-available methodology).

This lack of methodology is due to a number of factors, including: the complexity or simplicity of the available methodologies; the lack of data (probabilistic and deterministic); the lack of credible fire-safety analysis and design tools, and in some cases, the relationship of a methodology to a specific regulation (eg: the limitation in use of NFPA 101A, Fire Safety Evaluation System, as an equivalent method for compliance with the NFPA 101, Life Safety Code®).

The following concerns should be considered when undertaking a performance-based approach to fire-safety analysis and design. There is a need:

- to consider the level of acceptable risk (personal and societal);
- for clear specification of, and agreement to, fire-safety goals and objectives, and performance and design criteria;
- to understand how fire initiates, develops and spreads;
- to understand how various fire-safety measures (active and passive) can mitigate potential fire losses;
- to understand how people react in a fire situation;
- to apply credible tools and methodologies in the determination of the above factors;
- to consider the financial impact of fire-safety decisions; and.
- to address uncertainties in the analysis and design process.

In summary, given these common international goals, it was concluded that it should be possible to develop a framework for performance-based fire-safety analysis and design that is universally useable and acceptable.

Engineering analysis, design tools and methods

There is a need for engineering analysis, design tools and methods to support aspects of a performance-based analysis and design process.

For Example: a life-safety performance requirement may be based on an egress time for evacuation from a building, being no longer than the time it takes for hazardous conditions to build up in an emergency.

Engineering tools and methods would be used to perform or support such an analysis (with either a sufficient safety margin if deterministic assessment methods are used, or with sufficient probability of success if risk-based tools are used). In this context, engineering tools and methods encompass such items as computer fire-effects models, probabilistic models,methods, and specific design guidance and reference documents.

In a performance-based design structure, it should be known which engineering tools and methods are available, also, which analysis and design needs should be addressed, and where future development is required.

In this section, assessment of design tools and methods, fire-test methods, and fire-test data are discussed.

Assessment of engineering tools and methodologies

It is necessary to assess the engineering tools and methodologies available for working within a performance-based system.

As such, the SFPE formed an Engineering Task Group (ETG) to examine Computer Model Evaluation. The goal of the task group is to evaluate computer models used for fire-protection engineering applications.

The intent is to produce reports to assist the users of the models and the reviewers of designs to gain a better understanding of a particular model, its evaluated range of application, and its known limitations.

The first model under evaluation is DETACT-QS, a heat-and-smoke detector (DET) activation (ACT) model.

This model was selected as the first for evaluation due to its simplicity, limited scope of application, and its widespread use.

The task group has a number of subgroups working on various aspects of the evaluation, using American Society for Testing and Materials (ASTM) guides as the bases of the evaluation. To support the model evaluation effort, a series of fire tests was performed at Underwriters Laboratories, Inc in January 1997, and more tests were planned for mid-1997. The evaluation effort is focusing on sensitivity and uncertainty analysis.

The next model selected for evaluation is ASET. This model was selected for similar reasons to DETACT.

Once the DETACT evaluation is complete, the ASET evaluation substantially complete, and the process well defined and tested; parallel model-evaluation efforts will begin.

In addition to evaluating computer models, various engineering analyses and design methods were to be evaluated and compiled into easy-to-use engineering guides.

Thus, the SFPE formed another task group to deal with engineering practices. The goal of this task group is to develop detailed engineering practice documents on specific components of fire-protection engineering.

The intent is to research materials, evaluate Best Available Practices, and consolidate the information into guides.

The group's first task is the development of a guide on Assessing Flame Radiation to External Targets from Liquid Pool Fires.

This document will include three sections, envisioned as:

- thermal radiation from pool fires;
- radiant ignition of solids; and
- quantitative methods for skin-burn simulation.

Section I will focus on determining the incident radiant flux at a target location. Section II on the radiant ignition of solids, and Section III on quantitative methods to determine the effect on bare skin of a given radiant exposure.

All sections will include assessments of the accuracy of available methods, example calculations and limitations on the use of the methods. Future projects of this task group include extension of the Radiation guide to include building-to-building radiation and radiation from fire jets; a guide on developing pre-flashover design basis fires for residential and office occupancies; a guide on tenability criteria, and a guide on calculating the time for hazardous conditions in compartment fires.

Another project under way is the development of a guide for specifying design basis fires for evaluating structural members under fire conditions. This effort is connected to a joint ASCE/SFPE project to develop a standard on performance-based design of structural-fire protection, being led by SFPE member Dr. James Milke of the University of Maryland.

Uncertainty

There is uncertainty in performance-based, fire-safety engineering, as in any engineering process, as not everything is known about the materials and systems.

(The adjustment of Q'_{crit} (or t_{crit}) to provide a factor of safety, for example, is a means of addressing uncertainties related to fire and performance-based fire-safety engineering.)

In order to accurately predict material or system response, and engineer an appropriate solution, it is important to identify and address uncertainties. Fire-safety engineering lags behind other engineering disciplines in this area. Future efforts in the US will focus on this area.[xxv]

Risk concepts and approaches

A number of groups are attempting to promote risk concepts in performance-based building and fire-regulation development in the US.

These efforts include the National Science Foundation (NSF); the Society of Fire Protection Engineers; the International Code Council; the National Fire Protection Association; the Institute for Business and Home Safety; Factory Mutual Research Corporation; Clark University, and Worcester Polytechnic Institute.

Their objective is to outline a process that will aid in the identification, characterisation, and incorporation of risk concepts and analysis methods into building and fire regulations.

In meeting this objective, the proposed effort will:

- review the use of risk concepts over a broad range of regulations;
- review various approaches to identifying and characterising risk problems;
- identify fire risk issues in building and fire regulations; and
- outline an approach for identifying, characterising, and incorporating risk concepts and analysis methods into building and fire-regulation development.

The result should be a decision-making tool that will serve as a resource and guidance document to help the building and fire communities incorporate acceptable risk concepts into their regulations. Our research will aim to:

- improve the understanding of risks and associated costs from fire and natural hazards,
- address the impact of uncertainty on the development and use of

risk-based building and fire regulations, with a focus in the areas of application of new technologies and indeterminate uncertainty related to future human actions,

- assist codes and standards developers view, understand, and address building and fire regulation development as acceptable risk issues, and
- provide a basis for further development of risk- and reliability-based analysis and design tools for building and fire-safety design.

It is not within our scope to elicit risk perceptions, quantify risks, or quantify uncertainties. However, examples will be provided to demonstrate how these issues can be addressed by the building and fire-regulatory development communities.

These examples will:

- illustrate the process developing risk-based goal and objective statements that address building height and area limitation restrictions (as used in the current building codes). This will be done by focusing on the risk of injury, life loss, and property damage, and ways to mitigate those risks, instead of focusing on the specification of construction materials and building systems; and
- illustrate the process developing risk-based goal and objective statements that address the Occupancy Classifications by focusing on the risk of injury, life loss, and property damage, and ways to mitigate those risks, instead of focusing on the specification of construction materials and building systems.

The information and decision-making process of this effort will be a valuable addition to the area of risk-based decision making.

Furthermore, by focusing on risk issues the building and fire communities will be able to better address technical risks from fire and natural hazards, and the costs associated with mitigating those hazards. They will also be able to assess the overall benefits of the protection strategies that may be employed.

Ultimately, this effort will involve scientific and societal risk concepts in building and fire regulations. It should result in a regulatory structure more ready to permit innovative building construction materials and methods. The system should more readily permit risk-benefit and cost-benefit analysis as part of the decision-making process, while addressing the risks to life and property from fire and natural hazards.

Fire tests and fire-test data

Fundamental to performance-based fire-safety design is the need for fire-test data to evaluate and develop fire-safety models.
There are several issues embodied in the need for fire test data.

"The fire behaviour/performance of a product must usually be demonstrated by tests or by extrapolation of results from tests on a similar product. Only in a few cases - such as steel, timber, and normal concrete - may generic material data sufficiently characterise a product.

Trade is a significant part of the construction business.

Test-based certificates are essential for the fluency of trade. In Europe, where the CE-marking of construction products is to become obligatory, the role of testing will be even more important in the future.

It is evident that fire-safety engineers are going to make use of almost any test data available. Because standard testing is obligatory for manufacturers, it would be of great economical benefit, if the same tests could also provide the data needed for the performance-based fire-safety design".

This extract is from a paper presented by Dr. Matti Kokkala, Head of Fire Research at VTT in Finland and a convenor at the SFPE/Victoria University of Technology workshop, *Performance-Based Fire-Safety Design*, held at the Victorian University of Technology, Melbourne, Australia, on February 28, 1997.

Present test standards

Standard test methods have been developed mainly with the needs of prescriptive requirements in mind. The test scenario and the fire exposure have been defined using common sense rather than scientific analysis.

Theories behind test scenarios are not well known. Often even the fire exposure is insufficiently characterised. The measuring devices (eg: thick thermocouples) may lead to systematic errors.

The classification of products is also based on common sense. If a product burns quickly in a test, it would get a worse ranking than a product, which hardly burnt. Similarly, fire detectors can be ranked on their response times: the faster the alarm response, the better its ranking.

This philosophy has helped achieve the present levels of fire safety. However, the extension of the application of the test data is usually impossible. At best, the results of typical fire tests can be used to create analytical correlations.

These correlations are useful for comparing elements with new, alternative products. However, for quantitative hazard or risk assessment, the correlation methods are seldom useful. For in using fire-test data as inputs for a fire-engineering calculation, the calculation cannot be expected to be any more certain than any errors in the tests.

Due to costs, a large number of products are not retested. Variations are also evident in a large number of products, so the fairness of testing is sometimes questionable.

<u>For Example:</u> take two products with similar properties and variations. If one product represents the lower fractile while that of a competitor represents the upper fractile, the products shall end up with different rankings. If the two products have the same average properties, but different variations of properties, it may be that the manufacturer with the smaller variation (better quality) is not going to get any reward for his quality. In principle, the differences might be found during a sufficient number of follow-up testing, but in case of assemblies or fire-protection installations, this may never happen.

Test data needed for performance-based fire-safety design

The data needs of performance-based fire-safety design may be significantly different from those of prescriptive methods.

The data needed for performance-based design is of two types:

- input data for calculation methods; and
- data to verify a model or a method to be used for design.

The second type may not be necessary in a design process, but often an engineer needs it to evaluate a given engineering tool.

In addition to evaluating the characteristics of a model or method, data should also investigate the variability of properties. Such "variability" might include assessment of the probability of failure of a component in a fire-safety system.

Conflict about the needs of classification tests are not really an issue. This is because classification can be derived by ranking products based on the results of their output data.

However, perhaps a better approach would be to correlate results of the component performance in selected "large-scale scenarios"; these large-scale tests could then be used as a referee if needed. Recently, it has become almost obligatory to test products during "end-use" conditions.

This rather expensive requirement would be unnecessary if the performance of components in end-use conditions could be reliably gauged by calculation.

Ignition

In building design, ignition must always be considered. Statistics can be used to estimate the probability of ignition. Expert judgement is needed to identify the most likely ignition sources. This is particularly so if the contents of the proposed building is already known.

Ignitability depends on the thermal and the chemical properties of a product. By measuring the time it takes for a product to ignite under a series of controlled thermal-exposure tests, certain results can be derived.

These results can be used to estimate the thermal response and the ignition of a product under different conditions. Two test methods providing this information are the ISO 5657-ignitability test and the ISO 5660 cone calorimeter test.

More advanced methods to treat ignition are being debated in scientific literature, but it is hard to believe that any will eventuate in the near future.

Fire Growth

To assess temperature and smoke-spread increases, fire-growth rates need to be determined. Such rates are integral in the design of smoke and heat venting.

Most commonly, the set of four t^2-fires is used for this purpose.

However, this approach has been criticised (eg: by Babrauskas) because t^2-growth behaviour is based on a fire spreading at a constant rate on an evenly distributed fire load. No experimental evidence of this kind of behaviour exists, except, perhaps, in a very small fire. If this approach is adopted, no test data is needed, because no quantitative link exists between data and the rate of increase of the t^2-fires.

It has been argued that an exponential growth-rate expression would be better, but this theory is equally limited, and no quantitative link between test data and the growth rates exist. Evidently, an exponential growth-rate expression would better capture the rapid increase of intensity of fire when approaching flashover.

A few deterministic models exist to calculate fire growth in simple scenarios. These compare the real fire performance of products. They take input data from the cone calorimeter. Such models have been used successfully, however, they are yet to be extended to a methodology applicable to general building design problems.

Smoke and toxicity:

There has been much written on smoke and toxic gases in the past 30 years. However, the data is rarely in such a form that it could be applied to quantitative hazard assessment, in a scenario different from the test scenario.

Also, the data has not been scaled with the amount of product burned. The units of smokiness may also be such that no way exists to make it fit to the fire growth calculation methods.

For quantitative analysis, data should be expressed either as yields (dimensionless, mass of species *i* produced per mass burned) or in the case of smoke as light absorbing cross section (in m^2) per amount of material burned.

Methods are also appearing to predict the smoke production in ventilation restricted conditions, if the production in well-ventilated conditions are known.

Fire detection:

The engineering treatment of fire detectors resembles the treatment of ignition as a purely thermal process.

To predict a detector response, the response dynamics of a detector need to be known. For Example: the description of sprinklers by the RTI and response temperature fulfils these requirements. Similar response models are also available for smoke detectors [4], but the effort needed to derive the parameters through tests is more demanding than in the case of thermal detectors or sprinklers.

Suppression:

Modelling of suppression is in its infancy compared to the modelling of other fire phenomena.

Therefore, design of suppression systems or performance assessments must rely on empirical knowledge or applicable large-scale testing.

Fire resistance:

The accuracy of calculation methods for the fire resistance of loadbearing structures is significantly better than the accuracy of fire-growth models.

On the other hand, the performance of separating elements, in which the loss of integrity is critical, can seldom be predicted by calculation.

As regards fire resistance, there is a need to develop methods that would allow extrapolation of standard fire-test results to any other kind of fire exposure history. Such methods are available for the protection of steel, but hardly any exist for other types of structures or structural components. Activities underway in CIB W14, the Eurocodes, and in a joint effort of the SFPE and the American Society of Civil Engineers (ASCE) are addressing many of these issues.

In summary, only a fraction of the huge amount of test data available can be applied in quantitative methods for fire-safety design. The benefit to be gained by serving the needs of both the performance-based design methods and the classification-based design methods is evident. Taking into account the needs of performance-based design methods while developing new test methods would also increase the understanding of the purpose of testing. This would be seen by the industry as a significant benefit in the same way as the increased understanding of the code intent has been seen as a benefit of the performance-based codes.

A major change in the policy of regulators and Standards organisations is needed to provide appropriate test methods for performance-based design. It is a duty of the fire-safety engineering community to carry their needs, eg: to those formulating the national opinion on the strategies of international standardisation committees. The strategy of ISO/TC92 being developed is where such needs should be included.

The shortage of data applicable to engineering calculation methods impedes the advancement of performance-based design. If reliable data is not available, it is too easy to request that the design fulfil prescriptive requirements. It is clear that international co-operation in this area would be of great benefit.

2.3 Research capabilities, facilities, and funding

Significant testing, evaluation, and data is required to work within a performance-based fire-safety design structure.

Performance-based design methods are required, engineering analysis and design tools need to be assessed and developed, fire-test data for engineering analysis and design tools are needed, and corresponding test methods and apparatus need to be developed.

This requires significant research and funding. It is not likely that within any one country, there will be sufficient resources to target all of these needs. This highlights the need for:

- prioritising research efforts;
- focusing on strengths within a country (government and private sector);
- establishing government and private-sector collaborations to ensure high-priority efforts are accomplished in a timely manner; and
- seeking research capabilities and products (engineering tools and methods, and fire-test methods, apparatus and data) outside of ones country, and for establishing international collaborations.

2.4 Summary

In summary this section has provided a general overview of building-design technology required to support a performance-based regulatory system, with a focus on fire safety engineering concerns. In future editions and supplements, it is anticipated that the discussion will include other areas of building technology and information technology that may lead to better development, implementation, and support of a performance-based building regulatory system.

2.5 Country specific experiences

Japan

This paper summarises the technology used in our current building code, and the technical requirements expected to be implemented in a new version. Performance-based concepts are to be introduced to this code.

Structural safety

Two types of requirements are imposed simultaneously. There are provisions for different construction elements - such as timber or reinforced concrete - in order to ensure uniform performance.

There are also provisions for verification through calculation. Such calculation methods comprise dual modes, these include the:

- calculation of stresses in "elastic" elements based on "allowable-stress concepts" for dead-, live-, wind-, and snow loads, as well as medium-level earthquake motion, and;
- calculation of "load-carrying capacities" against strong earthquake motion taking account of ductility characteristics in "plastic" range.

Fire safety

Specific measures to ensure the safety of people and amenities in case of fire are provided independently. These take into consideration:

- methods of egress including stairs and staircases;
- travel distances;
- restriction of interior finishings;
- fire-resistance rating of construction methods for carcasses/spatial dividers;
- maximum floor area of fire compartments;
- fire protections of openings to thwart adjacent fires; and,
- facilities for fire brigade, etc.

For fire rating, regulations establish the performance assessments and certification systems are based on standard tests. They cover materials, slabs, beams, walls, columns or fire doors.

Issues- structural safety

It is common design practice in Japan to verify structural safety through calculations. This means it must be ensured that stresses and/or deformities do not exceed allowable limits when measured against given design values of loads, external wind and earthquake motion.

Problems to be solved include:

- identifying the "objectives" and "goals" of the requirements of a building code. (For Example: in Japan, the prevention of the structural collapse against probable maximum earthquake would be required as a minimum standard in order to ensure life safety).
- developing appropriate "verification methods" to examine and uphold the objectives and goals set for the building system.

Fire safety

Problems to be solved include:

- identifying the objectives and goals of the requirements of the code. (For Example: the prevention of the collapse of large-scale buildings during a fire, will be required to protect the surroundings from damage.);
- developing appropriate "methods" to predict "situations" which may occur on, in, or around buildings in case of fire. These would be based on the characteristics of building systems and their construction methods. Also taken into consideration would be the properties of materials used. (For Example: the prediction of fire occurrence, development, and diffusion to other spaces or adjacent properties.);
- developing "verification methods" to examine the capability of buildings and parts to ensure they comply with all objectives and goals. (Note: these methods are expected to be "practical" and "applicable" to existing engineering industry practices.)

Toward problem solving: structural safety

New verification methods are being developed and put to practical use. It is hoped that such methods will estimate the responses of structural systems faced with strong earthquake motions. Such responses include stresses, displacements and deformities in plastic range, energy absorption, etc.

It is planned to incorporate these new verification methods into our building code. However, conventional verification methods or specification type requirements will also remain. These will still be used, when appropriate, to verify safety levels taking into account existing engineering practices in what is known as the small-scale construction industry.

Fire safety

Where the objectives and goals of the building code have been clearly identified, it is intended to develop and establish appropriate verification methods which may prove more realistic and applicable to industry needs. These methods will then be implemented into the code.

Key concepts to be introduced in the new verification method/s include:

- predicting the scale and feature of fire and its development. This will be done by applying a ”fire model” where “variables” such as fire loads; use and occupation of buildings; characteristics of interior finishings, openings, fire equipment, etc are all examined and considered;
- assessing the “fire endurance capability” of structural systems based on the above “fire model”;
- verifying life-safety issues using the above fire model, taking account of factors such as the degree of affection imposed on structural members; dependability of fire detection; fire brigade action and smoke control; and
- incorporating fire-resistance ratings, combustibility classing of materials, smoke-control capacities and travel distances, etc., as variables in the fire model or verification process in the light of set objectives and goals.

Where it may be difficult to define the correlation between objectives and goals, and characteristics of buildings/etc in proper engineering terms, then current prescriptive provisions may remain if found to satisfy the objectives/goals.

The US Experience

Work has begun on a fire-engineering design guide for the United States. The contents are based on input from national building and fire communities and a review of fire-engineering design guides from around the world.

The starting point for the guide is the definition of performance-based, fire-safety design: an engineering approach to fire-protection design based on:

- agreed fire-safety goals, loss objectives, and design objectives;
- deterministic and probabilistic evaluation of fire-initiation, growth, and development;
- the physical and chemical properties of fire and fire effluents; and
- quantitative assessment of the effectiveness of design alternatives against loss objectives and performance objectives..[xxvi]

Viewing performance-based, fire-safety design as an engineering process, it can be divided into seven fundamental steps:

- identification of site or project information;
- identification of fire-safety goals and objectives;
- development of performance criteria and design criteria;
- development of fire scenarios;
- development of design fires;
- development and evaluation of trial designs, and

- development of final documentation.

These seven steps, found in most fire-safety engineering guidelines, are the basis for a performance-based, fire-safety analysis and design approach. The United States is looking at setting-up a similar scheme.

1. Identify site or project information

The first step is to gather information about the site, structure, facility or process.

This includes building characteristics, such as size, layout, use, and construction, with particular attention paid to special features such as high ceilings and large volume spaces (eg: atria or warehouses), or where high-occupant loading might be expected (eg: malls, auditoriums and stadiums).

Operational characteristics relate to specific functions of the building. This category includes special or unique processes, hazardous-material use or storage, areas of high-value equipment, and areas where down-time needs to be effectively zero, such as in a semiconductor clean room.
Finally, it is important to classify occupants. This classification will vary according to the building's use (eg: residential versus business). Classification should consider occupants' age; ability; whether people sleep in the building, and whether people can make their own decisions, or should be classified as groups to be assisted (eg: families with small children or school children).

2. Identify fire-safety goals and objectives

Goals are non-controversial statements, easy to agree upon and measured qualitatively, if measured at all.

In the area of fire safety, there are four goals that fit this definition:

- protection of life;
- protection of property;
- protection of mission, and
- protection of the environment from the unwanted effects of fire and fire control.

In the fire-safety design area, a fire-safety goal a statement that reflects the client's expectation of the safety levels desired. This definition is valid where the term "client" may be replaced with the term "public"; or from a corporate perspective, using the term "stakeholder"

As an example of how a fire-safety goal might appear in a code, consider the following from the 1994 NFPA Life Safety Code®: "[the code should] protect occupants - not intimate with the initial fire development - from loss of life."[xxvii]

Similarly, a business owner's protection mission might be to "protect my business from operational losses due to the damaging effects of fire." These are statements with which everyone can agree. However, everyone may not agree on how best to apply them. This is where objectives play a critical role.

Objectives are used to provide direction as to how a goal might be met. They are normally stated in quantifiable terms. In a performance-based code, a functional objective might describe how a building, or its systems, will meet a fire-safety goal.

An example might be to "give people - not intimate with the initial fire development - adequate time to reach a safe place without being overcome by the effects of fire." In essence, this says that the building and its systems must enable people to escape to a safe place to meet "life safety" goals.

In a performance-based design, however, an objective could be expressed as a client-loss objective. That is, some indication of the level of loss the client can tolerate.

An example of this might be to "protect the piece of equipment in Room X against the effects of fire such that a return to full operation can occur within 24 hours." Here, in order to meet its goal, the objective aims to ensure that equipment is not out of service for more than 24 hours.

Once the functional objectives or loss objectives are clear, there must be a means of identifying the level buildings and systems should perform in order to meet these objectives.

This is done through statements called performance requirements. Performance requirements are statements of the level of performance to be met by building materials, assemblies, systems, components, and construction methods. These requirements should have quantifiable parameters, and be measurable or calculable.

For Example: in a performance-based code, one might see performance requirements such as, "limit the spread of fire to the room of origin, alert the occupants prior to smoke spread beyond the room of origin, and maintain tenable conditions in the paths of egress until the occupants reach a safe place." Each of these requirements relates to how the building and its systems should perform in meeting a specific life-safety goal and functional objective. Each can be measured or calculated.

One can develop performance requirements for mission protection as well, such as, "limit the deposition of corrosive products of combustion to less than those quantities that would cause irreversible damage".

In this case, if the limit of product deposition is known, as well as the production and deposition rate, a design can be made to this requirement. This leads to the metrics against which the performance requirements will be assessed.

3: Develop performance criteria, design criteria

Performance criteria are threshold limits that describe a desired level of performance.

For Example: a common performance criterion is to prevent flashover in the room of origin. This is something that people can agree on as a "good thing" in preventing the spread of fire. However, it may be insufficient as a criterion for a design engineer who must select a fire-protection strategy to accomplish it.

Flashover is dependent upon a variety of factors, including compartment geometry and volume; fuel type; loading and characteristics, and compartment ventilation.

