Title: **Qualitative Versus Quantitative Aspects of Performance-Based Regulations**

Authors: Douglas Beller, National Fire Protection Association
Greg Foliente, CSIRO Building Construction and Engineering
Brian Meacham, Arup

Subject: Fire & Safety

Keyword: Performance Based Design

Publication Date: 2003

Original Publication: CTBUH / CIB Kuala Lumpur 2003 Conference

Paper Type:
1. Book chapter/Part chapter
2. Journal paper
3. **Conference proceeding**
4. Unpublished conference paper
5. Magazine article
6. Unpublished

QUALITATIVE VERSUS QUANTITATIVE ASPECTS OF PERFORMANCE-BASED REGULATIONS

DOUGLAS BELLER
NFPA International, USA

GREG FOLIENTE
CSIRO Building, Construction and Engineering, Australia

BRIAN MEACHAM
Arup Fire, USA

Abstract

Performance-based codes distinguish themselves from their prescriptive counterparts by specifying objectives (or goals) and functional requirements (also, functional statements or objectives), which are qualitative, and either specifying or referencing performance (or operative) requirements (or criteria) that can be used to assess whether or not the objectives have been met. The criteria can be either qualitative or quantitative, although one might expect them to tend to be quantitative, as quantitative criteria are ultimately needed for the rational development of methods of building design and construction. The issue of whether or not quantitative criteria should be part of the mandatory portion of a performance-based code is a constant focus of discussion. Some countries have extremely quantitative criteria written directly into their legislation. In other countries, however, the regulations are extremely qualitative and specify few quantitative requirements, which are mainly found in "approved" or "deemed-to-satisfy" documents, "acceptable methods" or other reference standards, guides or documents.

As can be imagined, there is considerable debate as to where, when and how building regulations should be quantitative. This paper provides an overview of the topic, indicating the range of approaches that could be taken: specifying criteria in the regulations, and thereby making them mandatory; referencing them in another document, so that they may be mandatory or not; or providing only qualitative criteria. A summary of the different approaches will be examined and presented after a review of the various practices from around the world.

Keywords: Performance-based building regulations; performance requirements; quantitative criteria, mandatory provisions.

1. Introduction

Many of the countries that have decided to pursue the development and promulgation of performance-based building regulations have used the Nordic Five Level Structure (NKB, 1978) as the model for their regulations. Figure 1 (Meacham, et. al., 2002), developed through the efforts of the Inter-jurisdictional Regulatory Collaboration Committee (IRCC), is an expansion of this model that includes risk (performance) levels which provides a critical link between the qualitative and quantitative portions of the NKB model. In this paper, "regulations" is used to mean the totality of documents that make up the mandatory technical provisions of a building regulatory system.

The model shown in Figure 1 can be adapted by regulation development agencies to reflect the desires of the local, affected or interested parties and the regulatory system within which they operate. In true performance fashion, however, no single model will address every country's needs. Because of this, differences will arise in the provisions of performance-based regulations developed by various organizations around the world.

One of these differences is concerned with the criteria used to measure whether or not a performance-based design complies with the mandatory requirements of the building code and may therefore be permitted as an "alternative solution" (a "performance-based design" is a design that is not in accordance with "approved" or "deemed-to-satisfy" documents, "acceptable methods" or other

reference standards, guides or documents, and that cannot be assessed by comparison with those documents). The issue regarding these criteria that will be explored in this paper is whether or not quantitative criteria should be placed in the regulations and, if so, where. "Where" in this case refers to the "mandatory line" in that the quantitative criteria can be either enforceable or not.

2. Background

The IRCC structure of Fig. 1 consists of a hierarchy, with either goals or objectives at the top. The goals/objectives are broad statements of what the building regulations are intended to provide. These goals may, for example, address the issues of safety, health, accessibility, and protection of buildings (CCBFC, 2000). Other examples of objectives are safeguarding people from injury and from loss of amenity, and protecting other property (NZ, 1992).

The next level down in the hierarchy are functional statements. Functional statements have been defined as "a statement which describes how a building achieves the Objective" (ABCB, 1996) or as "those functions which a building is to perform for the purposes [i.e. objectives] of this Act" (NZ 1991). As such, functional statements can be a qualitative way of indicating what steps must be undertaken to achieve the stated goal or objective.

