ROLE OF ACCEPTABLE SOLUTIONS IN EVALUATING INNOVATIVE DESIGNS*

Denis Bergeron, Architect, MSFPE
National Research Council, Canada

INTRODUCTION

Building regulatory systems around the world are going through dramatic change in response to changing stakeholder needs and political environments. The common element resulting from the changes however is the introduction of greater flexibility for the building code users. This is achieved through the explicit statement of the goals/objectives of the regulations and an increased use of performance-based requirements. This characteristic of these new building regulatory systems is an important feature for those wanting to encourage innovation and the advancement of new technologies.

In the past the prescriptive code provided the code users with solutions which were considered acceptable to the regulatory system. The knowledge was lacking as to how to express the desired outcome in performance terms so it was provided in the form of specification-based acceptable solutions.

A common characteristic of these new regulations, generally referred to as performance or objective-based, is that they include or are supported by at least one set of acceptable solutions which are deemed to deliver the required performance. An increase in the number of acceptable solutions will likely occur over time as new approaches and methods are employed in building construction. They will not necessarily all perform at the same level but they will all be considered to deliver at least the minimum level of performance expected by the building regulation in all areas covered by the regulation.

A point of departure within countries which have implemented performance-based or objective-based building regulations is how innovative designs are handled. Innovative designs are methods of complying with the regulations which differ from the acceptable solutions, usually but not necessarily project specific. Generally speaking there are two ways these innovative designs can be assessed for compliance against the regulations: assessing against the goals/objectives and performance requirements (first principles approach), or comparing against the stated acceptable solutions (benchmark approach). There are pros and cons to the two approaches and they can co-exist. The decision as to which approach or combination of approaches is employed in a specific country is governed by broader aspects of the legal system and desired regulatory framework being pursued.

Some areas of building regulations already benefit from sufficient knowledge to support the expression of performance requirements in measurable and verifiable terms. Examples include energy conservation, structural design, and some aspects of fire safety. In such instances, assessing innovative designs against performance requirements would seem a logical approach that could provide greater design flexibility while clearly specifying in quantitative terms the minimum level of performance expected by the regulations.

However the complete knowledge to express the performance requirements in measurable terms that can be verified at the time of construction still does not currently exist in all areas of building regulations. This paper will describe typical areas where performance requirements currently do not benefit from sufficient knowledge to be expressed in measurable and verifiable terms. Examples include sanitation, comfort, accessibility, and some other aspects of fire safety. These areas are often characterized by the significant impact of human behavior on the establishment of minimum levels of performance.

This paper will show how the role of the acceptable solutions has become very important in today's performance-based regulations. These acceptable solutions often implicitly determine the level of performance expected by the regulations. Acceptable solutions can play two roles:

1. in those areas where efforts are made to express performance requirements in quantitative terms, acceptable solutions can be viewed as an implicit statement of the performance level expectation of the regulations and their analysis can be used in developing quantitative performance criteria;

 Original paper appeared in Proceedings: 4th International Conference on Performance-Based Codes and Fire Safety Design Methods.

2. in those areas where performance requirements are not expressed in quantitative terms, acceptable solutions can be used to establish the baseline against which innovative designs can be compared to determine compliance with the regulations.

There are many issues and questions surrounding acceptable solutions, which must be addressed by those implementing performance-based building regulatory systems. CIB TG37, Performance-Based Building Regulatory Systems, is working to gather information and experiences related to these issues and questions. TG37 works closely with the Inter-jurisdictional Regulatory Collaboration Committee (IRCC) consisting of several countries engaged in building regulatory system reform. In many of these countries, the reform takes the form of a performance-based building regulatory system and IRCC focuses on identifying key issues for implementing such systems[i].

This paper will answer the following questions regarding acceptable solutions:
1. What are acceptable solutions?
2. What is the relationship between acceptable solutions and the goals/objectives and performance requirements?
3. What is the role of acceptable solutions in a performance-based building regulatory system?

This paper will present the work to date of TG37 in studying these issues and questions. This paper is a further development of earlier work accomplished by TG37 in analyzing acceptable solutions. This earlier work was expressed in a paper[ii] presented at the CIB World Building Congress 2001 in Wellington, New Zealand.