As such, a number of design parameters will be necessary to describe the means of preventing flashover. These are the design criteria: the metrics against which performance criteria are assessed.

Design criteria, unlike performance criteria, must be directly measurable or calculable (eg: temperature, thermal radiation, and smoke-layer depth). These become the criteria on which a design will be based.

To help put all these different requirements and criteria into perspective, consider the following example based on the goal of life safety.

The fire-safety goal is to protect people - not intimate with the first materials burning - from loss of life. (This is easy to agree with yet difficult to quantify.).

To meet this goal, one functional objective might be to provide people with adequate time to reach a safe place without being overcome by the effects of fire. (This provides a little more detail: one could imply that protection must be provided against heat, thermal radiation and smoke.)

To meet this objective, one performance requirement is to limit the fire spread to the room of origin.

To meet this performance requirement, one can establish the performance criterion of preventing flashover in the room of origin. (This is based on the fact that fire spread beyond the room of origin almost always occurs after flashover when the upper layer gases ignite and spread the fire front.)

To meet the performance criterion, an engineer might establish a set of design criteria such as a maximum upper-layer temperature of 500°C and a maximum heat flux at floor level of 20 kW/m^2. (In many cases, several design criteria will be needed.)

4: Develop fire scenarios

A fire scenario is a description of a fire from ignition, through burning, to eventual decay.

The range of fire scenarios developed should reflect both probabilistic and deterministic considerations. That is, how likely the fire is to occur, and if it does occur, how is it expected to develop and spread. There are many factors that one must consider when developing fire scenarios, including the:

- pre-fire situation: building, compartment, conditions;
- ignition sources: temperature, energy, time and area of contact with potential fuels;
- initial fuels: state, surface area to mass ratio, rate of heat release;
- secondary fuels: proximity to initial fuels, amount, distribution;
- extension potential: beyond compartment, structure, area (if outside);
- target locations: note target items or areas associated with client loss objectives along the expected route of spread for fire and fire effluence;
- occupant condition: alert, asleep, disabled, infant, elderly, etc;
- critical factors: ventilation (windows, doors), environmental, operational; and
- relevant statistical data.

In reviewing fire-engineering approaches from around the world, each one of the approaches considers the above factors, often under the similar headings:

- fire initiation and development;
- smoke development and management;
- fire spread and management;
- fire detection and suppression;
- occupant notification and movement to safety; and
- fire department notification and response.

Each of these must be considered in any performance-based fire-safety analysis and design approach for the United States.

5: Develop design fires

A design fire is an engineering description of a specific fire scenario. It may be characterised by parameters such as heat-release rate, fire-growth rate, species production, species-production rate, or other fire-related parameters that can be measured or calculated.

The most common way of characterising a design fire is through the use of a fire-growth curve. Fire-growth curve characteristics include a growth period, peak heat-release rate, steady-burning period and decay. A curve such as this would need to be adjusted accordingly for use in a design problem, especially where additional items become ignited and contribute to the fire. Design-fire curves need to be developed for every fire scenario considered for a compartment, building, structure, or process.

6: Develop and evaluate design alternatives

After the fire scenarios and design-fire curves have been developed, the next step is to develop and evaluate design alternatives.

A number of fire-safety design alternatives should be evaluated at this step, including the code-prescribed requirements. (The code-prescribed requirements often serve as a baseline for evaluation and review, and it is important to know if the code requirements meet the design objectives, exceed them, or fall short of them.)

The evaluation process is repetitive where a variety of fire-safety measures are evaluated against the design-fire curves and the design objectives. The addition of smoke detectors or automatic sprinklers, modifications to the ventilation characteristics, and variations to construction materials, interior finish and contents are evaluated during this process.

7: Documentation and specifications

The final step in the process is documenting the analysis and design and preparing equipment and installation specifications.

The analysis and design report will be a critical factor in gaining the acceptance of a performance-based design. It needs to outline the steps taken during the analysis and design, and present the results in a manner acceptable to authorities and clients.

At a minimum, the report should include:

- intent of the analysis or design: the reasons it was undertaken;
- statement of design philosophy: the approach taken, why it was taken, what assumptions were made, and what engineering tools and methodologies were applied;
- site or project information: hazard analysis and description of the structure, process and/or occupants, eg: hazards, risks, construction,

materials, use, layout, existing systems, occupant characteristics, etc;

- statement of client goals and objectives: the agreed goals and objectives of the performance-based analysis or design, who agreed and when;
- performance criteria: the design and performance criteria and the performance requirements to which they relate, including any safety or reliability factors applied, and support for safety or reliability factors where necessary;
- fire scenarios: the fire scenarios used, bases for selecting and rejecting fire scenarios used, assumptions and restrictions.
- design fires the design fires used, bases for selecting and rejecting design fires, assumptions and limitations.
- candidate designs: the design alternatives selected, bases for selecting and rejecting design alternatives, assumptions, limitations and uncertainties. This should include the specific design objective value (Q'_{do}) and the critical fire-size value (Q'_{crit}) used, comparison of results with the performance criteria and design objectives and a discussion of the sensitivity of the selected design alternative to changes in the building use, contents, occupants, etc;
- uncertainty factors: any uncertainty factors, how they were derived, and/or appropriate references;
- cost-benefit analyses: where cost is a factor in the decision-making process, cost-benefit analyses should be included as well;

- design tools and methods used: the engineering tools and methods used in the analysis or design, including appropriate references, assumptions, limitations, uncertainties, engineering judgments, input data, validation data or procedures, and sensitivity analysis;
- test, inspection and maintenance requirements: test procedures, maintenance schedules, etc;
- fire-safety management concerns: discussion on changes in use, contents or materials, training and education for building staff and occupants, etc; and
- references: software documentation, journal reports, handbook references, technical data sheets, fire test results, etc.

With regard the design and fire-safety management aspects, the use of a building should be considered. There should be clear indicators, in the design documentation, as to the limits of the design and to any specific factors that warrant a revaluation or redesign.

These may include change of occupancy, significant change of fuel loading, or significant modifications to the building or its systems.

Concerning equipment-installation specifications, a performance-based analysis and design may be undertaken. However, at the end of the day, the installation of the equipment, systems and features will have to be specified in exactly the way it is done today.

The analysis and design may consider a variety of features, and the resulting design may have modified sprinkler spacing, exit widths, or number of doors, but the installation specification will still indicate how many, what size, and where they go.

In this regard, the future for installers and inspectors will not significantly change.

3. Education

3.1 Scope

The process of change - particularly one as significant as the introduction of a performance-based environment - causes anxieties and concerns that must be addressed through education.

When technical requirements for building and construction are prescribed in manuals or codes, it is easy to ensure that rules and standards are met. Practitioners are guided by detailed specifications and provisions at the design, construction and certification stages. As a consequence, there is little need to deviate from a delineated path.

Similarly, the education of officials using prescriptive building codes is a fairly straightforward matter. Relevant programs focus on becoming acquainted with specific technical requirements, as well as instructing students on where to find references and how clauses are to be interpreted.

However, with the introduction of a performance-based building code, an entirely new environment is introduced. Requirements and specifications are no longer prescribed; only the performance output is defined.

This situation, while encouraging innovation and flexibility, places a huge responsibility on individuals involved at every stage of the process. The ability to verify performance-based design and construction techniques becomes a crucial issue. There is a need for building practitioners and officials to think beyond the historical bounds of their profession. They must be able to view many issues from a broader perspective. They must be able to work competently in an environment that has less structure and rules.

Risk and liability are important factors in the performance scenario. Previously, building practitioners knew that if they followed the requirements in the prescriptive documentation, they were reasonably certain of not being held accountable for any deleterious effects arising from construction.

With the introduction of a performance-based code, however, as greater levels of professional judgment and independence are called for, there is an increased need for the issue of risk to be managed appropriately. Research indicates that there are two crucial issues, which apply.

- Firstly, change to a code creates a need for education/training. The greater the number or complexity of changes, the greater that need becomes.

- Secondly, without a comprehensive education program in place, application of the options available within the performance environment, will be at best perfunctory.

National consistency is a critical factor in the equation. Any education program implemented in multi-jurisdictional countries must take account of the need for developing a program, which reflects a national focus, as well as highlighting specific local interests or other regional differences.

3.2 The need for education

When changes, which have significant impact on the regulatory environment, are proposed, the issue of education is a critical factor in the success or failure of that proposal. The move to a performance-based system of regulation will not only impact on building regulation but will have consequences for other legislation.

In regard to the discipline of building and building regulation, there is always a need for education. Whether codes are predominantly prescriptive or performance-based, changes occur continuously across the industry as new methods, concepts, materials and technologies evolve.

Changes in administration and related processing procedures also have varying degrees of impact. In all cases, it is necessary to pass on information to relevant parties. The nature of the change will determine the type of information, as well as the target audience.

Within the regulatory environment, rules and regulations (be they prescriptive or performance-based) form the basis of the practitioner's livelihood. Without sufficient, timely and accessible instruction, practitioners are unable to maintain the knowledge to perform their professional roles.

An inordinate amount of information is passed on to practitioners throughout their careers. However, notwithstanding the worthwhile objectives of continuing professional development programs, and the efforts of professional and industry and trade associations in general, it is probably an impossible feat to expect practitioners to keep fully abreast of changes without the provision of specific education programs.

In most countries a change to a performance-based code has quite rightly heralded a flurry of education initiatives. This is a positive move. (However, it may also be appropriate to reflect whether before the introduction of performance codes, there was in fact sufficient attention ascribed to education and training).

It will be difficult for regulators and others in the industry to keep working, and yet be expected to absorb information and changes that affect the very substance of their employment.

Issues of responsibility for education, associated costs and avenues for reaching audiences are covered in following sections in this paper.

Code development

The development of any building code involves research and development stages.

Once a code is completed and "out in the field", and as technology changes and construction techniques are refined, a technical building code should change accordingly. The process of creating these changes should involve a cross-section of the construction/building industry, such as authorities, builders, owners, and regulators.

Changes should be accessible to all relevant individuals. The reasoning for the changes, along with the meaning of a change, should also be disseminated.

Building legislation

Administrative processes need to change to keep abreast of the development in technology and construction techniques.

Changes such as the introduction of Private Certification would have an impact on the liability of the individuals involved, as well as the organisations that provide professional indemnity insurance cover.

Any new administrative processes need to be understood by the individuals who partake in them. Hence, not only is the building industry in need of continual education but so are peripheral industries.

Other legislation

Building legislation is not always consolidated into one piece of text administered by one authority. When this is the case, legislation that "overlaps" a building code needs to be reviewed to ensure that conflict between legislation does not occur.

Understanding the legal hierarchy of legislation is a key component in ensuring that conflict does not occur. The other pieces of legislation, for example, may be prescriptive, yet the building legislation may be performance based and if a performance-based building is constructed, it may cause conflict. This could result in costly rectification by the building owner/etc.

The building code authors should ensure that all levels of government are regularly consulted and given the opportunity to advise of the ensuing political environment and its possible impact on the building regulatory system.

Communication with, and education of, the authorities that enforce other legislation is vital in order to overcome conflicts and potential non-compliances.

3.3 Who requires education?

In devising an education strategy one of the fundamental questions to be addressed is the target audience.

From this process, it will then be possible to identify the different types of training and formal programs, which may need to be instituted.

There are three main categories warranting some measure of education, namely:

- building or regulatory officials (including enforcement officers/authority, as well as regulation policy makers);
- industry; and
- the community.

All three groups require different approaches and levels of knowledge. It is fair to argue that no one category is more important than another. However, different groups may require "prioritising" depending on the relevant regulatory environment.

Within the three groupings there are further classifications to be made which will help determine the correct strategy. For Example: industry can be sub-categorised as follows:

- those involved in the preliminary design stages, such as architects and designers;
- builders and other para-professionals, eg. plumbers and electricians;
- the varying engineering streams;
- trade and professional associations; and
- property owners and investors.

3.4 Addressing target audience perceptions

To implement a program that addresses the attitudes of target audiences (be they representatives of industry, government or the community), it is important to garner a good understanding of their feelings and levels of knowledge. In this way individuals are encouraged to participate in programs because they have had some degree of input at the developmental stage.

Although a general understanding can exist about a group's attitude to change, and specifically change to a performance code, it is dangerous to make generalised assumptions.

Training and education programs built about the premise that the educator (or regulator) knows the problems and attitudes of the target group will inevitably fall short of the mark.

This will occur either because the true depth of the attitude is not understood, or because the current level of skill and knowledge is not appreciated. Another danger for the well intentioned, but nonetheless misguided education officer, is that if detailed knowledge of the target group's current status (in terms of education needs and perceived threats) is not sought, the resulting program is likely to be shunned because of the lack of ownership.

3.5 Education development

It is imperative for those involved in developing education programs to have a good appreciation of the skill and knowledge of the target audience.

A number of assessments need to be made to determine the shape of the program. Whether or not new courses are developed, or existing curricula amended, will depend on the willingness of industry and/or those responsible for regulatory administration, to give priority to the education needs of the target audience and available resources, both financial and human.

Evaluation of current curricula

Before new or additional topics are developed, comprehensive analysis of existing curricula, in consultation with education providers, needs to occur. While this can be fairly labour intensive, depending on the number and range of programs on offer, it is essential to provide a streamlined curriculum.

Thus, the evaluation of curricula might not only result in adding information, but also amending existing topics to take account of new performance provisions. Some information may need to be deleted, or the emphasis of the teaching require a different focus.

The degree of change to curricula will obviously reflect the degree of changes in codes and legislation. The more substantial the differences, the greater the need to amend education programs.

In countries where there is not a standard curriculum in place across educational institutions, thought could be given to using the introduction of a performance-based code as an incentive for streamlining curricula. The success of such an endeavour would, however, depend on the reaction of education providers to such a scheme. There may, however, be a window of opportunity to set uniform objectives in terms of curricula output.

Academic needs

Close liaison with academic institutions is a key issue. Changes to existing curricula from an academic viewpoint requires considerable lead time.

In some countries it will be appropriate to strengthen links between relevant professional organisations and educational institutions to effect changes in curricula. In other cases, the government may be most suited to influence the providers of education.

In any event, a direct financial cost will most likely be incurred, as education providers will need to analyse existing programs and develop new course work.

Practical application

Education programs, which provide instruction only in the theory of a performance-based code, will not fulfil the needs of practitioners. It will be critical that a component of training be devoted to examples of design and construction performance solutions.

While it could be argued that without the underlying theory, students will fail to realise the importance of the new provisions, it is equally true that without constantly providing examples of how the theory will work in practise, those same students will find it difficult to translate their "classroom" knowledge to their working environment.

Moreover, if training sessions are delivered without seeking either participant interaction or the drawing forth case studies, it is likely that interest will be lost and information not absorbed.

Ideally, in addition to classroom case studies, programs would incorporate site visits. Notwithstanding resource implications, this form of practical application has a number of considerable benefits:

- it places students in an environment in which they are familiar and at ease ;
- the opportunity to at least partially test new ideas is instantly available;
- consequential ideas are likely to be raised amongst students when actually visiting construction sites; and
- the opportunity to see theories put into practice in the work situation, cannot be an underestimated as a most valuable training tool.

3.6 Awareness training

Making people aware of impending changes is an important part of an education strategy.

It provides opportunities to those involved in a code's development as it opens up the process to views that might have been disregarded. The feedback by participants at the awareness training stage can be useful for the development of the code and in shaping the longer-term education strategy.

Importantly, it allows individuals and organisations to have ownership of the new performance regime. While collaboration and participation may sometimes be regarded as a costly exercise, the eventual benefits can be substantial and can help to overcome resistance and frustration.

Content

The objectives and timing of awareness training will, to a large degree, determine the content and presentation style of the program.

If awareness training is implemented at the penultimate stage of the code development process, then content will need to be presented as a *fait accompli* and should reflect the major changes to technical provisions and underlying legislation.

Depending on the target audience (and their exposure to the new provisions), workshops could be implemented allowing participants to try new concepts within the safety of the training environment.

It may be, however, that during the code development, several awareness programs are run. For Example: part way through development, awareness training could outline the major proposed changes and seek feedback from participants about how these changes might be handled.

Thus, a key issue in determining the content of awareness training is the early identification of objectives. It is equally important to convey this to participants, as well as highlighting their required participation and any roles they are to assume.

Another factor to be considered in terms of content is ensuring that the information presented is as precise as possible; that objectives are well-defined, and wherever possible, code developers and other specialists are made available for delivering information and helping with sessions.

The content will be shaped by the needs of the target audience. Better results will be possible if the views of participants are sought before awareness training is implemented.

This type of research can be accommodated through relevant industry, trade and professional associations or other representative groups. Such a process avoids the situation where session presenters provide copious details about matters not critical to the audience.

If such research is not undertaken, then skilful facilitators should seek this information at the outset of the training.

Timing

The timing of the awareness training will be influenced by the program and the needs of the target audience. If the process is intended to elicit feedback for the development of the new code, it should be implemented well before the code development stage nears completion.

A careful balance must be struck, however, so that delivery does not occur too early when there is a lack of substantive information to offer.

If the seeking of feedback is not paramount to the process, awareness training may well be left until the code is ready for adoption. In this way, people are encouraged to attend by the imminence of the change. The danger here is that resistance may already be well entrenched and much of the "training" need to be spent on allaying fears and defending new concepts and practises.

Ideally, an awareness program should have several stages.

The first stage might be to announce proposed changes at a general level. The next part of the process could include sessions to gain feedback from potential users of the new provisions, followed by a final stage which provides participants with the opportunity to test the performance concepts and obtain a better understanding of the finer detail. At this point, audiences will benefit from practical exercises and the opportunity to work through case studies related to their own working experiences.

Audience

As a new code is being developed, most related industry people will benefit from awareness training. The needs of the audience will require analysis so the most appropriate program can be devised. Public awareness can be addressed through the media. If relevant consumer groups exist they can relay information.

Depending on how the new code is developed and the framework within each country, it may be useful to bring together industry and government in forums. This allows an exchange of viewpoints and provides insights, which might not usually be exposed. The downside of such an approach is that all the needs of diverse groups are rarely met.

Thus, an optimum strategy might be one where forums are convened at which general information is exchanged and specific meetings conducted on an occupational basis. In this way, participants can feel somewhat more relaxed about discussing issues of real importance to them. It also allows presenters and facilitators the luxury of developing specific material that hones in on issues of singular interest to occupational groups.

3.7 Educational content

There are a number of areas that will need to be addressed under educational content and this will depend on the regulatory changes intended and their target audience.

System maintenance

As the use of performance solutions increases so does the move from passive systems to active. It is these active systems, in particular, that form part of a performance-based system as approval must be operational at all times throughout the life of the building. To assist in ensuring this happens these systems need to be maintained.

Why?

Education of building professionals and owners in relation to maintenance is essential so that the conditions and expectations of operation of a system in a performance-based approval can be guaranteed and monitored. As performance building regulations are new, along with the concept of stringent maintenance for system performance, all involved parties should be trained to ensure that they are provided with the appropriate level of understanding of the type of maintenance that is necessary and the reason for it.

How?

Records of maintenance and procedures should be kept so all users understand what their responsibilities are during the life of the building. For each building procedures - outlining minimum maintenance levels required - are to be established by those involved in the design, construction and approval process.

Who?

The education of all people involved with the building is necessary to ensure the validity of the approval. The building owner, designers, installation and maintenance contractors, and the approval authorities all require education to ensure they understand the reasoning of a performance-based approval.

What?

The people being educated need to have an understanding of the systems within the building and how they operate. They also need to be aware of how the building's systems interface and what components allow for this.

They also need to appreciate and understand the maintenance and testing required for all the systems. Knowing how to record maintenance performance and where to store this information is also important.

Consequences.

Inadequate education may have significant consequences not only on the approval but also on building occupants. Little education will result in: an inability to understanding the building's systems; insufficient maintenance and testing, and potential system(s) failure at the time of required operation.

Supporting documentation.

The documentation of the building design and commissioning should be stored in an accessible repository. The method of storing this information should be in a pre-agreed form. It should be available to building owners and appropriate authorities to review the history of a building and determine the conditions or reasoning of a particular approval decision. This could be beneficial when proposing alterations to a building.

3.8 Bridging curriculum

Practitioners will have to upgrade skills and knowledge to gain the competence to comply with the new performance provisions. Part of the difficulty for those working in the industry is a general reluctance to undertake additional training. Moreover, issues of access to training become crucial, especially to those in the private sector.

It may be necessary to develop courses and other types of instruction off-site from educational institutions allowing more flexibility. Cost is another factor, in terms of lost business time and additional training fees.

Experience shows that if new competencies are not made mandatory, it is unlikely practitioners will undertake training once in the workforce.

Content

The content of bridging curricula will largely focus on the "new" concepts and philosophies in the performance code. The subjects included in a bridging program include:

- underlying reasons for the performance provisions;
- legislative background and changes to regulations;
- the performance hierarchy;
- differences between prescriptive requirements and performance provisions;
- fire engineering;
- issues of risk and liability; and
- the ability to solve problems and think laterally.
-

Timing

It is unlikely that bridging courses would have any impact if implemented before the introduction of a new code. Ideally, programs should be ready for implementation as the code is adopted, thereby assuring practitioners of information and training from the outset.

In many countries, the sheer numbers of practitioners and the slow uptake of the new provisions will probably require bridging courses over an extended period. Courses may well be most successful if tied into continuing professional development programs through trade associations.

Audience

Occupational groups in the industry who use prescriptive building codes will require some type of bridging training. Just as an awareness program will reflect the differing needs of the target audience, so too will bridging courses.

3.9 Providers of education and training

Within an education framework differing roles will be ascribed to a number of parties. The specific environment within each country will influence the roles of players, but some generalities do exist.

Education providers will vary according to training or the program being implemented. Most importantly, there is a need for linking of the various players so that each is able to provide input and support.

Thus, it may be worthwhile to establish a broad education network where information can be exchanged. In this way, providers are able to prepare in advance for incoming code and/or legislative changes and government instrumentalities are able to recognise resource implications.

Government

Generally, it is the domain of government to make and enact legislative changes, having given heed to industry requirements. If the performance code is adopted, and governments assume no further role, the passage of education and development strategies may be extremely slow and the uptake of the new provisions sporadic.

It is incumbent on government to ensure that the performance code can be readily adopted by industry. Part of this responsibility lies with education and training.

In some countries direct links with education providers may exist and thus government could help education providers and institutions.

Financial resources may be needed for curricula development or thought given to levying industry to provide appropriate education opportunities to practitioners.

Overall, however, it would not appear to be the role of government to directly deliver training, though it may be useful to provide spokespersons at introductory forums/etc.

If governments take a less visible role, however, it does not diminish its responsibilities. Assuming a role of coordination is an appropriate duty for governments and a crucial element in bringing together stakeholders. Governments' roles might therefore be largely confined to those activities which underpin an effective strategy, including:

- encouraging industry associations and professional bodies to inform and educate members of the new code;
- providing seed funding for development of revised programs;
- bringing together the various players for exchange of information; and
- ensuring consistency in the program content.

Code writers

Code writers are important in the education process. They can provide information about how and why the code was developed. During the development stage they should address forums and collate feedback. Their expert knowledge can be used during bridging training, to provide insights about interpretation of clauses.

Control authorities

Local authorities may include individuals in contact with industry. For this reason they are a potential source of valuable information.

Local authorities often understand the anxieties of practitioners. Thus an exchange-of-information framework between industry, code writers and education providers, should be in place.

During awareness training, industry may respond positively to local authorities being involved, if a relationship between the two has been established.

Generally, however, individuals in local authorities are not usually involved in training in the performing of their day-to-day tasks. Therefore it will be necessary to provide facilitation and presentation skills, if training is delivered via local authorities.

Universities and other tertiary institutions

Tertiary institutions are an acknowledged source of learning. Teaching staff are skilled at providing instruction. and they are set up to deliver in-house formal education.

There may, however, be scope for university staff to provide off-site courses, similar to long-distance education courses. It may be possible for qualified teachers to deliver short courses or programs off-site to practitioners. This addresses one of the issues surrounding adult education, which is an adult's, reluctance to re-enter the "classroom".

Industry associations and professional organisations

These are valuable links in the provision of education. Because many practitioners already belong to an association, relationships and contacts have been established. Information about the performance code can be channelled through existing avenues such as information seminars and other regular meetings.

Ideally, industry, through its associations and professional groups, would be involved in the code development. Thus, a sense of ownership can be built upon as long as channels of information remain open between industry groups and government, including code writers.