Operative requirements are the next step down the hierarchy. Operative requirements address specific topics within the regulations, e.g., structural stability, fire safety, sound transmission, etc. Therefore, an operative requirement is "a requirement which states the level of performance which a Building Solution must meet" (ABCB, 1996), or "those qualitative or quantitative criteria which the building is to satisfy in performing its functional requirements" (NZ 1991). Operative requirements are typically stated in qualitative or descriptive terms, but in some countries they also contain some quantitative aspects. It is these quantitative aspects that are needed for the next level down in the hierarchy.

Acceptable solutions form the lowest levels of the IRCC structure. An acceptable solution is considered to be a set of provisions which when met will deliver the desired performance as intended by the objectives and operative requirements. In this paper, the term "acceptable solution" is used in a broad sense and shall include prescriptive, deemed-to-satisfy solutions as well as those expressed in performance terms, including their verification methods. In general discussion, and in this paper, the phrase "acceptable solutions" is used to mean any documents, including verification methods, that are officially recognised as deemed-to-satisfy documents prescribing methods of complying with the mandatory requirements of the building code.

The focus of this paper is primarily on the operative requirements. The difficulty associated with operative requirements is that they lie at the interface between the qualitative, public policy aspects of the regulations and the quantitative, technical needs of verifying that a proposed design will comply with the regulations. There are several competing effects at work.

3. The Problem With Quantitative Statements

The mandatory provisions of building regulations ("the law") are public policy documents and as such tend to be qualitative in nature. The mandatory provisions provide the means of describing "what" must be done. Therefore, mandatory provisions tend to emphasise the upper two or three levels of the hierarchy discussed above: goals, functional statements, and performance criteria. These mandatory levels define "what" society requires from buildings. In essence, the upper two levels provide the broad intent and more specific "sub-intents" of the building regulations. Mandatory provisions might be drafted by code writers but they are made into law by legislators.

Once established, the law is not expected to change significantly over time. This is the argument most often used to keep the qualitative provisions of building regulations separate from the quantitative aspects that determine "how" compliance with the law will be accomplished. Mandatory provisions may take many months or years to change, depending on the legislative process employed by the adopting jurisdiction. Tools, methods, and information used by designers can change at a greater rate than this

and therefore quantitative provisions in building regulations may be obsolete when they are adopted and possibly result in unsafe conditions.

However, there might be a perceived difficulty in not mandating some quantitative values in performance-based building regulations. This problem arises when safety is the major concern, as opposed to an amenity. For example, if the building regulations of a given jurisdiction address both structural stability and sound transmission, the former can be considered a safety issue (i.e., the building will remain standing long enough to allow occupant evacuation) while the latter is an amenity (i.e., internal walls will provide some resistance to sound transmission but only to a reasonable level, not necessarily total elimination of sound transmission). Because the structural loading of a building is a safety issue, it is more likely that quantitative values for the possible loads a building may be subjected to will be included in the building regulations as minimum requirements. Conversely, quantitative values for sound attenuation may be viewed as overly prescriptive if included in performance-based regulations. Placing the minimum loads (i.e., safety related quantitative values) in the building regulations makes them non-negotiable. "Non-negotiable" in this context means that a minimum requirement has been established by legislators and, therefore, a societally acceptable minimum level has also been established.

One of the major problems that must be solved is how the building regulations provide the link between the qualitative statements (i.e., goal/objective, functional statements, and sometimes performance requirements) and the quantitative criteria which might be needed to assess a proposed performance-based design. In order to develop a design, numbers must be used. If the numbers used for a design are not stated in the mandatory requirements of the building code, and cannot be justified by comparison with the acceptable solutions or derived from the verification methods, then it is difficult to assess the acceptability of that design. In such a case, the building regulations do not provide a sufficient link between their public policy qualitative statements, which represent the values of society, and the quantitative aspects of the designer's job. If so, then the designer must attempt to interpret what the society values, choose quantitative values appropriately, and then convince the responsible building official or building control authority that the design does in fact comply with the building code. The problem in this case is that the designer may choose, and the official or authority may accept, values that are contrary to the desires of society.