The information offered in this paper results from discussions and responses of TG37 members to questionnaires on issues related to acceptable solutions. This paper attempts to reflect current understanding of the majority of members involved in these discussions and may not necessarily represent the position of any specific member.

PERFORMANCE BASED SYSTEM[iii]

Although the concept of performance-based building regulatory systems is relatively new, most countries engaged in such a reform agree, with some variations, on a performance system model[iv] which can be simplified for the purpose of this paper into two components:
1. a qualitative expression of the goals/objectives of the regulations and of the functional requirements to be met by the building as a whole, and/or for its systems, components and elements;
2. quantitative and measurable performance criteria and verification methods.

The qualitative portion of this model is the regulation expression of the needs and expectations of society to be met by the performance of the building or facility. The quantitative portion of this model contains the tools offered to the construction community for the design and construction of buildings. This quantitative portion is key to the performance system model.

Quantitative Performance Criteria

Some areas of building regulations already benefit from sufficient knowledge to support the expression of performance requirements in measurable and verifiable terms. Examples include energy conservation, structural design, sound insulation, and some aspects of fire safety. In such areas, quantitative performance criteria are available to the building design and construction community. Even in these areas, the term “performance” can have different meanings. In some areas, performance criteria can set the performance expectation of society to be met by the building as a whole. An example could be energy conservation regulations where the performance target to be met by the whole building may be set in terms of the total energy consumption without stipulating the individual contribution of the various building components and systems. In other areas however, performance targets will be set for building components and systems and regulations will not clearly establish the overall performance expectation of society to be met by the building as a whole. An example could be fire safety, more particularly in those areas related to fire growth (design fire characterization), fire spread (standardized test methods for flame spread and smoke contribution classification), fire resistance of building components (standardized test methods for fire resistance rating), smoke management, fire suppression systems, etc.

Qualitative Performance Criteria

It is however recognized that knowledge may not be readily available in all areas of building regulations to allow the expression of performance expectations in measurable and verifiable terms. Examples include personal hygiene, comfort and well-being of people, access and movement of people - including people with disabilities, safety of people from injury, aspects of fire safety - more particularly those related to prevention of fires and human behavior in fire emergencies.

Most building regulations have provisions aiming at reducing the risk of injuries to building users as a result of trip and fall accidents. Stair geometry and handrail design requirements are part of most building regulations. These requirements are generally prescriptive: stair rise and run dimensions (min./max. or ratio), handrail height (min./max.), etc. Sufficient knowledge is not available to support the expression of these requirements in performance terms. Past performance of stairs and handrails designed with such prescriptive specifications has proven to be acceptable. Embedded in these prescriptive requirements are performance levels that can be deemed to meet society's needs and expectations. Expressing such implicit performance levels in quantitative and measurable terms may prove to be a very difficult task. What aspects of performance should be defined? Rate of accidents in stairs? Nature and severity of accidents? Consideration for age groups?

This paper focuses on such building regulation areas where performance expectations are not easily expressed in measurable terms and where acceptable solutions can play an important role. The work done by TG37 on a case study is first briefly described in order to introduce the discussion on acceptable solutions later in this paper.

CASE STUDY

Two approaches in performance-based building regulations are referred to at the beginning of this paper. The first principles approach assumes that quantitative performance criteria are available or can be developed, while the benchmark approach relies on acceptable solutions (prescriptive specifications) to evaluate innovative designs. An apparently simple case study was used by TG37 to examine how these two approaches could be used in evaluating an innovative design solution in a performance-based building regulatory system.

The case study deliberately stayed away from fire or structural engineering examples because of the multitude and complexity of design and evaluation tools available, which would turn the attention away from the main topic being presented. The following case involving sanitary facilities was therefore developed and submitted to CIB TG37 and IRCC representatives from several countries with the purpose of describing what would the decision-making process be in their respective country for each of the two approaches: first principles and benchmark.