3.10 Delivery systems

There are a number of options in regard to delivery systems. In-situ programs at tertiary institutions are one method of instructing students in building and construction curricula.

Another option may be programs at technical colleges, which have always played a role in educating construction students.

The advantage of these institutions may be accessibility: - often technical colleges are situated outside capital cities and other areas where universities conglomerate. Technical colleges might offer a less-threatening environment to practitioners, many of whom will not have undertaken any kind of formal study since attaining their final qualification.

Distance education is increasing and its benefits include:

- accessibility (students can study at home, in their own time);
- the ability to work at ones own pace and cost (greatly diminished associated travel costs).

While students work in isolation for lengthy periods, most courses include interactive sessions available via television, modem, Internet and telephone/etc. The increasing use of interactive electronic communication is making self-study a more attractive option for many people.

If a large number of practitioners are employed in one site (for example by a local authority) it may be possible to arrange in-house training.

This does not necessarily mean that resident staff develop or implement the training. These functions could be outsourced.

The advantage of implementing on-site education programs is the level of commitment that the organisation is demonstrating. This sends a positive message to employees who undertake the training and also ensures that instruction actually takes place.

3.11 Continuing education

Continuing education is almost an alternative to bridging courses. Its viability will depend on whether mandatory pre-requisites are put in place to practise with performance provisions.

If mandatory qualifications are not necessary, continuing education will assume an even greater importance in the context of an education program. It will become vital to raise the motivation levels of practitioners to continue education opportunities.
Education and training providers must be competent in the development and/or delivery of suitable education and training. Industry organisations and individuals should ensure that education/training providers are suitably qualified and experienced to develop and/or deliver a suitable product.

Accreditation

One means of promoting the attractiveness of continuing education would be to require practitioners to complete further training in order to gain "accreditation".

This may be difficult to resolve in the short term. Some "grandfathering" clauses will be necessary to cover practitioners until they have undertaken the necessary courses or become recognised as "competent"

In any event, there are a number of issues to be considered including the setting up, or revising of, accreditation standards to reflect the new performance provisions. Whether or not matters outside education (such as insurance coverage and management competence) are taken into consideration, is another factor.

In the longer term, there may be merit in linking education standards to accreditation, as it is a means indicating an individual's demonstrated competence to work with performance solutions.

Continuing professional development

Continuing professional development (CPD) schemes are generally run by professional bodies with a view to members maintaining current levels of professional knowledge. In some organisations, CPD schemes are encouraged and members attend seminars and short courses.

If professional organisations have the ability to link CPD schemes to registration, this becomes an avenue for implementing successful education programs. Members who do not avail themselves of programs, will not achieve registration. This, begs the question about the capability of professional bodies to develop and deliver appropriate training.

Professional organisations may decide to outsource training responsibilities for this purpose and levy members to cover the cost of training.

The level of competence of industry

Before assumptions are made about this topic, a sound understanding of professional skills and knowledge across a diverse range of occupational streams is required.
That is, without undertaking a comprehensive skills audit, it would be unwise to assume that industry is either competent or incompetent in its understanding and application of building codes.There are some broad generalisations, which can be made through the analysis of available information.

Throughout the development of the building code, as well as during the education programs, it is possible to gain insight into the "competence" of practitioners.

Through these processes some countries will be able to identify that practitioners are well versed in prescriptive regulations and understand their professional environment.

In some instances, however, the introduction of change (as in a change to a performance code), will highlight certain deficiencies in practitioner competence. In these cases, the successful introduction of performance provisions, including training in new concepts, will be more difficult as the knowledge base is not sufficiently developed to cope.

Other indicators used to gauge industry competence include:

- the incidence of problems as referred to building authorities by aggrieved parties;
- insurance claims arising out of faulty construction practice;
- inquiries to regulatory bodies and professional associations, or possibly construction data collected through a central agency; and
- the sentiments of practitioners expressed at any number of venues.

If the incidence of building failure is low and community expectations and public health and safety are maintained, it is reasonable to assume that the industry is performing to a satisfactory degree. Whether or not individuals are performing to their optimum level of competence is another issue.

One avenue for addressing competence levels is through education programs, which reflect the needs of industry and support a reasonable standard of competence.

For this to occur, close liaisons must exist between education providers and professional and trade associations.

3.12 Feedback

Feedback is a key issue in education programs. As with any project work, the bringing together of key stakeholders from the start of development should not be overlooked.

Through the harnessing of opinions and knowledge, points of import are discovered. Such information will help shape content, emphasis, format and delivery mechanisms. Feedback at the conclusion of any stage of the process should be analysed and incorporated as appropriate.

A structured format of obtaining feedback can be helpful. It sends a positive message to participants that their views are being sought for a purpose, and ensures that convenors have open minds.

It is foolhardy, however, to canvass views and take no further action (even if it is to advise that certain issues are not being acted upon). The sense of ownership is quickly lost if people feel they are being misled or ignored.

Some of the most valuable feedback will be received at the code development stage

Industry views about skill and knowledge levels - its attitudes and fears - are as important as technical issues. They will provide signals about areas of interest and how best a program might overcome problems.

Similarly, at the awareness information and training stage, more information can be sought and analysed for incorporation into more formal and longer-term programs.

Mixed sessions of industry representatives and government officials allows for an exchange of views otherwise not clearly understood. Single professional forums will be likely to access not only more job specific information, but also some of the underlying attitudinal problems.

The success of gaining information is to be able to convince an individual that it is a worthwhile exercise, that any information will be handled with confidentiality and that opinions are valued.

Thus, the feedback process requires skilful handling. It would be of little value to ask questions and reassure participants about the validity of their views if sessions are conducted in a hostile or condescending manner.

3.13 General experience

Development of regulatory changes and implementing related education programs is costly. Sometimes, more so than the cost of the regulatory change itself.

A major consideration in developing education program is the costs involved and the ability to recover some, or all, of the development costs. Access to education and training programs should be available to all industry participants at a fair and reasonable cost.

Depending on the regulatory environment it may be appropriate for governments to subsidise training.

3.14 Country specific experiences:

Australia

A snapshot of the Australian experience highlights achievements in education. Awareness training has been undertaken on a fairly large scale (across all jurisdictions) and feedback indicates a high level of acceptance by participants.

However, by and large, the education strategy has lagged behind the development of the performance code. An awareness program was designed just before *BCA96* was published. Consequently, there was little opportunity for input from stakeholders about content and delivery options.

That noted, the program was designed to be as participative as possible and hands-on case studies were a feature of the training programs.

Continuing education for all professional groups is only now being finalised. There will need to be substantive collaboration with industry and professional associations to realise the objectives of this strategy.

In Australia, a priority order for education has been decided as follows:

- builders, property owners and developers;
- building surveyors and certifiers, fire engineers;
- designers, including draftpersons, architects, engineers; and
- the community.

Overall, educating people about the performance code will take place through established mechanisms. In the case of formal programs for students of recognised tertiary degrees, amended curricula and courses will be available through universities and technical institutions.

In the case of less formal qualifications being sought by practitioners, relevant associations will provide opportunities through continuing professional development (CPD) and other training and awareness courses.

Only one jurisdiction has restricted the use of performance provisions (a tertiary qualification to practise with performance is required in the state of Victoria), all governments are aware of the need for practitioners to undertake some form of upskilling.

This point is being exacerbated by the lack of national consistency in practitioner qualifications and the effect of Commonwealth legislation, which overrides existing state and territory mandatory pre-requisite qualifications. The effect of the legislation allows practitioners registered in any state or territory to practice across all jurisdictions in an equivalent occupation.

An issue in Australia has been the need to "standardise" education relating to *BCA96* so a national focus is provided to people irrespective of where they live. This of course has required the cooperation of all state and territory building administrations. Collaboration on education has been an important part of the process.

New Zealand

Introduction

The Building Industry Authority (the Authority) is an independent, Crown entity in New Zealand, established by the *Building Act 1991*. The Authority has a maximum of eight members, appointed by the Minister of Internal Affairs for a specific term. Members are supported by a small team of technical and professional staff.

The mission of the Authority is to be the single focus for effective building controls that promote health and safety: to manage New Zealand's building legislation.

The Authority administers and reviews the New Zealand Building Code. It updates Approved Documents that specify methods of compliance with the building code. It provides policy advice to government as well as information, advice and education to all sectors of the building industry and the public.

The Authority's role in education

The Authority has a statutory obligation, under Section 12 (g) of the *Building Act*, to disseminate information and provide educational programs on building control matters. A key objective is to improve understanding of building controls through education.

The Authority has technical staff with expertise in the legislation and associated documents. But the staff are not expert in all matters of building work and the Authority does not try to educate everyone about everything to do with construction matters. There are other organisations with technical expertise that help out.

The Authority contracts external presenters - with expertise in building control matters - to assist in the running of at least five nation-wide seminars a year on the Act and building code topics.

The Authority's staff speak at events hosted by other organisations and work on joint education projects with professional associations, such as the Building Owners and Managers Association (BOMA), and the Property and Land Economy Institute of New Zealand (PLEINZ). This amounts to more than 90 presentations a year.

The Authority staff produce educational materials, including an interactive computer-generated tutorial, as well as an Internet web-site.

The Authority's approach to education

A range of strategies has been necessary to be responsive to the building industry needs. There is a balance between the information that the Authority wants to convey and the philosophy of learner-centred[1] education and attitudinal change.

The following factors are important to the success of the Authority's education program:

- establishing and maintaining networks with education providers and professional associations within the building industry;
- making education accessible to all those engaged in the building industry;
- providing structured and systematic training which will ultimately link into the qualifications' framework and continuing professional development initiatives;
- being proactive in seeking opportunities for education;
- being responsive to requests from our customers (both written and verbal);
- adoption of the principles of adult learning; and
- prioritisation by need, size of group, strategic importance, and compliance problems.

● [1] *Learner-centred means that education is focused on the needs of the individual learner, the pace at which the learner wants to attain knowledge revolves around outcomes relevant to the learner.*

Target audiences

The target audiences for building control information are diverse in practice and knowledge. In addition, the information the Authority wants to communicate can simple or complex. These factors are taken into account when designing, marketing and delivering education.

The target audiences include:

- territorial authorities (managers, inspectors, counter staff);
- building certifiers;
- designers (architects, architectural designers, engineers);
- contractors (builders, plumbers, roofers, glaziers);
- suppliers (manufacturers, importers, distributors);
- exporters;
- home owners;
- owners, commercial buildings, building managers, developers;
- occupiers of buildings;
- educators;
- researchers and associated groups;
- government departments and agencies;
- professional institutions and interest groups;
- the relevant minister, and Department of Internal Affairs;
- international administrations; and.
- the media.

It is important for graduates of building-related courses to be aware of building controls before they enter the workplace. Here, the Authority established a dialogue with tertiary institutions involved in building-related courses, as well as the industry-training organisations.

As a result, the Authority commissioned a training-resource package for teaching building controls at an undergraduate level. It contains guidelines for tutors, lesson plans, handouts, posters, and a video. In late 1997, the contents of this pack were turned into a self-directed CD-ROM.

The qualifications' framework

There are 13 tertiary institutions and 10 industry-training organisations (ITOs) involved in training of the building sector.

Of particular significance to the Authority is the work of the Local Government Association ITO in conjunction with Building Officials Institute of NZ (BOINZ). This ITO has developed qualifications for territorial authorities, in particular building and plumbing and drainage inspectors.

Compliance and regulatory-control qualifications are being developed for people who apply and enforce regulations. This will involve a general certificate in compliance and regulatory control, endorsed in particular specialist areas (eg: building inspectors, plumbing and drainlaying inspectors).

The Authority has control over its own program and can try to encourage and provide resources to training providers. It cannot dictate what is delivered by other organisations.

In New Zealand we also have a performance-based education system managed by the New Zealand Qualifications Authority, the Education and Training Support Agency and Industry Training Organisations[2]. Thus any approach to formal recognition of qualifications in building controls or building-code subjects must be in liaison with these groups as well as with training providers (both private and public).

Barriers to education

The building industry may be in need of building controls education but does it perceive this need?
The role of the Authority is not only to educate, but also to "sell the concept" of the need to know. In addition the industry is made up of "hands-on" people - practical people - who may be averse to written literature and legislation. There are some attitudinal barriers to overcome.

The building industry often calls for more education but then places time and cost constraints on the request. Overall there is a tendency for education to be seen as a cost rather than an investment. The Authority has acknowledged this by charging a nominal fee, and varying the timing of educational events.

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[2] *NZQA - Two of the main functions of the New Zealand Qualifications Authority are to co-ordinate all qualifications in post-compulsory education and training and to set and review standards as they relate to qualifications. This has been achieved through the development of a national framework* ▪

Each group within the building industry finds it difficult to assess their educational needs. Each is very quick, however, to point out the shortcomings of others within the building industry. Thus there is an important role for the Authority to encourage and support groups in their continuing professional development.

Canada

Current position

In Canada, the provision of construction education and training has, under the Constitution, been devolved to the provinces and territories.

As a result, at the national level, the Canadian Commission on Building and Fire Codes (CCBFC) has no direct involvement in the delivery of education and training. However, there are two exceptions to this situation.

The provinces and territories have in the past requested the Commission to provide seminars on any code changes in the National Model Documents.

The second exception is that the Canadian Codes Centre, on behalf of the CCBFC, produces a number of resource documents in support of the codes. These resource documents are usually in the form of commentaries or guides on code-related issues.

Supporting the change to objective-based codes

Since the initiation to move Canada's code system to one based upon objectives - providing greater access to performance-based solutions - there has been a consistent effort to engage the community in the process.

This has involved an awareness program to the professional, organisational, manufacturing, and enforcement communities involved with the codes. Sometimes, one is lulled into thinking that saturation coverage has been achieved, yet, at the very next presentation one finds that there is another group where up to 80% of those attending are completely unaware of the impending changes.

Considerable efforts have been made to provide access to the transition process. All the documents and resource material produced on the code are made available to the public through the Internet and other channels.

Education and training for objective-based codes

As part of the transition process, a number of surveys were conducted throughout the industry in regards proposed changes to the code. It emerged that nearly everyone in the industry perceived a need for education and training support.

As a first step in addressing these concerns, the CCBFC initiated a series of workshops. Those participating included people responsible for education and training in various building organisations, professional societies, and tertiary education institutions from the provinces and territories.

From these discussions, it became clear that a base curriculum for the introduction of the new approach was needed at a national level. The initial focus was on the development of a core curriculum to bridge the existing codes and the new objective-based codes. Resource materials were developed in support of the curriculum. It was agreed that delivery of education and training could be undertaken by individual groups.

Partnerships for resource development

No one organisation or player in the codes educational field in Canada is in a position to fund the development of all the required resource material on their own. Groups involved in the delivery of codes-related education are looking at establishing partnerships to develop common resource material to help bridge the transition to an increasingly performance-based approach.

Japan

Current situation

In Japan, when any laws relating to building standards are revised, the Ministry of Construction must disseminate the contents of proposed changes. This is done via seminars held nation-wide for building officials, architects, building engineers and other parties involved in the building industry.

After the revision, if any discrepancies over interpretations occur, the Conference of Building Officials holds discussions with building officials to streamline interpretations and draw up commentaries on these discussions. The Ministry of Construction must then notify specified building administration agencies of these commentaries.

Jurisdictional administration agencies are responsible for confirming whether an individual building/plan conforms to standard.

The agencies must enforce any revisions to building laws.

If the agencies cannot judge whether a plan/building conforms to standard, because of confusion about the new laws, the Ministry of Construction consults with the agencies to confirm the interpretation.

In order to help building officials from these agencies/etc, remain up-to-date with revisions, the College of Construction, established by the Ministry, offers regular education courses in building administration.

In Japan, universities and high schools provide courses on architecture, engineering and civil engineering. However, the examination for *kentikushi* - the license to become an architect - requires a degree in architectural engineering or civil engineering.

Issues

Introduction of performance-based codes necessitates the education of building officials, architects, building engineers and others.

Therefore, it is helpful to include the subject of performance-based codes into architectural engineering degree courses. In this regard, the smooth and cooperative relationship between the Ministry of Construction and the Architectural Institute Japan would be beneficial for updating the content of the courses timely. In this context, how to re-educate existing building officials and architects is a pivotal issue.

The revisions occurring in Japan include two main changes to our building confirmation system. The first is the privatisation of building confirmation procedures. The second is the introduction of conformity certification systems.

In order to secure the effectiveness of these changes, it is vital to increase the number of building officials, architects, building engineers and other professionals who will maintain the new system. Moreover, it is critical how we secure the professionals who can educate these prospective building officials, architects and others.

Problem solving

In order to cope with the above issues, taking the performance-based codes into consideration, Japan is looking at:

- offering programs to improve the qualifications of existing building officials, (Japan's Conference of Building Officials is expected to prepare the program);
- disseminating the new system through professional seminars, (the Japan Federation of Architects & Building Engineers Associations and the Japan Federation of Architect & Building Engineers Offices are expected to hold the seminars);

United Kingdom

Some 13 years has elapsed since the 1985 Building Regulations introduced performance options. This major change from a very presciptive set of codes presented a challenge in respect of education.

Whereas designers, architects builders and enforcers were conversent with the strict prescriptive regulations and the 'deemed to satisfy' provisions, the work of assimilating the new format of functional requirements supported by guidance documents, (approved documents), was a daunting task.

In particular enforcers would now be required to be judgemental in assessing applications with a performance criteria.

Central government in the form of the Department of the Environment (now the Department of the Environment, Transport and the Regions) is responsible for building regulations in England and Wales. Scotland and Northern Ireland have their own government departments but have broadly similar regulatory systems.

In the lead up to the introduction of the 1985 regulations, the DoE played an important part in the education process. Seminars and road-shows were organised by the professional and trade bodies, e.g. Royal Institute of British Architects, Institution of Building Control etc., around the country with DoE staff participating. Teams of speakers were trained, with DoE assistance, to maximise the coverage. Care was also taken to ensure that local presentations were publicised to include all members of the building team.

Universities, technical colleges and other educational establishments were also targeted to ensure that the new legislation was adequately covered in the syllabus, and articles were placed in trade journals to explain in detail the new proposals.

The same procedure has been adopted whenever any major regulatory changes are introduced. One example is where new energy conservation levels were brought in in 1992, and here product manufacturers were keen to give nation-wide presentations, to provide guidance on meeting the new thermal insulation requirements, particularly with respect to their own products.

Because the very nature of performance based codes allows a flexible approach, it is crucial that there is a uniformity of interpretation in the checking process. Most professional bodies require ‘continuing professional development’, CPD to keep their members up-to-date with legislation and new building methods and materials. With the information technology available, there is access to all the latest information.

United States

The International Code Council is still in the process of developing a performance-based code system. Therefore our experience is limited in terms of education.

Education is one of the priorities of the development process since it is considered a key factor in making such a system work in the United States. Generally, the format and content of such a program would follow that described in concept in this chapter.

Due to the way building codes are developed and adopted in the United States the approach taken will be somewhat unique.

The education process has begun. More specifically, the ICC has been communicating with a number of building-industry organisations through presentations and short classes.

Basically, these are providing an awareness of the new concept and at the same time giving the ICC a feel for the level of existing knowledge. Such information will be helpful to the success of further education programs. The groups involved include code officials, designers and other related industries.

One obstacle that can be foreseen to slow down the education process is that such educational programs are not mandatory. More specifically, unless professional organisations require such classes for membership reasons or employers require a certain level of continuing education, the programs may not reach the intended audiences. Also, built into that problem is the lack of funds and time allocated by those affected by building regulations.

In terms of long-term educational needs, seminars are being developed in conjunction with organisations such as Society of Fire Protection Engineers. Such groups are to provide practical applications and case studies in understanding the workings of performance-based codes.

The education process will eventually need to proceed further than one-day seminars into mandatory curriculum at the university and technical-college levels. Also, funding must be accounted for, perhaps via possible education grants through the government.

Society of Fire Protection Engineers (SFPE)

Education is integral to the success of a performance-based regulatory system. This need is echoed in forums held on performance-based codes.

If all participants in the building design, development, construction, and enforcement are not comfortable with performance concepts, they will not be widely used.

Educational needs can be fulfilled in a variety of ways, including symposia, conferences, educational seminars, and publications. Although these efforts are common they often result in various disciplines talking to themselves instead of interacting with others

For successful education on performance-based concepts, this trend needs to change, and more cooperative efforts are needed.

In 1998, two efforts are being planned to bring together a cross-section of construction participants.

The SFPE along with the model code organisations and the International Council for Building Research and Documentation (CIB) are organising one conference.

The Second gathering is the International Conference on Performance-Based Codes and Fire-Safety Design Methods, Maui, Hawaii, in May 1998.

This conference will be held at the same location as the Pacific Rim Conference of Building Officials.

This promises to be a beneficial conference for building officials, architects, engineers, building owners, and many others involved in building design and construction.

A second effort under way between the International Conference of Building Officials (ICBO) and the SFPE is the development of two, one-day educational seminars, to be managed and offered by ICBO in 1998, on Engineered Fire Protection Alternatives and Computer Modeling for Building Code Officials.

An overview of these two seminars was presented at the 1997 ICBO Annual Business Meeting in Phoenix. Interest was high and feedback was positive.After the 1998 seminars, efforts will focus more specifically on performance-based codes and the use of the fire protection engineering technology in meeting the code.

In the future, additional cooperative efforts will be required, and will need to involve such groups as the American Institute of Architects (AIA), the Building Owners and Managers Association (BOMA), the Fire Marshals Association of North America (FMANA), and others involved in the building design, development, construction, and enforcement process. The efforts will need to focus on integrated design, performance concepts, engineering, and benefits of performance-based design.

Finally, to better prepare the design professionals of the future, the concepts discussed above need to be integrated into the educational programs for engineers and design professionals at the college curricula level.

University programs

There is one university in the US offering an "accredited" undergraduate degree in fire-protection engineering.

Since the program's inception, the University of Maryland fire-protection program has awarded about 650 Bachelor of Science degrees.

There is also an undergraduate degree program in fire protection and safety-engineering technology at Okalahoma State University, where the focus is split between occupational and industrial-safety issues and fire-protection issues.

There are two official graduate programs in the US that offer practical education at the Master of Science degree level to support the profession of performance-based fire protection engineering.

The University of Maryland has awarded about 25 Master degrees and Worcester Polytechnic Institute about 160.

There are also Doctorate programs at Worcester Polytechnic Institute and the University of California at Berkeley.

In addition, there are perhaps several thousand more graduate engineers from other disciplines that practice in the area of fire protection (eg: civil, structural, and mechanical engineering).

There are also a number of Associate degree and certificate programs in building and fire-protection-related technology throughout the US. These programs are most often attended by building and fire officials, and technicians working for product manufacturers, vendors, and installers.

4. Public policy

4.1 Scope and terminology

This segment considers legislation to support a performance-based code. It identifies major issues in the context of the cultural, societal, economic, and legal environments, in which a performance-based system will be implemented.

This segment does not address alternatives to legislation. It does not address the actual development of the performance-based code. It assumes that the legislation will be enforced by one or more control authorities with the power to prosecute.

4.2 Introduction

The public policy statements, if any, which have traditionally accompanied prescriptive codes have stated only the need to protect the general health, safety, and welfare of the public.

Prescriptive codes and Standards dictate how a building must be built, including what materials can be used, how they may be used and when they can be accepted.

Prescriptive codes and Standards in most countries have been developed over many decades by evaluating the "negative results" of previously applied provisions. Those collective experiences have lead to the unrealistic assumption that in all cases, given sufficient experience, the prescriptive provisions will yield the most appropriate results, (ie: will best protect the general health, safety and welfare of the public).

That type of thinking is flawed. It tends to generalise the solutions applicable to a variety of buildings without regard for the differences in how appropriate protection might be provided. Additionally, it does not examine the costs of refinements to the codes and Standards, or the resulting levels of safety.
Public policy can no longer ignore the modern world's capability to analyse and mediate threats to construction. These threats may be from storms, earthquakes, and corrosion/etc. Or from defective design - inadequate ventilation, plumbing cross-connections, leakages/etc. The addition of further prescriptive codes and Standards often leads to conservative solutions without critical examination of the results.

Such codes need to be supplemented by performance-based codes and Standards which encourage innovative solutions to protect the health, safety and welfare of the public. They must also achieve other public policy objectives related to construction.

When one considers existing buildings, the matter of public policy becomes increasingly complex. The question of application of new prescriptive provisions to existing buildings is raised.