Conversely, a problem with specifying mandatory requirements in quantitative terms is that it is very difficult to cover all possible future situations. Furthermore, quantitative requirements must cover the worst case, so that there is a danger that they might be unnecessarily restrictive for other cases. One way of dealing with this is for the system to allow building officials the flexibility to waive or modify the mandatory requirements, but of course there would need to be safeguards against misuse of such flexibility.

A final problem with specifying quantitative values in building regulations is that human beings are individuals and therefore not necessarily susceptible to the same level of a given hazard. For example, people of differing heights will be subjected to a smoke layer developed by a fire at different times if they are all standing. Compound this problem with differing respiratory rates (i.e., uptake of smoke,) various levels of general health (e.g., marathon runner, elderly, infant,) and the rate at which the products of combustion are metabolised. Therefore, the time at which an individual will succumb to the effects of a given fire will vary and specifying a single value of smoke exposure in the building regulations is not an optimal way of dealing with exposure to a fire's products of combustion. The same argument applies to almost all the operative requirements of any building code, and is particularly obvious if one of the objectives of the building code is to provide for people with disabilities.

4. Both Are Necessary

The title of this paper has actually established a false dichotomy. The question is not to include qualitative statements in building regulations at the exclusion of quantitative ones, or vice versa. The fact is that both types of statements are necessary in the context of performance-based regulations, but at different points in the process. The performance-based process establishes a continuum between the expectations of society and the design that is proposed to meet those expectations. As a minimum, the building regulations qualitatively define what society expects from the structures that

result from its provisions. At some point in the performance-based process those qualitative statements are translated into numbers and the designer is thus able to complete a design. The point in the regulations at which quantitative statements are found is a function of the body developing the regulations and the jurisdiction that adopts them.
A country-by-country overview of how the qualitative/quantitative issue has been addressed is now presented and is followed by a summary discussion of the main issues.

5. Approaches of Various Countries

5.1 Australia

The Building Code of Australia, BCA, (ABCB, 1996) is published in two volumes: one for residential classes of buildings and one for all other types of buildings. The BCA is comprised of objectives, functional statements, performance requirements, and building solutions. The objectives and functional statements are defined as guidance level provisions and the performance requirements and building solutions are defined as compliance level provisions. The building solutions are the means to comply with the performance requirements and may be either deemed-to-satisfy provisions (i.e., prescriptive provisions) or alternative solutions which require assessment methods to determine that a building solution complies with the performance requirements. A combination of deemed-to-satisfy and alternative solutions may be used in the same design.

In the BCA, the performance requirements are qualitative statements which define the required level of performance. For the structural provisions of the BCA, the deemed-to-satisfy provisions are a number of Australian Standards which define various structural loads. If the structure is designed to resist the loads stipulated in the referenced standards, the performance requirements is satisfied. If the deemed-to-satisfy provisions are not used, then the designer must demonstrate that the performance requirement is satisfied by using one of the available assessment methods: documentary evidence, verification methods, expert judgement or comparison to the deemed-to-satisfy provisions.

Thus, the BCA has qualitative performance requirements that facilitate their satisfaction by referencing quantitative values in established documents.

5.2 Canada

The Canadian Commission on Building and Fire Codes is providing the leadership to move the Canadian family of construction codes (building, fire and plumbing) to an objective-based structure. The target completion date of these codes is 2003 at which time authorities having jurisdiction will be able to put them into force. Current plans call for each code to be published in one document with two major divisions – Division A and Division B. There will be mandatory linkages from Division A to Division B and vice versa.

Division A will set out the objectives that the code addresses and the functional requirements (in qualitative terms) that solutions must satisfy. Its prime purpose is to state as clearly as possible what it is that society seeks to achieve with the code. This is best achieved by a structure based on the "tree" of objectives, sub-objectives and functional requirements of the code. Division A of the code is expected to remain relatively stable over time.

Division B will set out the quantitative performance criteria (where these are available) with which solutions must comply and provide deemed-to-comply solutions drawn from the current version of that code. (In this context, "solution" means any product, combination of products, system or spatial configuration which is proposed to perform a function regulated by one of the National Code Documents). Such solutions will be generic in nature.

The general objectives and qualitative requirements of a code do not change very frequently. Keeping these separate from the quantitative criteria and solutions opens up the possibility that authorities, such as provinces and territories, will be able to adopt Division A in their code legislation and not have to change that legislation very frequently.

Division B of a given code would change more frequently than Division A as new acceptable solutions are added and existing acceptable solutions are improved. It is envisioned that it would follow a regular cycle of revisions and be published in dated editions as at present. Division B could then be adopted as regulations, which need not involve the provincial/territorial legislatures.

Division B of the new codes, which is the division most likely to be used on a day-to-day basis by code users, will closely follow the current organizational structure of the codes. This can be thought of as a structure based on disciplines. For each requirement in Division B there will be a reference to the Division A objectives and functional requirements it addresses. The "intent" of every Division B requirement will be provided as guidance material only and will not form part of the formal structure. Such material will aide in the interpretation and general understanding of the code.

5.3 Japan

The Building Standard Law (Japan, 1998) adds performance-based codes for the first time in the Japanese building regulatory system. They deal with such topics as fire safety, structural safety and building equipment safety, where technological knowledge and experience are available. The Building Standard Law, which must be examined and amended in the Diet; i.e. the Japanese Parliament, only states objectives and functional (qualitative) performance requirements. The Law also declares that both quantitative (technical) criteria and deem-to-satisfy (prescriptive) solutions are given as acceptable solutions by the Cabinet Order (the law enforcement order) and/or the Construction Minister's Notification, which is relatively easy to change. The performance-based building codes consist of these legal documents suggesting a mandatory line. Thus, it can be said that Japanese approach is a quantitative one. However, there always exists an argument that the benchmark approach might exclude innovative and unique solutions, which fail to meet quantitative performance requirements but can satisfy functional requirements. In order to avoid this argument, there are such special provisions that solutions to which the Minister of Construction gives approvals after performance evaluation are regarded as acceptable solutions.

5.4 Netherlands

In the Dutch building regulation system, in force since October 1992, the Building Decree is the central document for the technical building rules. Based on the Housing Act, that does not contain technical rules, the Building Decree is a general administrative order, issued by the central government. The Decree has been changed twelve times till now; two of them are not in force.

In the Building Decree, standards play an important role. Wherever possible the Decree refers to standards ('NEN's') or parts of standards of the Dutch Standardisation Institute. These standards have been adapted to the Building Decree requirements and contain the determination methods intended to check if the work complies with the Building Decree requirements. There are 55 standards the Decree directly refers to.

The technical regulations of the Building Decree are expressed in performance requirements. In a clause, the performance requirement is based on a functional description. This description expresses the intention of the performance requirement. The performance requirement consists of a limit value and a determination method. The limit value indicates the minimum level of performance that has to be attained. As stated above for the determination method, the Decree usually refers to a standard of the Dutch Standardisation Institute. The presentation of the Decree doesn't follow the format of any other country or system. The Decree has all elements of the Nordic System and of the recommendations of CIB/TG11. The elements are split into:

a. the titles of the chapters (usage function and relates to works to be built and existing works);
b. the titles of the division (starting points: safety, health, usefulness, energy economy and environment);
c. the titles of the paragraphs (e.g., like structural safety, users safety, fire safety, social safety);
d. the titles of the sections (e.g., like strength of the structure, floor boarding); and
e. the content of the clauses (performance requirement based on a functional description).

Not all clauses have been formulated in terms of performance requirements because of incomplete discussions between government departments and the building industry. So far utility buildings and works, not other buildings, have some clauses which are only functionally formulated. Such a clause doesn't have a quantified level to fulfil. By the end of 1998 an alternation of the Building Decree had been published with performance-based clauses for all clauses which were functionally formulated in 1992. These alternation did not come in force. The reason of this decision was the wish to present the Building Decree by scheme-presentation. This project is still ongoing.

The Decree doesn't refer to codes of practice. Codes of practice give solutions or simplified determination methods. Codes of practice are linked to standards. Codes of practice may be used if there is a relation between the code and a performance-based clause. The user of the code has to check whether or not there is such a relation.