With a prescriptive approach, there is no concept that changes in technological knowledge or outside circumstances can leave a building out of compliance in regards the code. Once a building is built in compliance with the code, it stays in compliance, unless the building is altered or undergoes a change of use, or unless retrospective codes are passed.

Performance requirements impose regulatory burdens not present in a prescriptive approach and open up opportunities for innovative solutions. Because performance requirements state what the building element must achieve but do not tell the designer what materials to use, or how to assemble them, the designer must establish, to the satisfaction of the building official, that the design will achieve the required performance.

While this encourages innovation, discretionary freedom, and design flexibility, it also necessitates an acceptance of new technological risks. It also demands a comprehensive regulatory effort much more extensive than traditionally found in building construction.

That effort might extend as far as integrating the regulation of construction and use of buildings over their lifetime by cradle-to-grave regulation such as that required to regulate the aircraft and automobile industries.

Professional licensing, operating permits, public-safety responses, and insurance-based compensation systems can be used to control technological risk. Approval under these performance codes typically requires systematic evaluation as to whether the regulated system continues to meet the performance requirements.

4.3 Legislation

The implementation of codes, whether prescriptive or performance based, requires a legal underpinning.

Most, if not all, jurisdictions have building control legislation. In almost all cases some amendments to the present legislation, or some new legislation, will be needed to introduce a performance-based system.

The precise type of legislation needed - a national Act with supporting Regulations, Ministerial directives, state law, or whatever is appropriate - will depend on the constitutional imperatives of the jurisdiction concerned.

The same applies to the level of government affected by the legislation. However, buildings owned or controlled by any level of government will need to achieve the same health and safety performances as buildings owned or controlled by anyone else, with only rare exceptions.

In many jurisdictions, building control systems are fragmented, with separate pieces of legislation enforced by separate control authorities. In some cases, those separate pieces of legislation are made by different legislative authorities.

<u>For Example:</u> there might be national legislation covering the construction of new buildings enforced by the provincial governments, while at the same time a particular city has its own local legislation covering the fire safety of buildings, enforced by the fire marshals of that city.

In general, building producers and building owners can be expected to prefer building controls to stem from a single piece of legislation and for all building controls to be enforced by a single control authority. However, that might be impracticable. Building controls will need to operate in conjunction with other control systems such as planning and resource management controls, occupational health and safety controls, and so on.

There will need to be understanding between relevant control systems and the individual pieces of legislation. There might also be a need to protect the performance-based code from being overridden by other control systems, perhaps by including in the new legislation provisions to the effect that:

- legislation at a lower level shall be void to the extent that it purports to require buildings to achieve performance requirements additional to, or more restrictive than, those specified in the performance-based code; or
- other legislation at the same level shall not be interpreted as requiring buildings to achieve performance requirements additional to or more restrictive than those specified in the performance-based code unless that other legislation specifically states that it applies notwithstanding this legislation.

Whatever the nature of the legislation introducing the performance-based code, the following issues will need to be addressed:

- the social objectives of the legislation will usually need to be stated;
- the scope of the legislation will need to be stated, including its application to existing buildings;
- supporting publications, including all elements of the performance-based code, will need to be identified;
- there will need to be provisions for enforcing the legislation;
- there will need to be provisions for assessing whether the performance-based code has been complied with;

- there will need to be provisions for amending the performance-based code, including the guidance publications, without affecting its enforcement; and
- there will usually need to be various administrative provisions not directly related to the performance-based code.

4.4 Social objectives

Building control systems interferes with people's freedom to build what they wish.

The social objectives of such legislation are the reasons (public policy) which justify that interference. Therefore, the social objectives should be stated in the legislation. They are sometimes identified as the "purposes" of the legislation.

It might be enough for the legislation to state its purposes in general terms, such as "to provide for the design, construction, alteration, and maintenance of buildings", and require compliance with the performance-based code.

If so, then the goals of the code will equate to the social objectives. However, that approach can raise legal doubts about the law-making powers of the code writers when the code is to be amended.

Such doubts should not arise if the mandatory provisions of the performance-based code are formally incorporated in the legislation. In other words, the legislation would include the goals (social objectives), the functional requirements (if used), and the mandatory performance requirements. If so, then amendments to those mandatory requirements may well be more complex than if the code is a separate document and not part of the legislation.

In many jurisdictions the public may expect elected representatives, rather than code writers, to decide the extent - and the reasons why - building controls interfere with people's "building freedom".

The goals of the code will need to correspond to any social objectives stated in the legislation whether or not the code is incorporated into the legislation.

Similarly, the performance requirements of the performance-based code, and also any requirements of the guidance publications, will need to serve the purposes of the social objectives. That is because, in some jurisdictions, those requirements will be legally enforceable only to the extent that they serve the social objectives of the legislation.

For Example: if the legislation does not include water conservation as one of its social objectives, then the code should not include mandatory requirements for water conservation.

Any such requirements will be vulnerable to challenge in court as not being properly authorised by the legislation ("ultra vires").

Any corresponding requirements in the guidance publications, for example, that toilets shall have double-flush capabilities, will be similarly vulnerable to challenge.

The optional verification methods and acceptable solutions will usually be guidance publications and will rarely if ever be formally incorporated into the legislation.

The functional requirements, which form Level Two of a performance-based code using the Nordic Five Level System, need to be treated with caution. If they are included in the legislation, it will need to be clear that they are not absolute requirements, but are to be achieved only to the extent specified by the performance requirements.

In some cases the functional requirements have been used simply as a sorting device for arranging the performance requirements. In others, the functional requirements have been replaced by simple headings; in others they have been omitted entirely.

Identifying social objectives

Protecting health and safety will be social objectives in all building control systems. There are other social objectives, depending upon the relevant cultural, societal, economic, and legal environment. Such social objectives might include:

- amenity, welfare, and convenience (sometimes defined in health-related terms);
- physical independence for people with disabilities;
- protection of property (needs to be defined so as to state whether the property to be protected includes the building itself and its contents);
- protection of the environment;
- conservation of particular resources, for example water or energy from non-renewable sources; and
- minimum habitability requirements for residential accommodation.

Social objectives represent community expectations and public policies relevant to the design and construction of buildings. The legislation will need to protect people's freedom to build what they wish against interference that is not justified by the stated social objectives.

A first step to identifying social objectives which need to be in the legislation might be to analyse existing building-control legislation and existing prescriptive codes. These publications do not always identify their social objectives, but they do represent the "current level of interference with people's freedom" to build what they wish.

These publications usually specify accepted good practice. However, the reasons why the practice first became accepted might no longer be valid.

Where the social objectives of current publications can be identified, they will need to be considered for inclusion in the legislation. However, which social objectives are to be achieved by the legislation should not be limited to those in prescriptive publications.

Conversely, social objectives achieved by current publications might not be chosen for inclusion in the legislation, in which case the corresponding prescriptive requirements will no longer be relevant.

4.5 Commitment (to policy)

In the building regulatory field, the parties actively involved in supporting or opposing reform generally come from:

- government;
- various industry sectors (including engineers and architects, builders, product and system manufacturers, building owners and the like);
- the regulator community (ie. those charged with issuing approvals to construct, and usually with determining the extent of a building proposal's regulatory compliance); and
- special interest groups from within the general community.

Any building regulatory reform process is more certain of success if it has strong commitment from all these parties at its commencement. Obtaining the commitment of various parties is done via negotiation.

In any field involving legislative systems there is generally one party which must be committed to reform for it succeed. This group is the government sector responsible for effecting the legislative amendments. Should such support not eventuate, it could result in a number of outcomes, including:

- the legislation failing to be passed by government;
- the legislation being drafted in a manner which maximises the chance of the reform failing; and
- the implementation of the legislation being carried out in such a manner as to minimise the chances of the reform succeeding (eg. insufficient attention to education and training, insufficient attention to risk management processes, insufficient funding for reform and so on).

In essence, in any building regulatory system where reform requires legislative change, and a particular segment of government plays a key role, failure of the proponents of reform to gain the commitment of that segment will almost invariably result in either the total, partial or effective failure of the reform.

4.6 Scope of the legislation

General

People reading legislation should be able to understand what it covers, its scope, and their legal obligations.

In any particular jurisdiction, the new legislation discussed in this segment will need to include all the legal obligations considered necessary or desirable for supporting a performance-based building code.

Thus the scope of the new legislation will be limited by the social objectives. It will also be limited by the need not to conflict with other building legislation

Some other issues which might arise when considering the scope of the new legislation are discussed below, together with the corresponding enforcement provisions in terms of legal obligations imposed on control authorities and the public.

Because code writers cannot possibly foresee and allow for all possible situations, it is considered necessary to provide for waivers to be granted in special cases. That applies to a performance-based code as much as to a prescriptive code, although the cases concerned should be far fewer under a performance-based code.

For Example: a performance-based code might require buildings to prevent the spread of fire across legal boundaries. It might be appropriate to waive that requirement in special cases such as when the boundary is to a public space, or runs along the top of a high cliff.

It should be possible to waive a performance requirement in cases where that performance is not necessary to achieve the social objectives of the legislation. Such cases are particularly likely to arise in the alteration of existing buildings.

This segment does not discuss specific legislative provisions for such waivers.

Construction of new buildings

Application

The performance-based code will be appropriate for the construction of new buildings. It will also be suitable for the alteration of existing buildings given flexibility in administration.

However, that raises questions as to what is meant by the word "building", and whether some buildings need to be excluded from the legislation. The answers to those questions will depend on the cultural, societal, economic, and legal environment of the particular jurisdiction.

The following issues will usually need to be addressed in respect of the design and construction of new buildings :

- Is the legislation to apply to major civil engineering structures such as dams, bridges, canals, etc?

Such structures are frequently not covered by prescriptive codes, so they probably need not be covered by the new legislation. However, the social objectives apply to those structures also, and with a performance-based code it does not matter that there is no prescriptive code available.

- Is the legislation to apply to unusual buildings such as temporary buildings, relocatable buildings, mountain huts, tents, and so on?

Again, such buildings are frequently not covered by prescriptive codes, so they probably do not need to be covered by the new legislation. However, the social objectives apply to those structures also, and with a performance-based code it does not matter that there is no prescriptive code available. Furthermore, such buildings might seem unusual to code writers but not to building officials.

- Is the legislation to apply to specialised structures such as power transmission towers, constructed in significant numbers by a specialised organisation which knows more about them than any control authority?

Such structures could well be excluded from the administrative, but not from the technical, provisions of the legislation. In other words, the owner must construct such a structure in compliance with the performance-based code, but will not be required to obtain a building permit. A building excluded from the administrative requirements will not appear on the control authority's records of the built environment.

- Is the legislation to apply to minor buildings such as garden sheds and the like?

Again, it might be preferable to exclude such buildings from the administrative, but not from the technical, provisions of the legislation.

- Is the legislation to apply to all building elements?

In some jurisdictions there are separate control systems for such things as plumbing, electrical installations, lifts, and other specialised items which form part of buildings. It will need to be decided whether those things are to be brought within the new performance-based system.

- Are any private sector building owners to be exempted from all or part of legislation?

In some jurisdictions, types of building owners (for example, railways or electricity-supply companies) are excluded from parts of the system. It is difficult to see why those owners should be treated any differently in respect of non-specialised buildings. It might be better to exclude specialised buildings irrespective of ownership.

- Is the scope of the legislation to be limited by sovereign immunity?

Constitutional directives might prevent a federal government from being bound by provincial or state legislation.

- Is the scope of the legislation to be limited by administrative considerations?

  Administrative considerations might prevent some or all government agencies (such as government departments or the armed forces) from being bound by the legislation. On the other hand, there seems to be no good reasons to exempt government agencies from following the same procedures as everyone else, ensuring that their buildings achieve the social objectives of the legislation.

Enforcement

Most building control systems require a building permit to be obtained from the control authority before construction commences. Most require a completion certificate when construction is finished. These are usually, but not always, provided by the same control authority.

There are, of course, variations, particularly in respect of the number and nature of control authorities (perhaps for the building itself, for its electrical installations, its plumbing, fire safety, and so on), the availability of private certifiers, and the number and nature of the permits and certificates involved.

Someone acting independently in the public interest must be satisfied that the plans and specifications comply with the performance-based code as does the completed work. That general approach will apply equally well with a performance-based code as with a prescriptive code.

However, because a performance-based system requires the control authority to make value judgments and exercise a broader discretion, it is more important for control authorities to be continually monitored to ensure that they are correctly applying the code.

This can be achieved by random technical audits of control authorities (and private certifiers). In addition, dispute-resolution procedures can play a large part.

To issue a building permit or a completion certificate, the control authority will have to assess whether the plans or the completed work comply with the performance-based code. That raises three issues:

- How to ensure that the control authority receives all the documents necessary to enable it to understand what building work is proposed and to decide as to compliance? (The documents to be submitted to the control authority will always include the plans and specifications and where necessary will also include such things as subsoil investigations, design calculations).
- How to assess whether an alternative solution complies with the performance-based code? and.
- What liability, if any, will be incurred by the control authority if its assessment is incorrect?

It can be an offence to construct a building without a permit or not in accordance with approved plans and specifications. It is usually an offence to permit some other person to do so.

In some jurisdictions it is an offence to use a building before it has received a completion certificate, whereas in other jurisdictions the completion certificate is merely an administrative "signing off".

Existing buildings

In some jurisdictions, new buildings and existing buildings are covered by separate legislation.

The introduction of a performance-based system can be an opportunity to integrate the regulation of the construction and the use of buildings over their lifetimes.

Considering the "cradle-to-grave" approach in the context of a performance-based building control system raises issues relating to the alteration of existing buildings and compulsory maintenance and inspection of buildings.

Alterations to existing buildings

Alterations to existing buildings range from major extensions to minor improvements or refurbishment. Alterations might be made at the owner's choice or as a statutory duty if there is a requirement for compulsory upgrading.

Although a performance-based code can generally be applied to the new building work involved in any alteration, there may be practical problems.

For Example: suppose a new stair is to be installed in an existing office building. Constructing that stair with the geometry, landings, and so on which would be expected in a new building complying with the performance-based code might not be practicable within the space available. Sensible solutions for such cases can usually be achieved by reasonable waivers of the code.

Thus it seems appropriate for the legislation to make the same provisions for building permits and compliance certificates in respect of alterations to existing buildings, as it does for the construction of new buildings.

Compulsory upgrading of existing buildings

Most existing buildings will not meet social objectives to the same extent as new buildings, because design and construction techniques have improved.

At one extreme, the legislation could require all existing buildings to be upgraded from time to time, as necessary, to comply with the performance-based code/ and any amendments. At the other extreme the legislation could protect buildings from compulsory upgrading unless they constituted a danger to the public.

Requiring buildings to be upgraded as necessary to bring them in to line with the performance-based code, or amendments to it, is unlikely to be politically or socially acceptable even if economically sustainable.

If so, then a useful distinction might be between:

- Existing buildings, which fall so short of current performance requirements that they must be upgraded or demolished in the public interest. (Sometimes called "dangerous or insanitary buildings", although that does not cover all cases in which immediate upgrading might be justified); and
- Existing buildings which are non-complying in terms of current performance requirements to an extent which can be accepted until the occurrence of some specified event justifies a requirement for a specified degree of upgrading.

If that distinction is adopted, the legislation will need to specify when a building is so dangerous that public interest demands it be upgraded or demolished.

For Example: "a building which is of such construction or in such condition and is being put to such a use that it is reasonably foreseeable that loss of life is likely to result in the ordinary course of events".

The legislation will also need to specify events which trigger a requirement for upgrading. Many jurisdictions require some degree of upgrading on a change of use, and perhaps to lesser degree, on an alteration.

An alteration will generally increase the economic life of a building, making its non-compliance less acceptable. It is sometimes, but not always, easier to upgrade a building when it is being altered.

A change of use to a building is likely to increase the extent of the building's non-compliance, and in some cases, could make the building dangerous or insanitary. For Example: when new occupants exceed the capacity of the building's escape routes or the sanitary facilities.

Risk of loss of life may increase even though a building's use remains unchanged. For Example: imagine a residential building which houses the same number of people but as the years mount, they have become incapable of escaping from fire without assistance.

Whatever the trigger, the degree of upgrading required will need to be specified both in terms of:

- building functions, where performance must be upgraded. (For Example: means of escape from fire, access and facilities for use by people with disabilities, structural safety, and so on); and
- the extent of upgrading required and in particular whether it is to achieve the same level of compliance with the performance-based code as would be required for a new building.

If upgrading occurs when a building is altered, then the legislation must provide that building permits are not to be issued for alterations, which do not include the required upgrading.

If upgrading is required because a building's use has changed, then the legislation will need to provide that the use of a building is not to be changed without the approval of the control authority, or before any necessary upgrading has been completed.

It is not always easy to decide what constitutes "a change of use" for upgrading purposes. In such cases, the legislation might provide for permits and certificates to specify the use of the building in detail. For Example: "a ground-floor public library or upper-floor restaurant seating not more than 200 people".

Legislation might include regular inspections of existing buildings to identify those needing upgrading. Usually such action is only taken when matters are brought to the attention of the control authority.

The new legislation will probably need to include powers for the control authority to inspect buildings to ensure that they are not dangerous or insanitary. It might also authorise the control authority to take action in an emergency to secure or demolish a building, which poses a threat to public safety.

The legislation could also include provisions requiring owners to inspect, and if necessary upgrade, their buildings in respect of specific hazards or specific failures to achieve the social objectives of the legislation, including:

- recognised dangers, such as unencapsulated asbestos.
- newly-discovered dangers; such dangers will usually result in an amendment to the guidance document if not to the performance-based code.
- new objectives such as water conservation or energy conservation.

In most jurisdictions it is unlikely to acceptable, except in an emergency, for a control authority to require a building to be upgraded or demolished against the owner's wishes without a hearing in court.

Historic buildings

Most jurisdictions have legislation protecting buildings of cultural importance, usually described as "historic buildings".

The legislation introducing the performance-based code will need to have specific links to historic buildings' legislation.

However, there seems to be no reason why historic buildings cannot be subject to the same requirements for compulsory upgrading as other buildings. This is, provided there is flexibility to ensure that the upgrading is compatible with the historic buildings' features.

An historic building will have no value whatever if it is destroyed by fire, earthquake/etc. Sensitive upgrading may have protected it against these forces. (Better a historic building with an anachronous sprinkler system, than a heap of ashes).

Compulsory maintenance, inspection of existing buildings

The need for routine maintenance is the same with a performance-based system as with a prescriptive system, and is covered in the legislation of many jurisdictions. Nevertheless, it is an issue to be considered when legislating for the introduction of a performance-based code.

Regular routine maintenance of certain building systems - lifts and sprinklers for example - is essential to ensure the systems function as intended. The design of a building against fire would be very different if the sprinklers or emergency lighting could not be relied on. The issue of whether, and if so how, routine maintenance is to be ensured will need to be addressed when preparing building control legislation.

The need for routine maintenance arises particularly in respect of: certain automatic systems such as emergency alarms, lifts, backflow preventers, air-conditioning systems, and so on.

The legislation will need to be concerned with maintenance-sensitive systems and those systems where inadequate maintenance might not become apparent until someone is hurt or becomes ill. Coverage could be limited to systems in buildings and not with specialised systems of the nature of plant - present only in buildings for specialised uses, such as medical gas systems in hospitals or spray-painting booths in factories.

Good housekeeping.

The legislation will need to be concerned with only those features where poor housekeeping may create a significant hazard.

For Example: where routes of escape might be blocked by stored materials.

In some jurisdictions, the routine maintenance of non-specialised buildings and parts of buildings are controlled by separate legislation administered by specialised authorities. In other jurisdictions, routine maintenance of all systems comes under the building control legislation.

Usually, legislation requires that specified systems and features be certified periodically as having been accordingly maintained and inspected. In some cases, the procedures will be carried out by approved contractors or governmental inspectorates.

In other systems, the building control authority specifies or approves the procedures but the building owner is responsible for ensuring they are properly carried out, by qualified personnel (lift and sprinkler maintenance technicians for example). The owner issues an annual statement of compliance to the control authority, and publicly displays a copy of that statement in the building.

In most systems it is an offence to use or permit the use of uncertified systems or features.

Durability

An issue relevant to new and existing buildings is whether the legislation or the performance-based code should include durability requirements.

It is not always recognised that if buildings constructed in compliance with a performance-based code are to perform, as required, throughout their lives, then the code must include durability measures.

In fact, most prescriptive codes include implicit durability requirements, such as minimum concrete cover to reinforcing steel; protection of structural timber against termites and other insect or fungal attack; self-cleansing gradients for drains, and so on.

Nevertheless, durability is difficult to assess at the time of construction. It is better not to include durability as a performance requirement because of uncertainty and liability issues.

The difficulty is in devising specific requirements for the performance-based code corresponding to the implicit requirements of the prescriptive codes.

By ignoring the problem there might be difficulty in enforcing implicit durability requirements if the performance-based code does not include performance criteria for durability.

One solution may be to reveal the public expectation of how frequently various building elements will need to be replaced. For Example: corrugated steel roofing is generally recognised as needing to be re-painted after a certain number of years, and to be replaced after another number of years. Concealed plumbing, on the other hand, could well be expected to last the life of the building.

The general public expectation may depend on: how obvious it is that a building element needs replacing; how easy it is to replace, and how dangerous the building will become if the element is not replaced.

For well-established building materials and methods of construction those expectations will be based on experience and correspond closely to the durabilities achieved. Of course, those durability's are not necessarily the ones to be specified in the performance-based code, but they are a useful starting point.

Documentation

Another issue is whether the control authority, or some other body, is to house building records, or if there is to be no such office.

If there is an office, then the legislation will need to specify: what documents are to be kept in respect of building work; how long they are to be kept, and whether they are to be made available to specified parties, such as the owner or the public.

Costs, benefits, and funding

There are many direct and indirect costs of building legislation. There are also many direct and indirect benefits.

Costs are incurred by owners in preparing applications for building consents and completion certificates.

Control authorities attract costs making checks and inspections and via other activities in issuing those permits and certificates. Owners also incur costs while waiting for permits and certificates, and from any unanticipated delays.

Costs are also incurred in the maintenance of the performance-based code and the guidance documents, not only by the governmental body responsible for the legislation but also by code writers whose codes are affected, and possibly outdated, by the introduction of the performance-based code.

These costs need to be balanced by corresponding benefits. If the performance requirements of the performance-based code are too high, there will be a lack of balance and new buildings will cost more than necessary. On the other hand, if the requirements are too low, there will be inadequate protection of life and health. The cost-benefit balance needs to be considered when the code is first drafted, but also throughout its life, in the light of emerging information and changing technology.

It might be useful to require that the cost-benefit balance be constantly considered. Unfortunately, there does not seem to be an accepted methodology for this. In many cases, the balance is assessed by intuition (sometimes-called "engineering judgement"or "informed guesswork"). Nevertheless, it seems better to strive for a cost-benefit balance if only as a counter to the constant pressure to improve the safety and other attributes of buildings.

Most of the benefits of the legislation will be enjoyed by the public. Thus there is an argument for funding the legislation out of taxes, with no charges for building permits, completion certificates, and any other similar authorisations or verifications required by the legislation.

Most jurisdictions seem likely to reject that argument, and see building owners as enjoying the benefits of the legislation, which ensures that they do not harm the users and others affected by their buildings. On that basis, the owner is responsible for the building and should meet all the costs of complying with the legislation. Thus there is an argument for funding the legislation entirely out of building permits and so on.

It will frequently be impracticable for control authorities and others administering the legislation to directly recover costs. The large volume of "counter inquiries"; the need to consider public comments on proposed changes and so on, are difficult to assess for cost.

The legislation will need to identify what direct charges can be made to owners and how activities not directly chargeable are to be funded.

4.7 Supporting publications

General

The complexities of the design flexibility of a performance-based code makes it desirable for legislation to provide tools for assessing conformance with objective-based standards.

The legislation should provide for some, or all, of the following conformance assessment tools:

- examples of compliance and methods of checking compliance with the performance-based code;
- lists of proprietary products and processes which have been assessed as complying with the performance-based code; and
- rulings made by an authority authorised to determine disputes about compliance with the performance-based code and the guidance publications.

Examples of compliance and methods of checking

Examples of compliance and methods of checking compliance with the performance-based code are provided by Level Four and Five verification methods and Acceptable Solutions. These may be included in the performance-based code, but in this segment it is assumed that they will be in separate guidance publications.