Also, quality assessments may be used to prove that a solution fulfils the Decree. There is a list of assessments, recognised by the Minister of Housing, Physical Planning and Environment, which have a relation to one or more clauses of the Building Decree.

5.5 New Zealand

The performance-based New Zealand building code was introduced as part of a new building control system established by an Act of Parliament (NZ, 1991).

The building code itself is part of the building regulations (NZ, 1992) and represents the minimalist approach to performance-based regulations. The code consists of topic specific objectives, functional requirements, and performance requirements specified mainly, but not entirely, in qualitative terms. The topics covered by the building code are similar to those of other countries and include stability, fire safety, access, services and facilities (including plumbing and drainage, gas, and electricity), and energy efficiency. All of the New Zealand code is mandatory.

The code is supported by 35 "Approved Documents" (authorised by the Building Act as "documents for use in establishing compliance with the building code"), one for each topic.

5.6 Spain

The performance-based Spanish building code is currently under development. It was established by the Building Act, Act 38/1999 of 5 November 1999 (Spain, 1999) that the Government will approve it within two years after the act became enforceable, which occurred in May 2000. The Building Act establishes three categories of basic requirements related to the safety, habitability, and functionality of buildings.

The Code will develop those requirements that ensure building safety (structurally, in case of fire, and during use) and building habitability (hygiene, health and protection of the environment, protection from noise, energy conservation, thermal insulation and other functional aspects). The requirements on functionality (defined in the Act as Utility, Accessibility and the Access to telecommunications, audio-visual and information services) are and will be regulated by other jurisdictions such as the Autonomous Communities (Regions) having authority on the matter.

The Code will adopt the approach of performance (or objective)-based codes in order to promote innovation and technological development. The Code will be divided into two parts.

PART I is compulsory and comprises the:

Objectives, which express the essential interest of the user with regard to buildings, taken from Article 3 of the Building Act. Also, on a secondary level, objectives determine the conditions of the building that make it fit for the intended use. The purpose of objectives is to identify the response of the building's functions and its parts in accordance with human, social and economic needs that will be detailed in the requirements themselves.

Requirements (articles of the code) are the specific conditions (performance) that the building's design and construction must fulfil. This includes verifying that the building systems

and products used will comply with objectives. Requirements will have a technical content and will generally be expressed in a qualitative form, though in some cases it may be quantitative.

PART II is of an instrumental (non-compulsory) nature that comprise the:

Verification Methods, the tools for verifying and showing that a solution meets the relevant Objectives and Requirements; can be in the form of calculation methods, practical rules, tabulated values, etc.

Accepted solutions, which are regarded as being in compliance with the Requirements.

Part II will be comprised of the so-called Code Application Documents (DAC) that revise and re-arrange existing compulsory norms and try to close the existing normative gaps, using the experience gathered under the traditional norms. The DACs could contain prescriptive solutions and, in those fields where possible, performance rules.

5.7 United Kingdom

In England and Wales, building regulations are based on functional or goal-based, requirements. The Building Act 1984 provides the enabling legislation for the Building Regulations 1991 (as amended), which set out the functional requirements to be met.

Supporting this mandatory legislation, acceptable solutions are provided in Approved Documents (which indicate minimum standards to achieve compliance). These Approved Documents are non-mandatory and may refer to British and European Standards to support them. Approved product test certificates such as British Board of Agrement certificates and European Technical Approvals may also give guidance. Approved Documents contain both prescriptive and, where possible, performance solutions. Alternative methods which achieve the minimum standard can also be accepted by the control authority.

In Scotland there is different legislation and variations to the England and Wales system, but they are at present carrying out a comprehensive review of the whole regulatory system.

5.8 United States of America; ICC

The International Code Council (ICC) has published a "Performance Code for Buildings and Facilities." The performance code contains three parts: administrative, building and fire. The administrative part applies to both the building and fire parts and contains a unique section which discusses design performance levels. This chapter discusses the Use Group of the building (e.g., hospital, detention, power generation, etc.), and the Performance Group the building should be placed in, depending on identified risk factors (e.g., on-site hazardous materials, capabilities of occupants, etc.). Once a Performance Group has been established, the Maximum Level of Damage to be Tolerated is determined, based on the Magnitude of Events the building can be expected to experience at some time in its lifetime. The maximum level of damage can then be translated into performance criteria which is quantitative in nature. Also, there is a section titled "Acceptable Methods" which does not directly reference the prescriptive code but essentially deems it to satisfy the performance code. The key element of this document is instead of providing specific references to codes and standards or other applicable methods, criteria are provided to assist in the selection of an appropriate method for design.

The remaining chapters of the ICC Performance Code contain topic specific objectives, functional statements, and performance requirements. These topics include building stability, fire safety, and safety of users, among others. With the exception of some of the expected loads discussed in the performance requirements of the Stability chapter, there are no quantitative values in the ICC Performance Code. In this regard the ICC Performance Code is similar to the New Zealand building code in that acceptable solutions and other means of verification are not contained within the regulations. The main difference is found in Chapter 3 where further qualitative detail is provided in the form of levels of acceptable damage as they relate to different types and magnitudes of events.

5.9 United States of America; NFPA

The National Fire Protection Association (NFPA) is advancing codes by providing the design option of either prescriptive-based development or performance-based development. This option can be found in *NFPA 101® Life Safety Code®*, 2000 Edition. There are several other documents which do, and in the future will, have the same option, including *NFPA 5000 Building Code™*, which is currently under development with an expected release date of September, 2002.
NFPA develops and maintains a set of integrated ANSI accredited documents which fall into four categories: codes, standards, recommended practices, and guides. Codes and standards (i.e., which can be adopted as regulations) are divided into the text of the code or standard and informational material. The text of the code or standard consists of the mandatory requirements. All nonmandatory or informational text appears in one or more separate annexes. The provisions of NFPA codes discussed below are contained in the text and are therefore mandatory requirements, unless otherwise noted.

The provisions provided in the *Life Safety Code* address the construction, protection, and occupancy features necessary to minimize danger to life from fire. The code's goal is to determine the minimum criteria for the design of egress facilities to enable prompt escape of occupants from buildings or, where desirable, into safe areas within buildings. The *Life Safety Code* is set up in such a manner that the life safety design must meet the stated goals and objectives using either the prescriptive-based provisions or the performance-based provisions.

Performance-based life safety designs are based on an engineering approach to fire protection design which first establishes goals and objectives. The next step is to apply accepted engineering tools and methodologies (i.e., deterministic and/or probabilistic analysis) to the fire scenarios stipulated in the *Life Safety Code* and then to compare the quantitative assessment of the design alternatives to the criteria, as discussed in an annex to the *Life Safety Code*. The criterion in the *Life Safety Code*, while qualitative, facilitates the calculations required to demonstrate that the proposed design can meet the goals and objectives.

A similar approach has been taken with *NFPA 5000 Building Code*. The goals and objectives address safety, health, usability, and public welfare issues. Performance criteria, scenarios, and other pertinent provisions are provided in other sections of the code, with supporting informational material placed in annexes. The criteria are expressed in qualitative terms with references to methods of determining how they may be met.

Conclusions

Table 1 summarizes the qualitative and quantitative aspects of the building regulations of the countries presented above. The hierarchy columns provide a cross reference among the regulations considered regarding how the upper levels of the NKB/IRCC hierarchy are defined. The "Quant in Regs?" column is used to indicate whether quantitative values are within the regulations and are therefore enforceable. The final column, "Structure" indicates how the various regulations have been structured and other information.

As is evident from this table, there is no single way to deal with the issue of whether or not quantitative values are placed within building regulations. There is no doubt that they are needed at some point in the process. This is shown by the "Quant in Regs?" column of Table 1. At the two extremes, the regulations can have quantitative design values or not. Canada has opted to place them in a part of the regulations that is relatively easy to change, while New Zealand (and to a certain degree the ICC in the USA) considers the building regulations to be strictly a public policy document and therefore numbers are not desirable. There are also approaches between these two extremes. Some countries (e.g., Australia) have decided to provide a reference to the quantitative design values (i.e., Australian standards) in the regulations. Another approach is that taken by the NFPA *Life Safety Code*, in that the criterion is readily determined based on the qualitative description of the criterion: "No occupant not intimate with [fire] ignition shall be exposed to instantaneous or cumulative untenable conditions." (NFPA, 2000). Embedded in this criterion is the basis for predicting, numerically, a level of untenable exposure established by the regulators and designers, together.