It will be a matter for jurisdictions to decide whether its legislation provides:

- that compliance with the appropriate guidance publication establishes compliance with the performance-based code. If so, then the owner or designer has an absolute right to build in accordance with those publications, and the control authority cannot require anything more. Therefore, the guidance publications must be entirely prescriptive so that control authorities need not exercise any discretion or make any value judgments in considering work claimed to comply with the guidance publications. Of course, there is always room for technical disagreements about the interpretation of any particular prescriptive specification or code of practice.

or;

- that the guidance publications are for guidance only, and the control authority retains the power to refuse consent if it considers that, despite complying with the relevant guidance publication, the proposal does not comply with the performance-based code. If so, then the guidance publications will not need to be entirely prescriptive.

The alternatives chosen will probably depend on:

- the extent to which it is considered owners and builders need protection against any tendency by control authorities to adopt "home rule" requirements additional to those of the performance-based code, and
- the extent considered possible to comply with guidance publications (particularly current specifications, codes of practice and so on) but not comply with the performance-based code.

Referencing standards and similar publications

The legislation will need to identify the body, which approves the Level Four and Five verification methods and Acceptable Solutions. That will more appropriately be a governmental body than a Standards organisation.

Nevertheless, many of the verification methods and Acceptable Solutions will exist in the form of Standards and similar publications. However, some publications might need amendments to make them compatible with the performance-based code.

Future Standards might need to be written with a different approach and format for the same reason.

Guidance documents will need to reference Standards and similar publications, if necessary, with modifications for compatibility with the performance-based code. In the long term, those modifications should not be necessary as the Standards/etc are amended.

It is important not to underestimate the volume of work involved in keeping the guidance publications up-to-date with amendments and revisions of the referenced Standards. The body which issues or approves the Level Four and Five publications will need to work closely with the national Standards organisation and other code-writing bodies.

4.8 Assessing compliance with the performance-based code

The legislation will need to specify how control authorities (and any private certifiers) are to assess compliance with the performance-based code. The wording of the legislative provisions concerned can have a significant effect on liability.

In general, the applicant for a building permit or completion certificate will need to establish that the proposal or the completed building complies with the performance-based code.

At building permit stage, the control authority will need to assess the plans and specifications for compliance with the performance-based code.
If the applicant has used an Acceptable Solution or a verification method from the guidance publication then the task of checking is no different from what it would be under a prescriptive code.

If the applicant proposes to use an Alternative Solution, then there are several methods which the control authority can use to assess compliance, including those outlined below. (In either case, the completed building will need to be assessed for compliance with the plans and specifications for which the building permit was issued).

Plans and specifications: approval at first sight

In many cases, an Alternative Solution can be approved at first sight because its divergence from the guidance publication is trivial and obvious.

Many prescriptive codes such as the guidance publications tend to be written on the basis of standard member sizes. It will be possible to be satisfied at first sight that some interpolation between standard member sizes is appropriate.

Prescriptive codes also tend to provide for the worst case. It will frequently be clear at first sight that a particular proposal is very far from being the worst case so that the guidance document can be modified for the building concerned. In other words, become an Alternative Solution complying with the performance-based code.

Similarly, there might be little, if any, technical difference between jurisdictions as regards prescriptive specification or code of practice for a particular item, although matters of marking might be very different. If so, then another jurisdiction's publication could be accepted as an Alternative Solution subject only to whatever conditions, if any, are necessary to prevent confusion arising out of local non-technical requirements.

In such cases, the guidance publications will no doubt be amended to convert Alternative Solutions into Acceptable Solutions.

By comparison with an acceptable solution

Acceptable Solutions in the guidance publications cannot possibly cover every building. **For Example:** an acceptable solution for means of escape from fire might give maximum travel distances for a range of building uses, but is unlikely to include special cases such as, say, a fire station, in which longer distances might be approved by the control authority as an Alternative Solution.

Similarly, a platform lift with no enclosed compartment complying with the Acceptable Solution for passenger lifts, might be approved as an Alternative Solution to ramp access for people with disabilities between different floor levels on the same storey.

In each case, the question will be whether, on comparison with the appropriate guidance publication, the Alternative Solution provides the same level of performance.

Guidance publications from other jurisdictions

It is unlikely that any jurisdiction's guidance publications will cover all buildings. A jurisdiction may have no guidance for construction in aluminium or glass blocks, especially if those materials are rarely used in that jurisdiction.

However, appropriate publications may exist in other jurisdiction. If so, then those publications would provide a means of assessing any Alternative Solution involving the material concerned.

Of course, the control authority would need to consider not only the publication but also the system under which it was issued. It could be, for example, that the two jurisdictions had different social objectives. If so, the control authority would need to take that into account, and perhaps ask for additional provisions to meet its own social objectives.

Experience in use

Satisfactory experience in use might justify acceptance of an Alternative Solution such as a proprietary building method. Again, if the use has been in another jurisdiction, differences between the jurisdictions will need to be examined.

Calculations and tests

The guidance publications' verification methods are unlikely to cover all possible methods of structural mechanics in relation to earthquake loadings, for example, or the fundamental principles of thermal dynamics in relation to design against fire.

An Alternative Solution based on applying such principles could be demonstrated by calculation to comply with the performance-based code.

In some cases it might be necessary to support the calculations with test results. In others, a test not included in the Level Four verification methods might be sufficient to establish compliance with the performance-based code. For example, a roofing system could be tested in a wind tunnel.

Expert opinion

A control authority might have limited technical resources to assess an Alternative Solution. In such cases the "committee of experts" approach is useful.

Here, the building producer would submit an independent peer review by a committee of one or more experts to the control authority as evidence of compliance.

A control authority may accept the review as establishing compliance with the code, but only if satisfied that the reviewers were experts in the particular field.

Alternatively, the control authority could commission a review. The legislation might need to allow for that approach but not make it mandatory.

For some types of building, large dams for example, there appear to be no prescriptive guidance publications anywhere in the world. Such structures will usually be subject to a peer group review by an independent committee of experts.

The legislation might also provide that a control authority may, at its discretion, accept a design certificate from a building producer without any peer review. If so, the control authority could accept a design certificate from the engineer responsible for the design of foundations for poor ground.

It is sometimes thought that a control authority is accepting an Alternative Solution when it relies on an engineer's design certificate or the like. That is not necessarily the case, because such a certificate could well state that a building or part of a building (foundations or roof trusses) was designed in accordance with a verification method in a guidance publication.

Proprietary products and systems

Assessing whether a proprietary product or system complies with the performance-based code is no different from assessing any other building element or building design.

However, there are obvious advantages if such items can be approved by a specialist body acting on behalf of the control authority as with the European Agreement Systems.

Sometimes a system is integrated into the prescriptive codes, when specification of a test method requires that the test be conducted by an approved laboratory or accredited by an authority.

This can continue under a performance-based code, but it might be useful for the legislation to give formal recognition to the specialist bodies concerned.

Completed work

Checking that completed work complies with the performance-based code will consist of checking whether it complies with the specifications of the building permit.

The question will be whether the legislation will require the control authority or private certifier to make inspections, or whether it will be authorised to accept various forms of "expert opinion".

Whether or not the control authority makes its own inspections, the legislation will probably need to provide for an owner or builder to notify the control authority at appropriate stages of construction.

Those stages might be specified in the legislation or in the building permit.

4.9 Private certifiers

A main argument in favour of private certifiers is that by introducing competition for the assessment of code compliance, efficiency will increase and the charges of control authorities will be reduced.

In other words, control authorities faced with competition will smarten up their act with national benefits.

The introduction of private certifiers raises several issues, including specifying the relationship between private certifiers and control authorities.

A private certifier might become unable to continue inspecting building work in progress for many reasons. If so, then another certifier or the control authority will need to take over. Accordingly, the legislation should require that the control authority be notified if that occurs. Similarly, the legislation should provide for reasonably frequent notification to the control authority of progress with inspections by the certifier. Private certifiers cannot perform all functions of control authorities under the legislation. Private certifiers cannot usually act as an office of record. Therefore, the legislation will need to provide for private certifiers to lodge relevant publications with the control authority on the completion of a project.

Similarly, it might be seen as inappropriate for a private certifier to prosecute people who commit offences against the legislation (and it would almost certainly be uneconomic for the certifier). Thus the legislation will need to provide for private certifiers to notify the relevant control authority on becoming aware of an offence.

4.10 Technical disputes

Disputes arise about compliance with prescriptive codes. The same will happen about compliance with performance-based codes.

Currently, in some jurisdictions, disputes can be settled only by the courts. Sometimes, a technical body has the power to issue binding decisions on technical matters, subject to court appeals on questions of law. Such a body is likely to be of particular value in a performance-based system.

That value will depend on the speed and efficiency of the body's decisions.

Most disputes will be about a refusal to grant a permit or consent to build/etc. The legislation should make it clear that the body is a technical body substituting its own decision for that of the control authority or private certifier concerned, not a court deciding on an appeal and bound by rules of evidence and procedure.

In many jurisdictions the parties will have a right to appear at a formal hearing, but in practice the parties could be encouraged to waive that right and agree to a determination made "on the face of the documents".

After all, if decision as to compliance cannot be made from the plans and specifications - and other relevant reports - then what is needed is improved or additional documents, not an appearance by the parties or their lawyers.

The legislation will need to specify the nature of the dispute-resolution authority as well as the way disputes can be submitted.

The authority will be a committee of experts; an established panel or individually for each dispute.

A possible side effect of the ability to have disputes decided by an independent authority is that a control authority might avoid potential liability by refusing to assess an Alternative Solution. In effect transferring the assessment and the associated liability to the dispute resolution authority.

If that is a problem, it will indicate a need for a performance audit of the control authority. Once a dispute has been decided then that decision will be available for the guidance of all control authorities.

Parties to a dispute

Typically, disputes will be between an owner and a control authority in respect to a control authority decision, which the owner considers restrictive.

Owners are unlikely to dispute control authority decisions seen as “too permissive”. To cover such cases, the legislation could provide for parties other than owners to dispute control authority decisions.

Those other parties could include: neighbours, organs of government such as the health inspectorate, and recognised interest groups.

Any extension of the right to dispute control authority decisions on technical grounds raises associated administrative issues, particularly whether those entitled to be parties should be notified of control authority decisions or routinely receive applications for building permits.

Any such provisions are likely to increase the costs and delays of the construction process.

4.11 Technological risk

The introduction of a performance-based code encourages innovation, discretionary freedom, and design flexibility. However, it might also introduce greater technological risks and more extensive liabilities for the control authority in particular.

Under a prescriptive building-control system, building producers and control authorities do not need to make assessments as to the performance of a building; all they have to do is to decide whether it complies with the code. Admittedly, this is not as easy in practice as it is in theory, because most prescriptive codes are open to interpretation. Nevertheless, applying a prescriptive code does not necessitate the value judgments, which can arise with a performance-based code.

Prescriptive codes have been developed over many years by expert committees with knowledge of the technical discipline concerned. They will probably be conservative, and provide for the worst case

Following a prescriptive code amounts to following accepted good practice. Following a prescriptive code is therefore almost certainly a defence against liability (even if the building fails, the designer has done what any competent designer would be expected to do so that the failure could not have been prevented in the current state of knowledge, sometimes called an "act of God").

With a performance-based code, however, there is no distinction between worst and best case, all cases are required to achieve the code's performance requirements. In the extreme, only two people, a building producer and a building official acting for the control authority, need to agree that a particular building complies. The possibility for error is much greater under a performance-based system than a prescriptive system.

Thus a performance-based system can place greater responsibilities on individuals, and building officials in particular.

In assessing an Alternative Solution under a performance-based system, a building official must use higher levels of skill and judgment than under a prescriptive system.

Nevertheless, the technological risk must not be overestimated. The building industry makes extensive use of prescriptive specifications and codes of practice and will continue to do so, even when those publications are no longer mandatory.

Additional risk arises only with Alternative Solutions. Many Alternative Solutions are likely to be comparatively minor modifications of the guidance document.

4.12 Liability

Liability to prosecution for breaching the legislation is not discussed in this segment, which is confined to civil liability. The basis of legal liability for building defects is well established in most jurisdictions.

In general, anyone who injures or causes loss to someone else is legally liable to pay compensation. Of course, that grossly oversimplifies the law, and is subject to qualifications in different jurisdictions. Nevertheless, it is generally the case that a building producer or a control authority will be liable for the harm caused by a defective building, which they negligently designed, constructed, or assessed.

That applies to the individual engineer, architect, builder/etc, and to the building official. In each case, the employer of the individual will also be vicariously liable.

Legislating for the introduction of a performance-based code is an opportunity to consider public policy in respect of liability.

It is an opportunity to consider the effect of potential liability on how control authorities will allow innovative solutions under the performance-based legislation and the extent to which building producers will develop and use such Alternative Solutions.

All claims against control authorities will be in tort, almost always the tort of negligence or of breach of statutory duty. Claims against other parties will generally be for negligence.

Issues to be considered include:

- Should control authorities (and other bodies responsible for the development and enforcement of the performance-based code) be liable in respect of building defects which they should have prevented?
- If so, should that liability be limited or capped in any way?
- Should the current liabilities of other parties be altered in any way?

Control authorities and private certifiers

A control authority would typically be liable if it wrongfully issued a building consent or a completion certificate for a building, which did not comply with the performance-based code.

In terms of the introduction of a performance-based code, there can be opposite views on control authority liability.

On the one hand, it is said that such liability will tend to make control authorities over cautious and reluctant to accept Alternative Solutions.

On the other hand, exemption from liability may make control authorities too lax. In particular, there will be less incentive to employ adequate numbers of adequately-qualified building officials. This may result in a failure to achieve the objectives of public safety, as authorities accept Alternative Solutions, which do not comply with the performance-based code.

A suitable compromise seems to be to exempt building officials acting in good faith in the course of their employment from personal liability but to hold their employing control authorities vicariously liable.

A private certifier is in effect the private-sector equivalent of a control authority, and it should not be under any different liabilities than the corresponding control authority.

However, whereas control authorities undertake building control functions because they are required by the legislation, private certifiers are authorised by the legislation but have no legal obligation to undertake control functions in respect of any particular building and do so by choice and under contract to the owner or the builder or other interested party.

If the control authority has no liability, therefore, then a private certifier's liability will presumably be limited to contractual obligations independent of the legislation, as when a private certifier issues enforceable warranties in respect of its certificates.

In jurisdictions where control authorities are open to liability, the usual problem with private certifiers is to ensure that they carry sufficient insurance or are otherwise able to meet any award of damages against them. However, in jurisdictions where control authorities are excluded from liability, it is difficult to see why the legislation should require private certifiers to insure against potential liabilities for breach of contract.

Similarly, the same rules should apply to bodies, and their officers or employees, involved under the legislation as appointing private certifiers, determining disputes, writing guidance publications, and so on.

Limiting liability

Liability for failures to comply with the performance-based code can be limited or capped in various ways. See the following segments

Wording of the legislation

Careful wording of the legislation will define the control authority's liability.

If the legislation merely provides that a control authority shall issue a building permit if the plans and specifications comply with the performance-based code, the control authority could be almost in the position of an insurer, liable in respect of any non-compliance irrespective of the degree of skill and care with which the control authority checked the plans and specifications. In other words, the control authority will be liable simply because there is a defect.

On the other hand, if the legislation makes it clear that the control authority's duty is to use all reasonable skill and care, or some similar form of words, then the control authority will not be liable merely because there was a defect but only if it was negligent in failing to discover that defect.

In such cases the control authority's liability is effectively identical to liability for the tort of negligence.

Excluding joint and several liability

Joint and several liability means that if other wrongdoers were unable to pay their contributions, the control authority would have to pay the full loss.

Some jurisdictions currently exempt control authorities from joint and several liability so that they are liable for only an appropriate proportion of the total loss.

Although that might be seen as fairer from the control authority's point of view, it would not be seen as fair by an innocent victim faced with an unrecoverable loss. In general, the public believes that the point of the building control system is for control authorities acting in the public interest, to ensure that buildings comply with the performance-based code.

Limiting the time a claim can be brought to court.

Limits on the time a claim may be brought to court ("limitation periods') exist in most jurisdictions. In some jurisdictions, in respect of building defects, the limitation period for tort does not start until the defect becomes apparent.

Most building defects will become apparent in the course of construction or within a few years after completion, but some will not. In effect, therefore, anyone who can be liable in tort for building defects will remain potentially liable for the life of the building.

The problem is particularly obvious if the code contains durability requirements, but in any case the soil beneath foundations can settle for up to 30 years, the design wind, the design earthquake, and even the design occupant live loads might not be experienced for similar lengthy periods, so that defective design and construction might not become apparent until many years after the building was completed.

Such cases are rare but they are not impossible. After such lengthy periods, the control authority is likely to be the only available wrongdoer.

Of course, the applicable limitation period is not the only reason, which might prevent the victim from taking a claim to court. The wrongdoer might not be available to be sued, because of death, liquidation, or might not be worth suing. Admittedly, the control authority is always available and solvent, but the fact that a building fails does not give the victim a claim against the control authority; legal negligence must be proved.

Fear of being sued is not the main, or most effective, reason for building producers to ensure that buildings comply with the building code.

There is also commercial and professional reputations involved. The producer will need to satisfy the control authority as to compliance, so that whatever the limitation period, the owners and users are protected by the competence and integrity of the control authorities.

4.13 Need for regulation in a performance environment

Introduction

Conversion of prescriptive systems into performance-based systems is taking place within broader government policy objectives.

The benefits of performance-based systems are often expressed in terms of greater process efficiency, lower costs, encouragement of innovation and the like. But they are also often expressed in deregulatory terms through the reduction of prescriptive requirements and the easing of tight bureaucratic processes.

Some argue though, that the implementation of a performance-based system actually increases the regulatory regime.

This perception comes from the introduction of measures, many, if not all, jurisdictions regard as necessary to manage risks associated with performance-based systems.

Most jurisdictions introducing performance-based building regulatory systems, have modern regulatory development processes which require detailed reporting on costs and benefits.

Unless these reports show justification of regulatory change, then that change is not permitted. Such reports generally include consideration of a number of factors, including:

- the impact on the community, the relevant industry sectors and government of any regulatory change, particularly in light of the regulatory system's social objectives;
- the social, environmental and economic costs and benefits of regulating (or not regulating); and
- the impact any regulatory change will have on local and international markets.

Potential risks of performance

Issues connected with the introduction of a performance-based building regulatory include:

- the increase in the subjectivity of the decision-making process; and
- the concurrent increase in the complexity of the decision-making process.

The question most jurisdictions have asked is, how should they deal with and minimise the potential impacts of these issues?

The answer will depend on local cultural, economic, political, social and operational matters. The following two examples indicate how some of the more common answers to this question may lead to a perception of increasing regulation in a deregulatory age.

Means of managing risks

Expert certification

Most jurisdictions issue a final approval to construct. Traditionally, a major task of the people administering this process has been to gauge whether a proposal satisfies the building regulatory requirements. These people are finding themselves less able to assess levels of compliance with any certainty.

This has arisen because of: the greater complexity of building regulatory requirements and building technology, and the enhanced levels of knowledge necessary to make decisions in areas such as fire-safety engineering.

To overcome this there has been a trend towards "expert certification". This is where experts certify compliance with regulatory requirements falling within their area of expertise.

When a building regulatory system is converted into a performance-based system, decision-making difficulties are expanded.

Therefore, performance-based systems have expanded the expert certification option. There is, however, numerous means by which this expansion can occur. **For Example:**

- designers (including engineers) and product manufacturers can self-certify that their design or material or system accords with the building regulatory requirements;
- an independent certifier can carry out this function;
- legislatively enforceable rules can be developed governing the certification process; and
- detailed government operated professional registration processes can be set in place to control certifiers;

Concurrently, the expansion of expert certification raises a number of liability issues.

For Example:

- Who is liable for a certification?
- Does the body responsible for considering compliance share in the liability of an expert?
- Should liability rest with the owner/developer who engages the expert? and
- What happens in systems, which require an expert to be independent?

Again, there are several options for resolving these matters, such as:

- requiring experts to be insured, including such approaches as capping liability in terms of either or both time and money; establishing government-operated insurance schemes, and utilising either the traditional professional liability types of insurance packages, or developing something along the lines of the newer run-off cover packages available in some private certification jurisdictions;
- allowing liability matters to be resolved by the courts as part of common law;
- establishing specialist tribunals to deal with such matters; and
- legislatively limiting the liability of particular people in the decision-making train, such as the certifying expert, the person responsible for building regulatory matters, the owner/developer, and so on.

Clearly, decisions will require a wide range of policy decisions based on local conditions.

Decision guidance

The decision-making process under a performance-based system can cause with uncertainty, as people attempt to satisfy various elements of a building proposal to achieve the regulatory requirements.

Under a prescriptive system, such decisions are eased, with the compliance criteria precisely specified, (although in reality, of course, most modern building regulatory systems already contain some performance criteria, under which judgements must be made as to whether or not compliance is achieved).

Under most performance-based systems, the existing prescriptive requirements have been set to one side - as an option to achieve compliance - or as a means of testing other ways of achieving the performance requirements.

The lower the level of certainty, or prescription, the more often designers, builders and regulators will be called upon to exercise their judgement in regards when “performance” has been achieved.

Such judgements are often subjective. Even when objective data is available, subjective decisions must be made as how to use the data, how to interpret it, and whether or not it is applicable to the proposal.

Some examples of this are addressing this issue include:

- a range of guideline documents setting out processes which can be followed to achieve compliance;
- verification methods, which set out the means to verify whether or not compliance is achieved; and
- the introduction of various forms of "peer group" review of proposals to help ascertain compliance levels

4.14 Government vs. self regulation

Jurisdictions may address the potential risks of performance-based building regulatory systems by a range of actions which some may perceive as increasing levels of regulation.

A number of these actions, designed to address liability and decision-making complexity issues, may involve a variety of system elements, including:

- expert certification (under which suitably qualified experts certify the level of compliance of elements of a building proposal);

- building practitioner or expert registration systems;
- decision-making auditing processes;
- special insurance packages; and
- peer group review processes.

There are numerous options for implementing these system elements. These include total government control to total self-regulation, passing through options relating to the use of independent non-government bodies. It is not possible to say that any one of these options is generally right or wrong; jurisdictions will judge on the basis of local conditions.

The introduction of a performance-based building regulatory system does not require a substantial turnaround in the type of building regulatory system. For example, if a jurisdiction has a government-controlled system, there is no reason why that system should be changed to a non-government or self-regulated system and vice versa, when brining in a performance-based system.

An element which has caused some discussion is the move to expert certification of elements of a building proposal. This is separate to the creation of a form of "private certification", where a private sector alternative has been created to the government-operated monopoly of building functions. In those jurisdictions where the building regulatory system is traditionally government controlled this is a substantial change.

It is true that the initiating factors for performance-based reform and the introduction of private certification are to increase efficiency of the regulatory process, and decrease process timeframes and associated costs, without reducing regulatory quality.

Nonetheless, private certification is not necessary to effect performance and vice versa. However, while private certification is a separate reform action, its introduction requires careful consideration of the enhanced liability, and subjectivity risks, which may arise under a performance-based building regulatory system.

4.15 Country specific experiences

Japan

Current situation

In Japan, performance-based code is now being introduced through the amendment of the Building Standard Law. It took almost ten years for the Japanese government to come to the conclusion that performance-based code should be introduced. The first suggestion for performance-based code was brought up during trade negotiation for wooden products. After that, the concept of performance-based code was studied mainly by the Building Research Institute, which organized integrated research project for performance-based fire and structural code.

The major turning point of policy change for performance-based code was the Deregulation Promotion Plan set by the Murayama administration in March 1995, which was heavily accelerated toward performance-based code under the Hashimoto administration in 1996. In this plan, performance concept was mentioned as key concept for rationalizing building regulatory system. Following this plan, in November 1995 the Minister of Construction asked the Building Council, which is policy consultation board consist of academies, industry, and journalism people, to formulate policy report regarding introduction of performance-based code.

The report was submitted to the Minister in March 1997. Followed by the actual law writing process, the law amendment is now submitted to the Diet, and is waiting for discussion. Though the promulgation of the amendment law is expected to be in late June 1998, specific performance requirement and verification method will be described in government order or ministerial notification, which will be prepared after promulgation. The whole system of performance-based code is expected to take effect in 2000 after preparation and dissemination period.

Issues

In law writing process, the problem was how to introduce performance-based criteria in existing regulative framework. The Building Standard Law was created in1950, and has been existing for nearly 50 years. It was impossible to abolish entire law and to create quite new law with ideal structure of performance-based code, because continuity of regulatory system is essential and important not to create social disturbance.

On the other hand, each article of current code has specification code, and since such specification tends to have different aspect of performance requirement at the same time, it was hard to reclassify or rewrite articles to accept performance-based criteria.

For example, some specifications for fire protection codes had two side of performance requirement, i.e. both for avoiding fire spreading toward surrounding buildings and for avoiding having fire from outside.

Toward Problem Solving

Our conclusion was that performance-based code in Japan should be added in existing codes to avoid drastic change. The reason was that Japanese regulatory system need to have as much continuity as possible and that the variety of performance verification method is so far limited due to lack of technology development and lack of international harmonization.

However, this amendment will open the door to the full scale introduction of performance-based code, and the more new technological knowledge is accumulated, the more adoption of performance-based code will be promoted inside the Building Standard Law.

Though other codes such as gas plumbing code used in building confirmation system are not proceeding to performance-based code yet, the change in the Building Standard Law will promote changes in other codes. Also, since performance-based code is not introduced thoroughly, there will remain a provision for special approval system by the Minister of Construction for unique solutions, which, for example, do not satisfy mentioned verification method but satisfy performance requirement in different way, using different verification method.

New Zealand

New Zealand has two levels of government: national and local. The National government comprises the Parliament, in which the majority party or coalition forms the “central government" or "the Government" which has power to legislate on all matters. Local government has the powers of legislation as specifically delegated to it by central government through Acts of Parliament.

There is a distinction between Acts passed by Parliament and delegated or subordinate legislation - authorised by a particular Act - ranging from Regulations made by the Cabinet to bylaws, planning rules, and so on, made by local government.

The building control legislation consists of one Act, the Building Act 1991. It has one set of Regulations, the Building Regulations 1992. The performance-based building code is the First Schedule to the Building Regulations.

The Building Industry Authority is the central focus of building controls. It monitors the performance of the territorial authorities, city or district councils, which act as control authorities.

Social objectives

The objectives of the performance-based building code correspond to the purposes and principles set out in Section Six of the Act, namely:

- safeguard people from possible injury, illness, or loss of amenity in the course of the use of any building, including the reasonable expectations of any person authorised to enter the building for the purpose of rescue operations and fire fighting in response to fire;
- provide protection to limit the extent and effects of the spread of fire, particularly with regard to household units and other residential units; and other property;
- make provision in a building used for the storage or processing of significant quantities of hazardous substances to prevent significant adverse effects on the environment (whether within the immediate locality or otherwise) arising from an emergency involving fire within that building;
- provide for the protection of other property from physical damage resulting from the construction, use, and demolition of any building;

- provide, both to and within [almost all buildings except private houses] means of access and facilities that meet the requirements of that Act to ensure that reasonable and adequate provision is made for people with disabilities to enter and carry out normal activities and processes in those buildings; and
- facilitate the efficient use of energy, in the case of new buildings, during the intended life of those buildings.

Most of the social objectives where identified by the government-appointed Building Industry Commission. It recommended what became the Building Act after studying the requirements of local government bylaws. Other objectives were inserted by Parliament.

Scope of the legislation

The Building Act applies to all buildings, including government buildings. It covers all building work (there are special rules for electrical and gasfitting work to correspond to the Electricity Act and the Gas Act.)

"Building consents' (building permits) and "code compliance certificates' ("completion certificates') are issued by territorial authorities (local government).

Buildings include all structures, thus the Act covers major civil engineering works, such as dams and bridges, but not mines.

There is an extensive list of buildings for which building consents (building permits) are not required but which must comply with the performance-based building code.

Compulsory upgrading of existing buildings

The territorial authorities have power to require existing buildings to be upgraded only if they:

- are positively dangerous or insanitary (court order needed);
- are to be altered (no building consent unless means of escape from fire and access and facilities for use by people with disabilities of the building as a whole are upgraded); or
- are to have a change of use (as for alterations).

The degree of upgrading required to bring the building to compliance is defined as "nearly as is reasonably practicable to the same extent as if it were a new building". This requirement has caused considerable complaint, especially from designers who wanted more specific rules. However, it seems to be working well and the objections have reduced but not disappeared.

Compulsory maintenance, inspection of existing buildings

Each building with one or more specified systems is issued with a "compliance schedule", listing the maintenance procedures compulsory for those systems.

Some procedures must be carried out by "independent qualified persons' approved by the territorial authority. The owner is required to post the list prominently inside the building and send to the territorial authority an annual statement ("building warrant of fitness') that all compliance schedule procedures have been properly completed in the previous 12 months.

Durability

The building code requires all building elements defined as "easy to access and replace and whose failure would be readily detected" to achieve performance requirements for five years. This increases to 15 years for elements moderately difficult to access or replace, or whose failure might go undetected during normal use, and becomes "indefinite" (but not more than the life of the building) for elements such as foundations.

The durability of most building materials and building elements (steel, concrete, timber, plumbing, and so on) is well established by experience. However, the durability requirement has caused significant improvement in manufacturers' literature.

Supporting publications

The Building Industry Authority has published a series of "Approved Documents' specifying (largely by reference to Standard and the like) acceptable solutions and verification methods. Compliance with the relevant Approved Document equates as compliance with the building code.

Assessing compliance with the performance-based code

A control authority is required to be 'satisfied on reasonable grounds' as to compliance with the building code before it issues a "building consent" (building permit) or a "code compliance certificate" (completion certificate). However, it must accept compliance with the Approved Documents, an accreditation or determination issued by the Building Industry Authority, or a certificate issued by a "building certifier" (private certifier).

Proprietary products and systems

The Building Industry Authority, on the basis of independent testing and appraisal, issues "accreditations' of proprietary products and processes which must be accepted as establishing compliance with the performance-based code.

The main problem is in ensuring that the manufacturer's instructions for the installation or use of accredited items are sufficiently specific.

Completed work

Owners or builders must give specified notice to the territorial authority when work will be ready for inspection at certain stages, but because of the 'satisfied on reasonable grounds' test, there is no duty on territorial authorities to make any inspections.

Private certifiers

"Building certifiers' (private certifiers) are approved by the Building Industry Authority. They may be individuals or corporations. Their approval is limited according to the specific qualifications and experience of those responsible for certification. New Zealand has no specific qualification requirements for either building certifiers or territorial authority officers.

Building certifiers are required to carry insurance approved by the Building Industry Authority, but in the prevailing insurance market it appears to be impossible to obtain insurance which would genuinely make a building certifier as financially capable of meeting an award for damages as is a territorial authority.

Technical disputes

The Building Industry Authority issues "determinations' in respect of technical disputes. Determinations are legally binding, subject to court appeals on questions of law only.

Because of their precedence value, determinations are detailed and reasoned decisions rather than quick "yes or no" answers. That means that they take at least three weeks and usually closer to six weeks (not helped by inadequate initial documentation from applicants). The Building Industry Authority recovers its costs from applicants whether or not they are successful. There is only a modest charge for disputes over individual houses and small apartment buildings.

Presumably, because of the time and cost involved, applications tend to be in respect of disputes involving significant costs.

The most common dispute is over whether it is "reasonably practicable" to install a lift in the compulsory upgrading of an existing building. Other disputes relating to access and facilities for use by people with disabilities, and disputes about fire design, comprise the bulk of the determinations.

The parties to a determination are limited to owners, territorial authorities, building certifiers, various governmental bodies such as the Fire Service and the Ministry of Health, and neighbours but only in respect of the protection of their own property (usually from flooding).

Technological risk

The performance-based code has been in force for five years. To date there have been no examples of increased risk.

Liability

Some lawyers have advised their territorial authority clients to limit their potential liability by refusing to accept anything other than compliance with the Approved Documents. This advice does not seem to be widely followed and has not led to any applications for determination. Indeed, one territorial authority known to have been given such advice has issued many building consents for alternative solutions.

There have been no decided cases on liability under the Building Act. However, because of the "reasonable grounds' test, it is expected that territorial authority liability will be effectively identical to their pre-Building Act tort liability. Building certifiers are expected to be liable on the same basis.

The Building Industry Authority is also exposed to the equivalent of tort liability in respect of issuing the Approved Documents, approving building certifiers, issuing accreditations, and so on.

Limiting liability

Officers and employees of the Building Industry Authority and territorial authorities are protected from personal liability if they acted in good faith.

Joint and several liability applies.

There is a 10-year limitation period, running from the act or omission on which the claim is based, for any civil proceedings arising out of the construction, alteration, etc of a building. That protects building producers as well as the Building Industry Authority, territorial authorities, and building certifiers.

New Zealand has a compulsory accident insurance scheme, and as a consequence the courts cannot award compensation in respect of injury or death.

United Kingdom

When new regulations were introduced in 1985, to include the provision of performance-based regulations, prescriptive solutions were retained in areas where it was difficult to provide a performance option. The approved documents (AD's) gave guidance on achieving the minimum standard for health and safety.

Over the years many designers have used the AD's as regulations for case of obtaining approval.

The government has indicated that as the current balance between prescriptive and performance based regulations seem to have been accepted, ie the option for the designer to choose which method being retained, there are currently no proposals to make major changes in the regulatory structure, other than minor up-dating.

The government also hopes to reduce the content of AD's by introducing more reference to British Standards/European Standards Codes of Practice and other guidance documents.

The current policy of bringing more private inspectors (AI's) into the building market has had the effect of making local government enforcement bodies more efficient to face the challenge of competition.

Some form of self-regulation has been mooted, but has not been progressed to date due to public safety concerns.

United States

This explanation assumes that a performance-based code has been established for the International Building Code (IBC).

There are still decisions to be made in this process. The purpose of this article is to outline elements that must be addressed in the United States, and to provide some direction in these areas when using a performance-based code.

In addition, this article provides background information on how each component interrelates in a performance-based code and the purpose of each component.

International code council

Unlike other nations, the United States' building codes are not developed or promulgated by the federal government.

Instead, they are developed by three private organisations:

- the Building Officials and Code Administrators, Inc. (BOCA);
- the International Conference of Building Officials (ICBO); and
- and the Southern Building Code Congress International, Inc. (SBCCI).

They are adopted by individual states on a regional basis (north-east, west of the Mississippi; and south-east, respectively). To eliminate the production of three separate model codes and minimise unnecessary regional differences, the three organisations formed an umbrella organisation - the International Code Council (ICC), to develop a single set of national codes (eg:, mechanical, plumbing, and building).

As part of the development of the International Building Code (IBC), a Performance Committee has been established to develop a performance-based framework.

In about 2000, the ICC's code will be published as part of a "family of International codes", which includes the IBC, the International Mechanical Code (IMC), the International Plumbing CodeTM (IPC), and related codes.

The ICC code will provide an opportunity for innovative building products, methods of construction and designs to meet the owner's objectives, while still providing the protection afforded by the intent of the codes.

Performance international building code

Following are the draft Intent and Scope statements for the Performance International Building Code.[xxviii]

The intent and scope statements are included to explain the relationship of the performance provisions to the entire document.

Intent

The intent of the performance-based code is to provide a reasonable level of health, safety and welfare, and to limit the damage to property from unintentional and natural events expected to impact buildings and structures.

Accordingly, the code intends to provide for:

- an environment free of unreasonable risk of death and injury from fires;
- a structure that will withstand anticipated loads associated with normal use, wind, snow, earthquakes or the severity associated with the location in which the structure is constructed;
- a design that provides acceptable means of egress and access;
- arrangements to limit the spread of fire, both within the building and to and from adjacent properties;
- adequate ventilation and sanitation facilities to maintain the health of the occupants; and
- adequate arrangements for natural light, heating, cooking and other amenities designed for the comfort of the occupants.

Scope

A performance-based code provides minimum requirements for buildings and structures and includes provisions for structural strength, stability, sanitation, access egress, light, ventilation, safety to life and property from fire - in general, to secure the life safety of occupants and the integrity of property.

This includes use and occupancy of buildings, structures, facilities and premises, their alteration, repair, maintenance, removal, demolition, and the installation and maintenance of all amenities including, but not limited to, such services as the electrical, gas, mechanical, plumbing and vertical transportation systems.

The intent and scope statements address all portions of the code and are similar in nature to what may be found in the administrative portion of the current code.

Performance structure

The performance provisions of the code provide a set of objectives, functional statements and performance requirements for major areas that must be satisfied to meet the intent of the code.

The components of a specific design that satisfy the three levels are called "Acceptable Solutions."

A design professional may comply with the prescriptive code provisions (eg: IBC Chapters 1-35), a combination of prescriptive and performance provisions, or a full performance approach as described in the Acceptable Solutions section for each major topic area.

Objectives

Objectives state what is expected in terms of societal goals, are topic specific and deal with particular aspects of performance required in a building, such as safeguarding people during escape and rescue.

Functional statement.

The functional statement explains why the objective must be met. **For Example:** to give people adequate time to reach a place of safety without exposure to intolerable conditions.

Performance requirements.

Performance requirements are detailed statements that are necessary to achieve the requirements of the functional statement.

Acceptable Solutions.

The acceptable solutions are the specific verification methods and acceptable technical solutions that may be utilised to achieve the performance requirements that, in turn, meet the objectives of the code. To be acceptable, the user has three basic options:

- performance approach (testing, modeling, calculations, etc.),
- prescriptive approach, or
- combination of performance and prescriptive approaches.

These new ICC performance provisions are intended to provide a performance-based structure superior to published provisions for alternative materials, design and methods of construction, and testing contained in the current National, Standard and Uniform Codes.

Typically, these alternates have been used for specific building components (eg:, smoke management and exiting of large auditoriums), but the building official, fire official or appeals board find themselves in the position of determining acceptance criteria with only general guidelines.

In the current code provisions, little guidance was provided to designers or code enforcers. By contrast, the standards, guidelines, etc., in the Acceptable Solutions of the ICC Performance Code allow the designer the flexibility to determine the design methodology, levels of risk and the performance level of the owner's needs as well as meet the intent rather than the letter of the code.

Architects and engineers have requested this flexibility for several years, and with the performance provisions, the designer now has the choice of using prescriptive, performance or a combination of these provisions.

In addition, guidelines or standards on acceptance criteria will be an integral part of the ICC Performance Code package, which enforcement officials have requested to accompany the alternative methods option in the past.

Acceptable Solutions will vary in form and style. Many will be technical standards published by professional standards' writing organisations and accepted by national consensus review processes.

Others will emphasise analysis or methods that establish a formal process for design, acceptance of materials, or protocol for testing and acceptance, and may not be consensus standards.

National Fire Protection Association

The National Fire Protection Association (NFPA) is the consensus-based standards-making organisation responsible for development of the National Fire Codes®, including the National Electrical Code®, the National Fire Alarm Code®, and the Life Safety Code®. In 1995, the NFPA published the report, The National Fire Protection Association's Future in Performance-Based Codes and Standards, which outlines NFPA's vision for performance-based documents.

This vision is to develop documents that offer both a prescriptive-based option and a performance-based option in the same document.

The user will have the choice to select the most appropriate path.

For the performance-based option, the report discusses the need to develop fire-safety goals and objectives, performance requirements, and performance criteria, make assumptions concerning building use and occupants, develop design fire scenarios, and select suitable engineering tools and methods for undertaking the fire safety analysis and design. An example of how a NFPA standard might be formatted is also provided. At the present time, efforts are under way to develop performance-based options by the Life Safety Code Technical Committees, the Atomic Energy Technical Committee, the National Fire Alarm Code Technical Committees, and others.

Technological risk

As codes- and standards-making committees discuss the transition to performance-based regulations, a number of questions related to “acceptable” or “tolerable” levels of risk have surfaced and need to be addressed, including:

- What are the sources of hazards considered by the regulations and how are they defined (eg:, wind loads, ground forces, fire loads, toxic products of combustion)?
- What is the severity of outcome (level of risk) contemplated by the regulations (eg: total building collapse, structural deformation, injury, death)?
- How are the risks characterised and defined (eg: a probability of fire or structural failure over the life of a building, the expected number of deaths per year, the expected number of deaths over the expected life of the building)?
- Who defines the levels of acceptable or tolerable risk (eg: the codes- and standards-making committees, the building design team, the building owner, the local government, the public, a combination of these groups)?
- How can acceptable or tolerable risk concepts be incorporated into building and fire regulations in a manner that is supportable, clear (unambiguous), and enforceable?
- How does one enforce a regulation based on acceptable or tolerable risk over the life of a building (eg: how does one account for future changes in use, occupancy, and risk)? and
- What uncertainties are associated with risk-based regulations and risk-based solutions, and how may they be handled in the regulatory process?

Currently, the committees lack comprehensive and broadly accepted guidance as to how to address these questions.

This is why the transition to a performance-based system is moving so slowly. If provided with adequate information and assessment to begin addressing the above questions, the committees will be better equipped to competently incorporate risk concepts into performance-based building and fire regulations.

In turn, this will help the United States realise innovative, safe, cost-effective and sustainable buildings through the application of performance-based analysis and design concepts within a performance-based regulatory system.

Economic concerns

Performance-based codes and fire-safety analysis and design methods would be incomplete if it did not consider some level of cost-benefit analysis.

The SFPE Focus Group, as well as others internationally, have identified cost savings as a critical factor in the transition from a prescriptive-based to a performance-based regulatory system.

One argument is that money can be saved by minimising redundant fire-safety measures, prescribed by current codes and standards, when a performance-based design is undertaken.

It follows, then, that a cost-benefit analysis will be required as part of the design justification. This issue should be addressed as part of any performance-based fire-safety analysis and design approach.

Legal concerns

No discussion of performance-based codes and performance-based design would be complete without consideration of legal concerns. A common legal concern is that of liability: for the design professionals and for the enforcement officials.

Under the current prescriptive-code system, the requirements are clearly laid out and compliance can be straightforward. This gives designers and enforcement officials something to hide behind should a future "problem" occur in the building.

However, many buildings are not built precisely to code, and the defence of "I met the code" is not as concrete as it once was, especially when more appropriate measures are available.

Under a performance-based system, designers and enforcers are concerned about what they are designing and how it will be enforced.

However, it is estimated that some 90% of the time, the prescriptive code, as a Deemed-to-Satisfy document, will be the design and enforcement guide.

(In the other 10% of the cases, there will be discussion between the owner, the design team, and the enforcement officials, and the design will be based on the agreements reached. In essence, this is the same process as an "equivalence" or variance today).

Significant liability issues may result from the selection of design approaches and design criteria.

This is where design guidance documents will play an important role. If the guides become "standardised" or recognised as "acceptable practice," it may help reduce liability exposure.

In those cases where a design professional cannot support assumptions and assertions, liability exposure will be greater.

There will likely be other issues as well, and although it would not be beneficial to the design community to have lawyers draft the building regulatory system, it would be beneficial to obtain their input and expertise as the process develops.

Enforcement concerns

Intertwined with the legal concerns are enforcement concerns. Enforcement officials want to know what they are approving, how they will enforce design requirements, and what their liabilities will be.

A complete performance system will actually provide more and better tools for designers and enforcement officials to perform their duties. It should be remembered that, even if a performance-based design is undertaken, detailed drawings and installation specifications will be required.

Legislative concerns

As performance-based codes are being developed, most legislative aspects have yet to be addressed.

The legislative environment in which codes will be adopted and enforced is important. With regard to risk, what do local communities believe to be acceptable levels of risk? How are qualifications of design professionals handled? How will a performance-based code fit into existing legislation? These are just a few of the legislative concerns that have yet to be addressed.

5. Support framework

This section examines the regulatory infrastructure components and requirements needed for the development, implementation, use, and enforcement of a performance-based regulatory system.

These issues should be considered in the context of the cultural, societal, economic, and legal environment in which the performance-based system will be implemented and used. These issues include:

- Standards.
- Enforcement of performance-based codes
- Legal context
- Liability
- Evaluation of products
- Recognised solutions

The impact of all components needs to be considered when establishing a performance-based regulatory system. Each has the potential to disrupt a successful implementation.

5.1 Standards

Although most jurisdictions have well-established national Standards' systems, regulators are moving toward the adoption of regional and international Standards when drafting regulations. This is often to facilitate trade and other political agenda, but it is also looking to establish a more homogeneous technical basis to codes.

Standards have traditionally been developed by industry. Industry did this to help produce a stable market place for their products, rather than meet the needs of construction codes based upon minimum societal acceptable standards.

Many standards are still prescriptive and often fail to establish outcome-based requirements. As such, they pose problems when attempting to establish regulation based upon outcome rather then proscribing, materials and process.

Test standards

When establishing a criterion value for specific performance, it is advisable to measure the criterion against a specific test. Otherwise, disagreements can occur over the choice of test method applicable. It is not unusual for different test methods - purporting to test the same performance characteristics on the same sample - to produce different test results. This results in a situation were one test may pass the criterion and another fail it.

Establishment of outcome-based construction standards

Many Standards that are references in construction are prescriptive in form, relatively few are performance- or outcome-based. However, this is not true of all areas of construction. For Example: in the area of structural engineering the majority of Standards are performance based.

Standards of practice for design.

When dealing with performance requirements - in particular those expressed in "qualitative" terms - it is not possible to predict all the factors that may impinge upon the situation. In most cases codes have in the past dealt with this by making reference to "good engineering practice" and occasionally by reference to design guides.

As the use of performance-based solutions increases, the design community and the compliance-assessment community will be need to develop an understanding that the solution has been subjected to a rigorous and systematic design process. Such systematic approaches are the basis of "good engineering or design practice".

Maintenance standards.

There will be an increased reliance upon active systems in many performance-based buildings. It will therefore be critical that these systems be maintained so that the design performance level does not deviate. Although some Standards establish compliance with design criteria, there are relatively few in the area of maintenance.

The general problem with general maintenance Standards is that each performance solution will have unique characteristics. A maintenance Standard would have to take this into consideration. Establishing compliance with such maintenance standards/schedules is another issue and is dealt with elsewhere in this document.

Installation and construction Standards.

A number of these exist and are mainly prescriptive. In some jurisdictions there are specific requirements associated with the quality of workmanship involved in the construction process whereas in others the code does not deal with the issue.

Qualifications of design professionals.[3]

The qualifications and skills of a designer will vary, based on the type of project and the degree of analysis needed.

Performance-based designs will require more analysis than the same building designed in conformance with the prescriptive code. This is because performance objectives require the designer to make many decisions relative to compliance with applicable performance requirements and acceptable solutions.

Increased documentation of these decisions and their solutions will be necessary to verify compliance. Therefore, the qualifications and skills are different and increase with the complexity and size of building design.

It is incumbent that the professional designer become competent in this area of practice, where more analysis and new skills are required, before taking on a project based on performance-design techniques.

Design professionals and support staff have a responsibility to learn technical and performance-based skills through professional and/or university programs before embarking on a performance-based project.

The team must be qualified to enforce the responsibilities necessary to design the proposed project. Theoretical proposals must be adequately analysed and justified to develop a concept through design detail (eg: selecting materials, passive fire-resistive barriers, active mechanical/electrical systems, etc.).

The increased qualification and skill requirements are especially important for fire-protection engineers who may need fire-modelling skills to develop a number of scenarios appropriate to the design proposal. The architectural skills to design and lead a team through the performance-based provisions of the code must also increase.

The processes discussed in the acceptable solution of each objective must be met and documented by a member of the design team. This will require extensive team member coordination to produce a systems' design with compatible components.

As always, large projects using performance approaches require engineers with a high level of skills in the structural, electrical and mechanical disciplines, necessary to undertake a major building design.

Qualifications can be both objective and subjective. In most cases, the primary

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[3] *This section is excerpted from a paper prepared by Robert D. Weber, P.E., C.B.O., Director of the Clark County Nevada Department of Building, and Chair of the ICC Performance Committee, entitled "ICC Performance Code: Guidelines for Use." It has been supplemented by text provided by IRCC members.*

requirements for being considered "a qualified consultant" relate to education and experience. To be considered a "qualified engineer," however, some jurisdictions may require some form or official recognition.

In the United States, for example, authorities require registration or licensure as a Professional Engineer (PE) in order to practice as an engineer. Licensure as a PE is regulated at the state level, and is most often obtained by completion of a Principals and Practices examination in one of many engineering disciplines (eg: Civil, Structural, Mechanical, or Fire Protection Engineering), as administered by the National Council of Examiners for Engineers and Surveyors (NCEES).

Other countries have similar views. However, in many cases, it is a result of attaining membership in a profession society rather than by examination.

At the contractor level, qualifications may be determined by registration or certification. In the United States, technicians are generally registered by the state through certification by such organisations as the National Institute for Certification in Engineering Technologies (NICET).