Quantitative values do indeed have a place in the building design process. However, whether or not they are placed within the building regulations is a choice that is left to the organization developing the regulations and is a function of the both the local political processes and the people that are being regulated.

Acknowledgements

This paper was developed by a task group of CIB TG37 as one of a set of papers related to the implementation of performance-based regulatory systems. While the words are those of the authors and reviewers, the concepts are the result of discussions at several TG37 and Inter-jurisdictional Regulatory Collaboration Committee meetings and from the cumulative experience of the members, many of whom are involved in the development and/or enforcement of performance-based regulatory systems in their own countries. The authors wish to express their thanks to Ms. Beth Tubbs, convenor of TG37, for the diligence and hard work she has brought to that position.

Additional acknowledgement is due Brian Cashin of BIA, New Zealand for his review and recommendations.

References

ABCB. 1996. *Building Code of Australia*, Australian Building Codes Board (ABCB), Canberra.

CCBFC. 2000. *Objective-Based Codes: A Consultation on the Proposed Objectives, Structure and Cycle of the National Building Code*, Canadian Commission on Building and Fire Codes (CCBFC), Ottawa.

Japan. 1998. *The Building Standard Law of Japan*, Ministry of Construction and The Building Center of Japan, Tokyo.

Meacham, B., Tubbs, B., Bergeron, D., and Szigeti, F., "Performance System Model – A Framework for Describing the Totality of Building Performance", *Proceedings of the 4th International Conference on Performance-Based Codes and Fire Safety Design Methods*, Society of Fire Protection Engineers, Bethesda, MD, 2002.

NKB. 1978. *Structure for Building Regulations*, The Nordic Committee on Building Regulations (NKB), Report No. 34, Stockholm

NFPA. 2000. *NFPA 101® Life Safety Code®* National Fire Protection Association (NFPA), Quincy, MA.

NZ. 1991. *The Building Act 1991*. New Zealand Government, Wellington.

NZ. 1992. *The Building Regulations 1992*. New Zealand Government, Wellington.

Spain. 1999. *Building Act, Act 38/1999 pf 5th November 1999*. Spanish Government, Madrid.

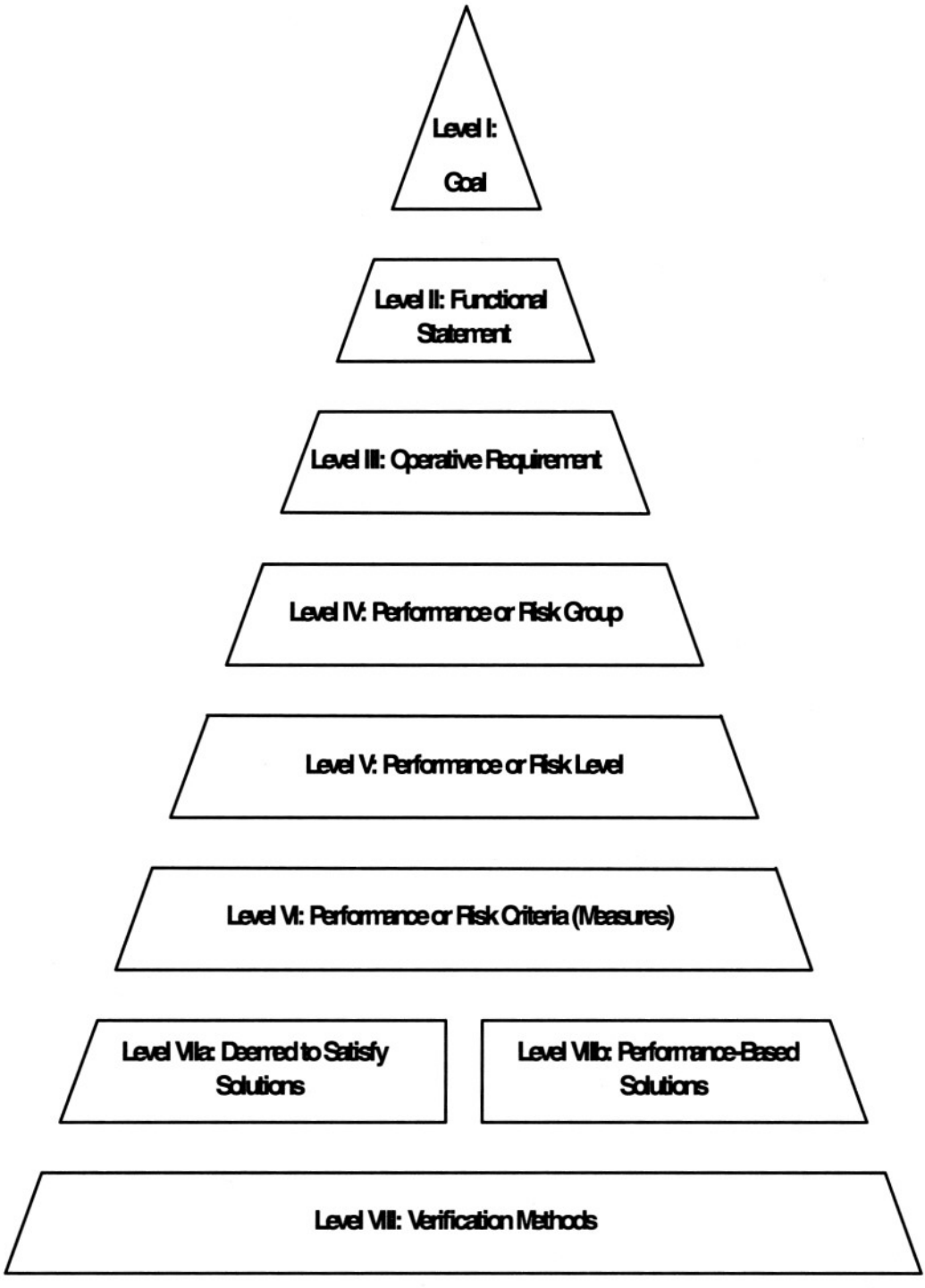

Fig. 1 Hierarchy of Performance-Based Codes

Table 1. Country Summary

Country	Hierarchy			Quant. in Regs?	Structure
	1st Level	2nd Level	3rd Level		
Australia	Objectives	Functional statements	Performance requirements	By reference	Objectives and functional statements are guidance level provisions and the performance requirements are compliance level provisions
Canada	Objective (and sub-objectives)	Functional requirements	Performance criteria	Yes	Two divisions: A contains objectives, functional requirements.; B contains quantitative performance criteria; mandatory links connect A to B and B to A.
Japan	Objectives	Functional requirements	Performance requirements	Yes	Objectives, functional requirements, and quantitative performance requirements are all included in the regulations. The regulations also include prescriptive solutions and procedural options for unique solutions.
Nether-lands	Performance requirement and functional description together in a clause; performance requirement refer to a standardized determination method			By reference	All elements (objectives, functional requirements, performance level, determination method and links between elements of the regulation) are stated together in a Decree divided into chapters (usage functions: to be built and existing), divisions, paragraphs, sections, and clauses. Codes of practice are placed outside the regulations.
New Zealand	Objectives	Functional requirements	Performance requirements	Few	Objectives, functional requirements, and performance requirements are the only provisions of the regulations.
Spain	Objectives	Requirements	N/A	Few	Objectives and Requirements are mandatory while Verification Methods and Acceptable Solutions are considered to "Instrumental."
United Kingdom (England and Wales)	Objectives (in Building Act)	Functional or goal-based requirements	Performance statements (sometimes in guidance documents)	None in regulations but are in Approved (guidance) Documents	Objectives and functional requirements are mandatory, supported by detailed minimum standards in Approved Documents, with some performance standards for guidance.
United States: ICC	Objectives	Functional statements	Performance requirements	Few	Objectives, functional statements and performance requirements contained in the regulations. Administrative provisions and design performance levels provided as guidance.
United States: NFPA	Goals	Objectives	Performance criteria	Indirect	Includes prescriptive and performance-based options. Body of document contains mandatory language; including goals, objectives and qualitative performance criteria. Annexes contain explanatory material regarding several ways to determine if criteria have been met.