In the area of fire-protection technologies, NICET certification is available for sprinkler-system technicians, non-water fire suppression systems, and fire-alarm systems. State and local authorities also register trade persons, such as electricians, plumbers, and pipe fitters.

In addition to the need for licensures and certifications, the "qualifications' for any project should include the knowledge, experience, problem-solving capabilities, and ability of the participants to clearly articulate and communicate problems and potential solutions. (Simply because someone is "licensed" does not automatically mean they are "qualified." Likewise, the lack of a license does not mean someone is unqualified.)

Although many of these factors may be subjective, they can be determined through the review of similar projects, interviews and one-on-one evaluations.

Gathering this kind of background information is part of the documentation process, and may well be a regulatory requirement.

Designer responsibilities

The design team has a responsibility to work as a unit to provide a systems approach. This is achieved by analysing building components and systems to ensure they are compatible with the performance provisions.

A single principal design professional is recommended to ensure that the coordination of every aspect of the design package is accomplished. The principal design professional's role includes the following:

- coordinating the team to ensure that design methodologies and assumptions are compatible for a systems-approach design and that the performance code provisions are met as well as the applicable prescriptive code provisions where used;

- functioning as a point of contact for all participants during the design phase, which includes the design team, architects, engineers and allied consultants, owners, contractors and building officials;
- ensuring that design/construction documents are coordinated, comprehensively complete, with appropriate delineation between plans and related documents, and contain the necessary support documentation to verify compliance with provisions;
- functioning as a point of contact with the building official to ensure that the construction documents are filed with the government entity for review, approval and construction permits. This ensures timely response to questions, revisions and requests for additional information on any construction documents;
- functioning as a point of contact for the design team following permit issuance, responding to changes, clarifications or additional information that may be required during the construction and verification process;
- ensuring that full architectural and engineering services are provided for the project, including certification of building elements as may be determined by the building official. Complete construction documents must be prepared and submitted to the building official, which may include any of the following:
- plans and specifications;
- calculations to demonstrate that the design analysis meets the standard professional practices and "acceptable solution" requirements;
- computer modelling and analysis with the program name and description, program objectives, input and output units, characteristics, and related information so that a professional peer can verify compliance with the performance provisions and professional standard practice;
- assumptions, limitations, and factors of safety used in the analysis and design;
- identity of applicable components that comply with performance and prescriptive code provisions;
- identity of performance levels and objectives;
- identity of performance criteria used;
- description of scenarios used with applicable data to demonstrate various design approaches and conditions meeting performance provisions;
- description of the methods used to demonstrate that standards of care were taken for using a building systems design approach;

- scope of inspection and testing requirements to demonstrate compliance with design provisions;
- scope of quality assurance techniques proposed to demonstrate that construction complies with the construction documents; and
- identity of maintenance requirements of the building that the owner must undertake in the future use of the building and their frequency (eg: inspections, testing, service or maintenance activities).

Quality assurance program

A quality assurance team approach is recommended during the design and construction process to meet performance-code requirements. The team should include design professionals, building official representatives for plan review and inspections, a special inspector/third-party inspector, a testing agency, and contractor/s.

Although such a is beneficial for prescriptive-code projects - including minor deviations based on alternate material and methods - performance-based designs require more communication between the parties with fewer assumptions by the contractor.

The construction documents are the basis of design approval. They are the governing requirement for verification by inspectors and for testing agencies. Deviations from such documents require the contractor to consult with the design professional to evaluate and approve revisions against the project objectives before obtaining approval from the building official.

The process helps obtain the owner's buy-in for construction to comply with design documents. Consequently, there is less leeway given to the contractor for not complying with the plans since the contractor and owner should have a front-end commitment with all parties.

Certification by accredited person or organisation

There is a need to ensure that those people approving designs are also well qualified.

Historically, this had been the province of building officials, or building control officers; part of the local government. Typically, to hold such a position, one had to demonstrate some level of competency and gain recognition through formal education (eg; building surveyor, engineer, architect) or certification (eg: Certified Building Official, CBO). In a performance-based system, however, there may be third-party individuals or groups responsible for building approvals or certification.

If a third-party approval process is in place, the education, qualifications, and experience of the third-party certifier should be addressed in the manner described in 0. In short, there should be mechanisms for evaluating the qualifications of certifying individuals. In addition, the legal implications of third-party certification or approval should be addressed within the system.

Also, the qualifications of organisations that certify building components and systems needs to be addressed. For example, all countries have "recognised test laboratories' where products are tested against various Standards and certified for a particular use.

For these organisations, the qualifications and experience are generally not a concern.

However, there are also independent test laboratories or services that provide similar services. In cases were such independent, or alternate certifiers are used, there needs to be some way to assure the level of quality required.

In the United States, this quality assurance is provided, in part, by "evaluation services' associated with the model code development groups. In these cases, the evaluation service takes on the responsibility for evaluating compliance with code requirements, often utilising the independent test laboratories for actual testing services.

If a product is submitted to the evaluation service, the certification it receives will be assured by the service, and not by the test laboratory used for the actual testing. This results in a certification that the produce meets the requirements for the code; the same outcome that would be achieved if testing was performed by a "recognised" test laboratory.

Building maintenance and owner responsibilities

Once a building is constructed to the approved construction documents, the owner is responsible for maintaining it as required.

Critical areas determined by the design professional may require inspection, testing and/or service at predetermined intervals to ensure continued compliance through the life of the building.

These requirements must be detailed in writing with a specific notation that such requirements can be released only upon the approval of the building official. In several countries, the owner is required to file verification documents annually to demonstrate that the building is being maintained. If this is not done then the certificate of occupancy is revoked or not renewed.

When a building is to be remodelled or undergo a significant change in use, a qualified design professional is required to evaluate the existing building construction documents for the proposed change. The building official then must verify, in writing, that changes will not adversely impact the building based on prior performance-construction documents.

Proprietary products and systems

Assessing whether a proprietary product or system complies with the performance-based code is no different from assessing any other building element or design.

However, there are obvious advantages if such items can be approved by a specialist body acting on behalf of the control authority. For Example: the European Agreement systems, or the evaluation services concept used by the model code organisations in the United States.

The evaluation services concept used in the United States allows products or systems to be approved for compliance with a particular portion of the prescriptive code.

The evaluation services operate under the alternate materials and methods sections of the code. This section permits use of alternate designs or products provided they are equivalent in safety, sanitation, suitability, strength, effectiveness, fire resistance and durability.

Approvals are incorporated into the testing process for Standards. This method eliminates a potential burden to industry and provides a level of confidence to local authorities. Approvals are published in evaluation reports made available to interested parties.

Another service provided by the evaluation services groups is laboratory and quality control/ inspection agency accreditation.

This service can be essential to authorities, as they will have an increased level of confidence in test results or inspections received from such sources. This particular recognition is based on ISO Guides 25, General Requirements for the Competence of Calibration and Testing Laboratories and 39, General Requirements for the Acceptance of Inspection Bodies.

Such systems can continue under a performance-based code system but in some cases legislation providing recognition to such agencies may be necessary. Also, this type of system may be appropriate as an independent review source for a performance-based design.

5.2 Enforcement of performance-based codes

General

The legislation will need to specify how control authorities and private certifiers are to assess compliance with the performance-based code. The wording of the legislative provisions concerned can have a significant effect on liability.

The legislation should also provide that the following must be accepted as establishing compliance with the performance-based code:

- compliance with the guidance documents. When the building producer chooses to comply with a guidance document, the control authority can check against that prescriptive document in exactly the same way as under a prescriptive system; and.

- a certificate of compliance issued by a private certifier. In order to certify compliance, private certifiers must make exactly the same assessments as control authorities.

In practice, there are several methods of assessing alternative solutions, each of which can be used by the control authority or by a private certifier including:

Approval at first sight

In many cases, an alternative solution can be approved at first sight because its divergence from the relevant guidance document is trivial and obvious.

Many prescriptive codes such as the guidance documents tend to be written on the basis of standard member sizes. It will frequently be possible to be satisfied at first sight that some interpolation between standard member sizes is appropriate.

Prescriptive codes also tend to provide for the worst case. It will frequently be clear at first sight that a particular proposal is very far from being the worst case so that the guidance document can be modified to for the actual building concerned, in other words become an alternative solution that complies with the performance-based code.

Similarly, there is a Canadian plumbing Standard which is basically identical with the corresponding US Standard except for the colour specified for a particular class of pipe. Obviously, if both countries had performance-based codes specifying the same performance requirements for plumbing, the Canadian Standard would be approved in the US and the US Standard in Canada, in each case subject only to whatever conditions, if any, are necessary to prevent confusion about the class of pipe actually used.

The prescriptive plumbing codes of New Zealand, Australia, and the UK are all cited in the New Zealand guidance documents as acceptable solutions. Their codes are significantly different, but effectively identical levels of safety and hygiene are achieved in each of those countries. However, it is becoming increasingly popular in New Zealand to combine parts of two or more of those acceptable solutions to produce an alternative solution. For example, designing the soil stack and connections, using floor waste gullies, to the Australian code results in fewer connections than under the New Zealand code, but designing the drain into which the stack discharges to the New Zealand code allows for gradients too flat to be accepted under the Australian code. There are some worst-case situations where that particular combination of code requirements is not suitable, but there are many where it is suitable and can therefore be approved as an alternative solution.

In such cases, of course, the guidance documents will no doubt eventually be amended to convert alternative solutions into acceptable solutions.

By comparison with an acceptable solution

The prescriptive acceptable solutions in the guidance documents cannot possibly cover every conceivable building. For example, an acceptable solution for means of escape from fire might give maximum travel distances for a range of building uses, but is unlikely to include special cases such as, say, a fire station, in which longer distances might be approved by the control authority as an alternative solution. Similarly, a platform lift which does not have an enclosed compartment complying with the acceptable solution for passenger lifts might be approved as an alternative solution to ramp access for people with disabilities between different floor levels on the same storey.

Guidance documents from other jurisdictions

It is unlikely that any jurisdiction's guidance documents will cover all possible types of building. For example, a jurisdiction could well have no guidance document for construction in aluminium, say, or glass blocks, if that material was rarely used in that jurisdiction. However, appropriate documents could well have been issued for some other jurisdiction. If so, then those documents would provide a means of assessing any alternative solution involving the material concerned.

Of course, the control authority would need to consider not only the document itself but the system under which it was issued. It could be, for example, that the two jurisdictions had different social objectives. If so, the control authority would need to take that into account, and perhaps ask for additional provisions to meet its own social objectives. Similarly, the design loads and other relevant matters will need to be examined.

Experience in use

Satisfactory experience in use might justify acceptance of an alternative solution such as a proprietary building method. Again, if the use has been in another jurisdiction, differences between the jurisdictions will need to be examined.

Calculations and tests

The guidance documents' verification methods are unlikely to cover all possible methods of applying the fundamental principles of structural mechanics in relation to earthquake loading, for example, or the fundamental principles of thermal dynamics in relation to design against fire. An alternative solution based on applying such principles could be demonstrated by calculation to comply with the performance-based code.

In some such cases it might be necessary to support the calculations with test results, if only to establish figures to be used in the calculation.

In other cases, a test not included in the level 4 verification methods might be sufficient to establish compliance with the performance-based code. For example, a roofing system could be tested in a wind tunnel.

Expert opinion

In some jurisdictions, some if not all of the control authorities will have limited technical resources for the assessment of alternative solutions. In such cases the "committee of experts' approach is useful.

Under that approach, the building producer would submit an independent peer review by a committee of one or more experts to the control authority as evidence of compliance. A control authority should be able, but not be obliged, to accept such a peer review as establishing compliance with the performance-based code, but only if it was satisfied that the reviewers were in fact experts in that particular field.

Alternatively, the control authority itself could commission such a review. The legislation should allow for that approach but should not make it mandatory.

For some types of building, large dams for example, there appear to be no prescriptive guidance documents anywhere in the world. The design of such a structure will usually be subject to a formalised peer group review by an independent committee of experts.

In other cases the control authority should be able, but not obliged, to accept a design certificate from a building producer without any peer review. For example, the control authority could choose to accept a design certificate from the engineer responsible for the design of foundations for poor ground. It is sometimes thought that a control authority is accepting an alternative solution when it relies on an engineer's design certificate or the like. That has rarely been the case in New Zealand, where many such certificates are issued but are almost always to the effect that a building or part of a building (foundations, for example, or roof trusses) was designed in accordance with a verification method in the guidance documents.

Proprietary products and systems

Assessing whether a proprietary product or system complies with the performance-based code is no different in principal from assessing any other building element or building design. However, there are obvious advantages if such items can be approved by a specialist body in effect acting on behalf of the control authority. Obvious examples are the European Agreement systems, or the Canadian Construction Materials system.

In some cases, the system concerned is integrated into the current prescriptive codes, such as by the specification of a test method which requires that the test shall be conducted by a laboratory approved or accredited by a particular authority.

Such systems can continue under a performance-based code, but it might be useful for the legislation to give formal recognition to the specialist bodies concerned.

5.3 Enforcement tools and methods

Most building control systems require a building permit to be obtained from the control authority before construction commences. A completion certificate, or the like is, to be obtained when construction has been completed, (usually but not always from the same control authority).

There are, of course, variations, particularly in respect of the number and nature of control authorities (perhaps for the building itself, for its electrical installations, for its plumbing, for its fire safety, and so on) and the number and nature of the permits and certificates involved.

Enforcing the legislation covered in this report usually means an independent control authority - acting in the public interest - checks the plans and specifications for a proposed building for compliance with the code. It then inspects the building at appropriate stages of construction and on completion for compliance with the approved plans and specifications subject to any approved amendments.

That approach will apply equally well with a performance-based code as with a prescriptive code.

However, because a performance-based system requires the control authority to make value judgments and generally exercise a broader discretion, it is more important for control authorities to be continually monitored to ensure that they are correctly applying the performance-based code.

This can be achieved by random technical audits of control authorities (and private certifiers). In addition, dispute-resolution procedures can play a large part.

Depending on the scope of the legislation, it might need to provide for enforcement:

- from the time when it is proposed to construct a building until the construction is completed;
- throughout the life of a building in which the legislation requires ongoing routine maintenance of specified systems or features; and
- when an existing building is required to be upgraded or demolished.

Construction

In order to issue a building permit or a completion certificate, the control authority will have to assess whether the plans and specification or the completed work complies with the performance-based code. That raises two issues:

- How to assess whether an alternative solution complies with the performance-based code? and
- What liability, if any, will be incurred if the assessment is incorrect?

It is an offence to construct a building without a permit or not in accordance with the approved plans and specifications. It is usually also an offence to permit some other person to do so.

In some jurisdictions it is an offence to use a building before it has received a completion certificate, whereas in other jurisdictions the completion certificate is seen as merely the administrative 'signing off" of the building permit and it is not an offence to occupy an uncompleted building unless it is dangerous or insanitary.

Maintenance of buildings

In some jurisdictions, maintenance of non-specialised buildings and parts of buildings are controlled by separate legislation administered by specialised authorities. For Example: lifts or automatic-sprinkler systems. In other jurisdictions, routine maintenance of all of those systems comes within the scope of the building control legislation.

The usual approach is for the legislation to require that specified systems/etc be certified annually as having been maintained and inspected in accordance with procedures. In some cases, the procedures will be carried out by approved contractors or governmental inspectorates.

In other systems, in New Zealand for example, the building control authority specifies or approves the procedures but the building owner is responsible for ensuring that they are properly carried out, by qualified personnel where appropriate. The owner issues an annual statement of compliance to the control authority, and publicly displays a copy of that statement in the building.

In most systems it is an offence to use, or permit the use of, uncertified systems or features.

Upgrading buildings

The approach of requiring all buildings to be upgraded from time to time as necessary to bring them to compliance with the performance-based code, is unlikely to be politically or socially acceptable even if economically sustainable.

If upgrading is required when a building is altered, then the legislation will need to provide that building permits are not to be issued for alterations which do not include the required upgrading.

If upgrading is required on a change of use, then the legislation will need to provide that the use of a building is not to be changed without the approval of the control authority. It is not always easy to decide what constitutes a change of use for upgrading purposes. The legislation might also provide for permits and certificates to specify the use of the building in detail, for example "floor restaurant seating not more than 100 people".

Legislation might include procedures for inspections of certain types of buildings to identify which require upgrading. Usually action is taken on such buildings only if they come to the control authority's attention.

At the very least, the new legislation should include powers for the control authority to inspect buildings to ensure that they are not dangerous or insanitary. It should also authorise the control authority to take action to secure or demolish a building which poses a threat to public safety.

The legislation could also include provisions requiring owners to inspect, and if necessary upgrade, their buildings in respect of specific hazards or failures to achieve social objectives, including:

- currently-recognised dangers, such as unencapsulated asbestos;
- newly-discovered dangers, which usually result in an amendment to the guidance document if not to the performance-based code; and
- new objectives such as water conservation or energy conservation.

In most jurisdictions, it is unlikely to be acceptable for the control authority, except in an emergency, to require a building be upgraded or demolished against the owner's wishes without a hearing in court.

Private-sector involvement in conformance assessment

Private certification is currently one of the major reforms in building control. The issue must be considered in any of liability and performance debates. The introduction of a privatised approval system allows for demarcation and separation to be established between the responsibilities and functions of regulatory authorities and professionals assuming responsibility for design and construction certification.

For a privatised system to be successful, it is necessary to establish suitable legislation on procedures and functions for practitioners.

This is especially important with regards to practitioner registration, random auditing, enforcement and disciplinary action, levels of liability and responsibilities.

Clear ethics and practising guidelines for building practitioners are also needed. These factors help ensure that community health, safety and amenity standards are maintained.

In a privatised system, and in a performance-based framework, the overall certification of a building should not be limited to one sole practitioner. This is due to the direct contact and involvement of all design disciplines with the building certifier in the approval process.

In the Australian experience, traditionally in a government or local authority system, the involvement of some practitioners in the approval process has been from a distance with the lead consultant (usually the architect) having the only contact with the building control official.

Based upon the number of practitioners involved in the design process using performance-based regulations, it would be unrealistic for the building certifier to be able to assess all aspects of the design and hence, reliance upon other practitioners would be common practice.

To date, the debate concerning privatisation has mainly centred on the professional ethics, liability and competency of building control professionals. These issues have particular relevance when considering the reform agendas concerning performance-based building codes. Certification, be it private or government based, has advantages and disadvantages.

Advantages

The major advantage of a private certification system is the flexibility it provides to the construction industry.

A private building control professional is accessible by a design team and can be involved in designs right from the start. However, this practice has been criticised due to the "intimacy" of the building practitioner responsible for certification to the design, and the possibility of direct involvement in the design process.

The level of involvement of the certifier in the design process is common in jurisdictions with private certification. Thus, privatised systems need to ensure building certifiers are limited to an approving function. Ethics and an awareness of statutory obligations need to be mandatory for all practitioners.

In addition, an awareness of the statutory obligations by building owners and developers is needed. This is important in a performance-designed building due to the maintenance of active systems required.

The level of competence of building practitioners in some Australian jurisdictions using a privatised system, has been lacking and in need of improvement. However, it has been found that the common market place is beginning to provide direction with competency levels increasing to meet market demands and expectations.

Factors which have resulted in increased professionalism include:

- legislation being introduced by the relevant jurisdiction limiting the level of activity of some practitioners such as the restricting their use of performance-based solutions or their ability to certify commercial buildings;
- requirements for additional post graduate studies to be undertaken; or
- practitioners who are lacking the desired level of competence being gradually eased out of the market place.

Experience in Australia has found that private certification has significantly changed the traditional focus of the building control professional.

Where private certification is used, the building industry has developed an expectation that the building control professional is not just the approval authority but rather, a building regulatory consultant who advises on all legislation relating to construction.

However, it is necessary to ensure that a clear delineation between the responsibilities of being the approval authority and those of a building regulatory consultant is provided. Building certifiers must be ethical and aware that statutory obligations are their primary objective.

Accountability and ethics

The issue of ethics, accountability and professional conduct requires consideration in a privatised system. It has been argued that within a more flexible performance-based framework, some building certifiers with low ethical standards would yield to commercial pressures.

This may be the case in some instances. However, it can be argued that building certifiers are no different to any other professional placed in a position of trust by the community and subjected to market forces.

However, with the establishment of;

- a code of ethics by the relevant professional associations;
- a suitable degree of responsibility placed upon the individual by legislation; and
- registration of practitioners under legislation including requirements to maintain competency levels through continuing professional development;
- practitioners in a privatised system should have the same ethical standard as those practitioners within a government agency responsible for building control.

When considering ethics, it should be noted that they are moral principles that lay down guidelines for conduct. Within the context of all members of the building profession, they incorporate the responsibility:

- for skilful practice and advancement of the profession;
- to observe a mode of professional practice in colleague relations; and, more importantly;
- to serve clients and the community faithfully and to observe the moral principles of society;
- to clients encompasses the duties of impartiality and independence - there is a requirement that a building certifier be completely removed from the their dealings with a client; and
- to the community and to observe the conventional moral principles of society entails the need to always have the public interest as their main objective.

Though building certifiers are not public servants they are responsible for public safety and are placed in a position of trust.

Even though the level of community awareness in a privatised system is increased due to its transparency, the community cannot effectively judge or supervise all of the actions of a building certifier. Therefore, the public must depend upon the competence of the building certifier and trust that they will perform their duties responsibly and in the public interest.

The Australian experience with private building certification has traditionally found that private practitioners responsible for building control are the most regulated and controlled professionals in the building industry.

Enforcement

Formal qualifications, registration by appropriate boards and legislation can provide reassurance that a practitioner possesses the necessary training and competence. It cannot guarantee the practitioner's level of responsibility in the use of those skills.

Therefore there is a need to ensure accountability to protect the public. Legislation should ideally possess preventative mechanisms such as appropriate and adequate enforcement of certifiers, random auditing and a process for disciplinary action.

An advantage of private certification is the level of scrutiny to which it is exposed.

The transparency of a privatised system creates an environment where the professional is held more accountable for their actions. This is reflected in the proportionate liability regimes being introduced which distribute responsibility equitably.

Independent auditing, peer review and the means for disciplinary action on an individual are an integral part of a private certification system. Procedures for enforcement are paramount to ensuring that public protection and community expectations are maintained.

These processes need to be bound by a legislative framework to ensure that enforcement can be undertaken. However, it can be argued that such processes should not be limited to a privatised system. The requirements of independence and impartiality must be supported by appropriate disciplinary procedures. While some ethical breaches, such as failure to carry out work promptly and efficiently, are not of sufficient magnitude to warrant serious action and may lead to a reprimand, a failure to act in the community interest requires harsher penalties. The magnitude of penalty should reflect the seriousness of the offence.

Liability

Privatisation of building control functions allows the transfer of liability and risk from government authorities to the private sector.

It is necessary that the level of liability of the private practitioner be closely monitored and that legislation ensures a clear understanding of responsibilities and functions.

It should clearly outline that liability be proportioned among all practitioners involved in the design, approval and construction process. Within a performance based framework this is important due to difficulties for the building control professional to independently assess performance-based solutions without further certification from other design professionals.

As part of the overall liability issue, a private certification system should also include mandatory provisions for professional indemnity insurance. However, liability and professional indemnity insurance are issues for any authority regardless of their composition. Such insurance would also need to be mandatory for all professionals involved in the design, approval and construction of buildings.

The competency and education of professionals involved in the certification process is also of significance. In Australia, jurisdictions that have moved from a government-based system to privatisation have had initial problems with the level of competence of some practitioners.

Disadvantages

The Australian experience has shown that problems relating to competency and professional actions stem from the government system in which the new private practitioners had been trained. For example, an official from a municipal council - consisting mainly of houses with no high rise or commercial buildings - may commence practice as a building certifier and approve buildings in which they had no experience.

The issue here is the need for practitioners to recognise their area of competence and expertise and to practise within those boundaries. Registration will help overcome this problem, particularly if a national registration scheme is introduced.

Generally, in the Australian privatised systems the above responsibilities have been retained by government and regulatory authorities. Government and regulatory authorities were recognised as best equipped to deal with enforcement issues.

It was also recognised that under a privatised system, practitioners would generally not be inclined to carry out enforcement roles. This is due to the amount of time and resources needed to implement such procedures. Building owners are unlikely to pay fees for regulatory enforcement of this nature.

Education

When the technical requirements for building and construction are prescriptive, the education of practitioners is reasonably straightforward. However, in using performance-based codes, a new approach is required.

The ability to verify performance-based solutions is important in ensuring that building designs meet community expectations. To ensure these expectations are not compromised, academic institutions - together with the appropriate bodies responsible for the registration of practitioners - need to develop courses which provide training for practitioners allowing them to assess performance-based solutions.

The functions of government authorities and private practitioners need to be clearly established in a privatised system.

Matters such as public safety in existing buildings, means of protecting the public between building sites and public roads, etc. all need to be addressed.

A privatised system is usually based on the approval process for the design and construction of building works and does not adequately cover these issues.

Costs

In comparing the costs of private certification with a government system in Australia, it was found that building approval costs have decreased.

In the commercial sector of the construction industry, approval costs have risen for the initial building approval. However, these increases have been generally offset by a reduction in approval times.

The emphasis on time versus money cost saving is generally not as critical to the home owner in the domestic sector of the industry. Therefore, it has been suggested that certification is only a viable option for commercial projects.

Fees in private certification should reflect a user-pays system in which market forces are dominant. They also reflect the real cost of obtaining a building approval that is generally not the case in a government system due to subsidised fees.

Conclusion

Private certification together with a performance-based regulatory framework can provide flexibility to the building industry. This is only possible when a legislative framework is established to ensure that the functions, accountability and liability of practitioners are clearly established, together with an appropriate means of support and enforcement.

The debate concerning the entire concept of private certification continues. Areas to be addressed before the development of legislation to introduce private certification include:

- professional ethics;
- accountability;
- competency;
- code environment;
- education; and
- liability.

Until these matters can be agreed upon, the introduction and acceptance of private certification by government regulatory jurisdictions cannot occur.

Publication of approved examples of compliance

In some jurisdictions it is possible to publish designs that comply with the performance requirements of the code. This, however, does raise the issue of copyright.

Publication of designs is not a widely-practiced approach. In part this is due to the factors that may result in a design solution being acceptable in one context but not in another. When publishing examples it is difficult to specify external factors that allow it to be compliant. It would be even more difficult to specify the external factors that would make it non-compliant!

Levels of government

There are many frameworks within regulation can, and are, enacted. The role of enforcement is found at different levels within a regulatory system.

Normally building Acts or Regulations are enacted at a national level, although some countries regulate construction at a subsequent level of government. The latter is the case in Canada and Australia where the states or provinces enact their own legislation outside of Federal legislation.

The base legislation, usually in the form of an Act and its associated regulations, brings into force one or more associated documents which, through reference in the primary legislation, normally become enacted as the enforceable code.

The level of government, at which the enforcement of code takes place, also varies from one country. In most cases, the operational enforcement body (Authority Having Jurisdiction) is at the local or municipal government level.

Solutions available as public records?

Solutions to performance requirements in the form of design documents are usually lodged as public records. Concern has been expressed about protecting intellectual property rights for these documents.

Although they are a matter of public record and therefore open to anyone, in most countries the laws relating to copyright, if not patent law, would apply, to some extent, to the rights of the original designer.

Require specific maintenance program for a specific building and design.

A number of performance-based solutions proposed rely upon active systems of one kind or another.

This tendency away from passive systems towards active systems brings with it an increased dependency upon maintenance of the systems once they are operational.

There has also been a tendency to minimise the existence of redundant (provision of secondary/tertiary) protective systems as a functioning active system would obviate the need for such redundant systems.

The key word here is "functioning" and in a number of cases concern has been expressed that specific maintenance programs are required, often building and system specific, to minimise the likelihood that an active component of a performance solution should fail to operate.

An added problem exists in jurisdictions where the building-control legislation stops once the building becomes occupied. Although the initial building owner may be aware of the crucial dependence of the buildings performance upon maintenance of its systems/solutions, both active and passive, without good maintenance schedules, subsequent owners may be unaware that a failure of a system may significantly jeopardise the continuing compliance of their building.

Legislative exclusion (exemption for requirements/compliance)

Most countries have legislative exemptions for compliance with building regulations. These are often related to governmental buildings or facilities. In many cases, governments, as good citizens, will try to meet the local building requirements.

The key question in the context of performance-based designs is regarding the possibility of imposing an increased risk upon the community adjacent to such buildings or facilities.

Again, there will be an increased reliance on active systems remaining operational. There is even concern that the act of maintaining these systems can actually increase the risk of an active system failure. Statistical simulations of maintenance work on atomic power stations have indicated that with maintenance there is actually an increased risk that some part of the system will fail to operate when required; clearly a Catch 22 situation

Non-compliance ramifications

Failure to comply under a performance-based code is no more or less serious than for a prescriptive code. The only area of possible complexity is where the performance is stated in terms for which there are no measurable criteria.

Where quantifiable performance criteria are established, an appropriate test method must be specified. In fact, if there is more than one test method that could be applied in a specific context it could be possible that for the same requirement one criteria value may be associated with test method one and a different criterion value be associated with test method two.

Such differences in the criteria value could be due to the different test methods incorporating slightly different parameters and yet there being general agreement that they both represent an appropriate quantification of the performance required.

Impact of governmental immunity on a regulatory system.

Some governments have chosen to grant certain players in the system, immunity from various aspects of the regulatory system. An example is the exception of some governmental buildings from regulations and thereby granting themselves immunity from failing to comply with the broader regulations.

One other frequently seen aspect of governmental immunity is its use to remove building inspectors from liability for their "errors and omissions' when carrying out their statutory activities. Here, there has to be a good audit system in place to ensure that an acceptable level of "due care and attention" is being applied.

This issue again appears under the issue of liability and the reasonable expectations of a claimant that a failure of a building official to detect a compliance failure and thereby for the claimant to gain some justifiable accounting for such a failure.

5.4 Process for accepting new solutions

Each country will have its own approach to establishing new solutions. Having stated this, there are likely to be common features to each system.

Acceptance of new solutions will occur at all levels within an AHJ. This will range from the individual level where a building inspector on a day-to-day basis will find a variant solution acceptable, to the local level where a solution will be accepted for use locally or within a regional. Finally, there will be mechanisms established for recognition at a national level.

5.5 Country specific experiences

Japan

Current Situation

In Japan, relatively weak status of building officials in local self-administration system tends to prevent regulatory system from acquiring talented human resources for building officials to cope with performance-based codes. Building regulation is supposed to work for as national and uniform system, in other words, job of building officials in local government is not for serving for their own local government but for maintaining the national building control system. This situation sometimes makes it hard to create buy-in attitude from local government. Also, building confirmation is not permission. Building officials must say yes as long as building application fits to specified codes, and there are not so much room for them to give their own guidance. Talented people hesitate to enter this field fearing their job is narrowly defined and monotonous.

Issues

Buy-in attitude of local government is very important for luring qualified human resources. Administrative reform in which national government role in building regulatory system is transferred to local government will encourage local government to consider building control as their own duty for their community, and they will try to provide more sufficient human resources in this field. Also, privatization of building control system, in which private organization is allowed to issue building confirmation certificate and inspection certificate, will bring fair competition and efficiency. However, in case of performance-based code, further system is needed to help building officials and private confirmation/inspection organization to make proper and effective judgement under performance-based code.

Toward Problem Solving

To facilitate performance-based code, new approval system for solutions which fit with performance-based code is going to be introduced in the Building Standard Law to support building officials and to reduce their burden. In this approval system, the Minister of Construction can approve certain solutions which satisfy performance requirement prior to be submitted to building officials. Building officials must automatically accept approved solutions. In this case, solutions are either certain design specifications or actual building materials, parts, or equipment. Also, the Minister can make eligible organizations to conduct this approval system. This system is expected to serve as major apparatus in performance-based code.

United States

The review and approval process[5]

The building officials and staff who review designs of a prescriptive code are assumed to continue reviewing and approving buildings in the future. This is based on the traditional role of reviewing plans on an audit basis to seek code-complying plans that meet minimum levels of public safety.

Alternate design submittals have traditionally required a higher level of documentation to justify equivalence to the code provision..

Performance code provisions are objective-based, which allows the design professional to meet the intent of the code and thereby alter the factors of safety that have been accumulated in the prescriptive components of the code.

Although this allows the designers more latitude in developing greater creative buildings at a lower construction cost, the cost of design, including the degree of analysis and verification, will increase.

Therefore, review of construction documents will require higher levels of qualified plan review as design professionals become more sophisticated and skilled in the future.

Building officials may have a higher level of success in the construction document review process when they require the design professional team to comply with the content of this document for performance-based designs.

This includes requiring documentation with applicable justification for the right to submit performance-based designs. Otherwise, the design documents must comply with the prescriptive provisions of the Building Code.

Before building officials begin reviewing performance-based design plans, they should evaluate their skills to determine if they are adequate. This includes evaluating education qualifications and experience needed to review performance-based designs and analysis before selecting one or more of the following options:

- determine if the staff meets requirements based on education, engineering and architectural registration and continuing education levels needed to perform tasks;

- upgrade the plan reviewer's educational and professional qualifications;

- acquire third-party review services via a consultant plan reviewer with applicable qualifications; or.

- utilise peer review processes providing that individuals meet an appropriate level of qualifications, standards of ethics and accountability.

Performance-based design projects have been more successful when project criteria and reviews have been included through design review and construction with an agreed quality assurance program.

The building official may require that the design team submit a written report via the principal design professional who documents the intended design goals, the elements to be designed to the performance code provisions, how they will meet the applicable performance code provisions, methods and analysis for demonstrating compliance (eg:, fire modeling, fire protection, exiting, other life-safety features), and proposed testing and inspection to demonstrate construction compliance.

Quality assurance process[5]

A quality assurance team approach is recommended to obtain a building that meets performance code requirements. The team should include design professionals, building official representatives for plan review and inspections, a special inspector/third-party inspector, a testing agency, and contractor/s.

Although a team is beneficial for projects designed in accordance with prescriptive code provisions, performance-based designs require more communication between the parties with fewer assumptions by the contractor that it is permissible not to comply with the approved plans.

The construction documents are the basis of design approval and the governing requirement for construction and verification by inspectors and testing agencies for compliance.

Deviations from the approved construction documents require the contractor to consult with the design professional to evaluate and approve revisions against the project objectives before obtaining approval from the building official. The process also helps obtain the owner's buy-in for construction to comply with design documents.

Consequently, there is less leeway given to the contractor for not complying with the plans since the contractor and owner should have a front-end commitment with all the parties.

Building maintenance and owner's responsibility[5]

Once a building is constructed to the approved construction documents, the owner is responsible for maintaining it as required by the documents.

Critical areas determined by the design professional may require inspection, testing and/or service at predetermined intervals to ensure continued compliance through the life of the building.

These requirements must be detailed in a written form and recorded with the deed with a specific notation that such requirements can be released only upon the approval of the building official.

In several countries, the owner is required to file verification documents annually to demonstrate that the building is being maintained safely, otherwise, the certificate of occupancy is either revoked or not renewed.

When a building is to be remodelled, renovated or undergo a significant change in use, a qualified design professional is required to evaluate the existing building construction documents for the proposed change.

The building official then must verify, through a written report, that the amended design or change will not adversely impact the existing building based on approved performance construction documents.

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[1] Unless otherwise noted, the following discussion is excerpted from, Meacham, B.J., "Assessment of the Technological Requirements for the Realisation of Performance-Based Fire Safety Design in the United States - Phase I: Fundamental Requirements," Proceedings of the Second International Conference on Fire Research and Engineering, SFPE, May 1998.

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6. Process management

This chapter deals with issues to be addressed when developing and implementing a performance-based code. More specifically, it is hoped that the contents of this section will provide a better understanding of the scope of the overall process of code development and implementation.

6.1 Interdependence of issues

Due to the nature of performance-based codes, many issues dealt with separately as components must now be dealt with as a system. This interdependence is not only existent within the code but also involved with the implementation process and enforcement.

In terms of the use of the code for a specific design, performing separate design processes for different aspects or functions of a building is inappropriate. An example may be the design of a smoke-control system and a heat, ventilation and air conditioning system (HVAC)

If such designs are not correlated, then a dysfunctional design is possible. If an HVAC system does not interface with the smoke-control system properly the smoke-control system may become ineffective when an emergency warrants its use. This problem exists within a prescriptive system but a performance system simply emphasises this interdependence.

Interdependence of issues goes beyond the design process when discussing performance-based codes. It deals with all the policy and regulatory infrastructure issues surrounding the use of construction codes.

For instance, traditionally the fire department has served the role of maintaining buildings once they have been constructed. Performance-based codes emphasise the maintenance of buildings due to the systematic approach of such codes. Therefore, more involvement may be seen from the building officials after construction.

Possible overlap of enforcement must be addressed in other areas where different regulatory roles will overlap. The building regulations may provide provisions to protect the environment, but there are other agencies that protect the environment. Essentially, in a performance-based code system every decision must be evaluated systematically whether the matter concerns the design process or policy issues surrounding the implementation or use of performance- based codes. This interdependence creates the necessity for a team approach.

The other issue goes beyond clarifying the roles of enforcement agencies. This issue is the overall design, construction and maintenance process that includes the enforcement authorities, designers, contractors, material manufacturer, owners and the public. Performance-based codes necessitate a team approach. Every decision made will affect the outcome.

Communication is another important issue. Communication with any affected parties is essential to the success of performance-based codes. Such communication cannot occur unless proper funding is provided.

6.2 Communication

One of the most important keys to the success of performance-based codes is communication.

Without an appropriate level of communication the appropriate level of support, also termed "buy-in", necessary from the persons or organisations affected by building regulations will not be obtained.

Communication gains such support by reaching out to affected parties through seminars and public speaking opportunities, and involving people in, and also informing them of, the development process. This helps instil a feeling of ownership.

Communication will assist in alleviating the fears of those affected and assist in demonstrating system benefits. Once the initial communications are accomplished, a longer-term plan must be formed to ensure the success of the process.

6.3 "Buy-In"

A key element gained from proper communication is the "buy-in" of the affected parties. These parties involve a wide range of people that includes enforcers, designers, contractors, researchers, policy makers and the public.

The "buy-in" is gained through the successful introduction of the concept of performance-based codes. The introduction may be in the form of short talks and discussions held with groups; seminars where practical examples are provided, and the integral involvement of these groups in the development process.

To assist in the promotion of such codes all available means of media should be used.

6.4 Long-term

Once the "buy-in" is obtained it is important to remember the long-term communication needs of such a system.

The different groups involved must be communicating and interacting, educational programs should be established, and most importantly, any new information concerning the code development and maintenance process must be disseminated.

Performance-based codes have many interdependent issues. This interdependence forces a team approach to the use of the code.

Basically, a system which encourages communication between interested parties must be in place. An example may be the link necessary between researchers and code enforcers and designers.

The researchers develop tools used by these parties and the limitations and scope of such tools needs to be appropriately communicated. As part of that link the designers and enforcers need to communicate their needs to the researchers.

Another example is the communication necessary with the policy makers and the public from the code enforcers and the design and construction industry. This is necessary since as the implementers must understand the needs of the community, since it is the reason building regulations exist.

6.5 Timing/phasing

The timing of the development of performance-based codes is critical. The appropriate time is dependent on many issues, some which are discussed in other sections of this chapter.

Essentially, the correct amount of financial and political support is necessary to make the process work. Depending on how codes are adopted and enforced within a country, levels of support necessary will vary.

For instance in some countries, code adoption is dependent on the state and local authorities. Therefore, more support is necessary to ensure adoption since more time is necessary to receive the proper buy-in of the policy makers. In other countries, the code is developed and implemented on a federal level so it is much easier to implement a new process. There are no other options available. Therefore, less time is spent on the adoption process and a lower level of buy-in is necessary. More specifically, the essential parties involved with the development and implementation process must be convinced of the need for performance-based codes.

If the concept is introduced at an inappropriate time - when there is much concern with the use of such codes - the concept may never get a fair review.

Implementation must recognise the ability of the users. More specifically, the time for the retraining of designers and enforcers, for example, must be considered. The success of implementation may also depend on the current trends of the country such as deregulation or economic decline.

Once it is determined that the time is right, the amount of information provided must be appropriate. People generally have a difficult time accepting change. Therefore, an evolutionary process versus a revolutionary process is usually more appropriate.

Again, the evaluation of how much change can be handled at one time is dependent on the regulatory system and the capacity for change of that particular country. Also, this depends on the evaluation of current abilities of those affected.

6.6 Resource management

There are many factors in a performance-based system that must act systematically in order to be effective. Again, these factors include keeping all necessary parties involved, maintaining all components of the system and all the necessary supporting documents such as the prescriptive solutions.

Resource management is actually an aspect of communication since without an organised means of information dissemination or coordination between different entities and authorities, the support of those working with such a system will be lost.

6.7 Who manages?

It must be decided who will manage the system and how it will be done.

This will depend on how codes are used within each country. The managing bodies may range from the national government, local government or model code development organisations. In any case, it must be recognised that one group or several groups will be working together to maintain and direct activities.

Having a clear direction as to the workings of the system will be a positive sign to those working on a code. In addition to managing the materials the responsible persons or organisations must play a part in managing the different groups involved including industry, research, public, designers, contractors and enforcers.

6.8 What is to be managed?

There are several areas that need to be managed. The first is the code and all the related support documents and services.

Users must be able to efficiently access any necessary tools for design, construction and enforcement. These tools must be reviewed and revised continually.

When there are varying organisations or agencies producing documents, it is the responsibility of these organisations to notify all interested parties of such activities. All interested parties must be able to participate.

The acceptance and use of performance-based codes depends on educational programs. These programs need to be widely available and well managed. They may be hosted by a centralised system or several organisations and industry groups. In some countries this may be an easier task due to the regulatory structure.

Another area that needs attention is related to the emphasis on maintenance. This means formalising a process to provide an appropriate program. A major area to be managed is the keeping of records, which is particularly important with the use of performance-based codes.

6.9 Cost

All of aspects of developing a new code involve costs, which must be accounted for in order to make the system work.

Costs may be incurred by one source or a series of sources. Either way, the need for financial support must be determined. More specifically, these costs relate to the education programs, the development process, the resource management aspect, and support at a policy level.

6.10 Who should pay?

The initial development cost of a new code may vary in each. Regardless this process involves many meetings and long hours In addition, once a code is developed it must be implemented. The implementation cost will also vary since some countries federally mandate codes, in others the code is adopted on a state or local level. The enacting legislation may be more difficult to obtain when such codes are not federally mandated, thus requiring more labour to convince the policy makers of the benefits of such a system.

The education process is a necessity in order to successfully implement and use a performance-based code system. Education requires funding which needs to be allocated. This may come from a private or public source but such issues must be addressed "up-front."

Finally, one of the criticisms of performance-based codes is the lack of design tools and performance criteria available to designers and enforcers due to lack of technology.

In order to obtain such technology, research must be conducted. The main barrier to research is appropriate funding. Funding has typically come through industry and the federal governments. It should be recognised that research funded by industry can be specific to a particular area resulting in limited application.

There are many areas that must have financial backing to make this process a success. This funding must also be consistent.

The issue becomes: Who is responsible to provide such funding? This responsibility will vary from country to country due to the regulatory and political environments.

For instance, funding from a particular interest group may be deemed inappropriate where in another country such partnerships are acceptable. In addition there maybe a strong feeling from the public that if regulations are to exist then the regulatory agencies should be responsible for such funding. In any case it is pertinent that the source of financial support be designated.

6.11 Education

Education programs must reach all those affected by the implementation and use of building regulations.

Education programs should deal with initial familiarisation of the concept and longer-term educational notions. Programs can range from short lectures to university courses.

The amount of activity in this area will be quite extensive and will need proper funding. Many times it is difficult to see the direct impact of such programs on the system. In some countries this funding may come directly from the federal government, and in others the educational programs may come from private organisations.

6.12 Development process

In order to maintain the quality and integrity of the performance-based code system, proper attention must be given to the development process.

This process includes the enacting legislation on a policy level, the actual building regulations which are usually the qualitative portions of the code, and the acceptable solutions which in many cases includes the prescriptive codes and standards, engineering methods and testing procedures.

Overall, these processes require many meetings and related activities to create a finished product.

One of the most costly processes involves the research community through the need for testing and exploration of new methodologies. The development and also maintenance of the system allows a constant review and improvements to be made. The process is critical and must be funded. This funding includes the support for meetings and related research necessary for the perpetuation of the process.

6.13 Resource management

It is essential that the resources necessary to make such a system work, such as the acceptable solutions available for design be easily accessible perhaps through a centralised source. Such organisational activities come at a particular price.

6.14 Policy level

There will be different approaches to code enforcement. This may involve a shift in roles of enforcement personnel and also the involvement of building owners and the community.

Policy makers must understand this shift and provide consistent funding. This is critical since in many countries there has been a trend to downsize government bodies.

Policy makers must recognise the needs of a performance-based system and be sure that if the funding is not being provided via public money, then other means must be found. These costs exist with the current prescriptive codes and in many ways performance codes are simply emphasising the need for policy makers to focus on these issues.

7. Appendix

7.1 Terminology

Acceptable Solution: a method of complying with the performance-based code specified in the guidance publications.

Alternative Solution: a method of complying with the performance-based code not specified in the guidance publications.

Automatic backflow preventer: an automatic device used to protect water supply systems against contamination from unintended reversals of flow.

Building element: any structural or non-structural component or assembly associated with a building. Included are fixtures, services, drains, and permanent mechanical installations for access, glazing, partitions, ceilings, and temporary supports.

Building permit: a permit (sometimes called a consent or authorisation) from the control authority to commence construction in accordance with approved plans and specifications (sometimes called a building consent).

Building producer: a person responsible in any capacity for the design and construction of any part of a building.

Completion certificate: a certificate from the control authority verifying satisfaction that all work under a building permit has been properly completed. Sometimes serves as an occupancy permit.

Construction: includes alteration, relocation, and so on.

Control authority: the authority which enforces the building control legislation.

Existing building: (a) a building competed before the legislation introducing a performance-based system came into force; or (b), a building erected under the performance-based system and for which a completion certificate has been issued.

Guidance publications: publications, making up Levels Four and Five of a performance-based code, which may, but not must, be used to establish compliance with the performance requirements of that code. Guidance publications specify "**Acceptable Solutions**", sometimes called "examples of conformance", frequently by reference, with or without amendment, to current prescriptive specifications for materials, building elements, and even complete buildings. Guidance publications also specify "verifications methods", frequently by reference, with or without amendment, to current design codes and test methods.

Liability: civil responsibility as distinct from criminal responsibility. The legal obligation to pay money to another person suing for a private wrong. When a wrongdoer is liable to a victim for a building defect, the wrongdoer will be liable for some or all of the money necessary to remedy the defect and recompense the victim for any directly related losses and sometimes for pain and suffering. The basis for liability varies between different jurisdictions. The report is written in terms of liability as it generally exists in Commonwealth jurisdictions.

Liability in contract: liability arising from a breach of contract.

Liability in tort: liability arising from a civil wrong other than breach of contract. Owners' and building producers' liability in tort for building defects will almost always be for the tort of negligence. Control authorities' liabilities will almost always be for breach of a duty imposed on the control authority by the legislation. Liability in tort is said to be "joint and several" when two or more wrongdoers are each responsible for the full amount of the same loss, for example where a building producer negligently causes a defect which a control authority negligently fails to discover. The victim can sue any of the wrongdoers (almost inevitably choosing the control authority as the most financially capable), and that wrongdoer may in turn sue each of the others for amounts allocated on the basis of responsibility for the loss (usually of the order of 20% responsibility by the control authority, 80% by the building producers).

Vicarious liability: liability of employers for the wrongdoing of their employees in the course of employment.

Owner: The owner of the building concerned. References to building producers usually apply to owners also on the basis that the producer is almost always either the owner or the owner's agent.

Performance-based code: a code as described in CIB Publication 206: *Final Report of CIB Task Group 11 Performance-based Building Codes.* Performance-based building codes are, in most instances, structured in accordance with various variations of the Nordic Five Level System:

- Level One - Goals
- Level Two - Functional requirements
- Level Three - Operative requirements (sometimes called "performance criteria" and referred to in this segment as "performance requirements')
- Level Four - Verification methods
- Level Five - Acceptable solutions.

Person: includes both people ("natural persons') and organisations.

Private certifier: person other than the control authority authorised to assess compliance with all or part of the performance-based code.

Statutory duty: a legal duty imposed by legislation.

Tort: a civil wrong other than breach of contract.

Solution: a method of complying with a performance-based code.

Use (of a building): what a building is used for sometimes called its occupancy. May be general ("place of assembly", "residential") or specific ("cinema seating 250 people", ‘single-family detached house", "30-unit apartment building"). Many buildings have more than one use.

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