CASE:
In order to save space for the construction of a new concert hall, a design team proposes to reduce the number of available water closets (from what is required by prescriptive specifications) in close proximity to the spectators seating area. In order to demonstrate that this proposal is satisfactory, the design team puts forward the following argument:
Studies have demonstrated that many people spend unnecessary time using public sanitary facilities. The proposed washrooms and water closets will incorporate several new features that will reduce the amount of time a person is likely to spend using these facilities: annoying background music, unpleasant odours, aggressive colours, uncomfortable appliances, bare minimum circulation space, etc. People will spend less time using the public washroom facilities and the sanitary needs of the occupants will therefore be met with fewer water closets.

QUESTION:
Could you briefly describe what would be in your country the decision-making process for evaluating this proposal - keeping in mind the two approaches described in the paper: first principle and benchmark - especially with respect to:

1. establishing what is the acceptable level of performance of sanitary facilities in a concert hall,
2. checking the proposal against the goals/objectives, functional requirements/statements, performance requirements, etc.
3. using the acceptable/deemed-to-comply solutions.

The results of this consultation were quite surprising. It appeared that no country could readily apply the first principles approach to this case and that the qualitative nature of the goals/objectives, functional requirements and performance requirements made it necessary to use other tools to evaluate the proposed innovative design. None of the building regulations consulted had been able to express the design criteria for sanitary facilities in quantitative and measurable terms. Related performance statements remained qualitative with ample use of non-measurable terms such as suitable, convenient, appropriate, etc.

First Principles Approach

Some members nevertheless explored the possibility of using a first principles performance-based decision-making process for this case. This exercise raised a number of concerns without identifying a clear direction. The following is a list of some of the concerns raised. It represents some of the issues that could be required to be addressed and documented by the proponent in order to provide sufficient evidence that the innovative design is acceptable and satisfies the goals/objectives and functional requirements of the regulations:

1. The designer should present design load, the parameters used and the final solution should be documented.
2. Establishing the acceptable level in a concert hall would have to consider parameters regarding health, hygienic standards and possibly comfort and amenities. It would also have bearing on related items like ventilation requirements and noise reduction affecting each individual.
3. For building products there are durability requirements, and sanitary appliances may be chosen according to expected use.
4. Relating this to a more engineering like approach a type of risk analysis method (as a product of consequence and frequency of occurrence) may be used and the «risk» level established. This should again refer the material factor (the failure or breakdown of the appliances) and the load factor - population, demographic parameters, time assessment etc.
5. Checking the proposals against the goals/objectives would have to consider the cumulative effect of the solution.
6. What are the physical limits to what is necessary time spent in a washroom, and what time is desirable for secondary functions like washing hands.
7. The use and the load on the facilities shall be considered. The number of persons, demographic patterns the uses (rock or classical concerts), the level of catering or serving drinks and assessing periods of intervals.
8. Consider the likelihood of alternative patterns of behaviour and possibility of changed behaviour. This would relate to whether the public would be familiar with the facilities and if so the likelihood of being prepared for alternatives.
9. Consider the secondary effects of the proposed solution: aggressive colours may lead to violent behaviour, unpleasant odours may have a negative effect on occupants of adjacent spaces, etc.

The general reaction to the use of a first principles approach in this case study was that questions on the performance expectations of the existing regulations remain unanswered. The broad range of concerns raised is an indication that several aspects of the proposed solution need to be examined and that no guidance exists in the qualitative goals/objectives and performance requirements. This fairly long, although partial, list of concerns is also an indication that a first principles approach in this case may rapidly lead to a very complex and expensive design and decision-making process. Looking at each of the concerns listed above also reveals that they raise questions in areas where scientific knowledge, statistical data or information on past performance are not readily available. This otherwise very simple case study seems to identify an area of building regulations – sanitary facilities – where more research and studies are needed in order to support the expression of the performance requirements in quantitative and measurable terms. Another aspect may simply be the lack of cost benefit or need to even approach this topic from first principles. This may be why such technical information has not been generated.

Benchmark Approach

Comparison with the prescriptive specifications of the acceptable solutions was identified as a viable avenue. The benchmark approach process was generally perceived as simpler and more straightforward than that of the first principles. It was suggested that the proposal could be assessed by comparing the amount of queuing time taken for the patrons to use sanitary facilities complying with the prescriptive specifications with the numbers being proposed under the performance-based solution. This would provide the necessary benchmark for the assessment to take place. If the queuing times to use the proposed performance-based solution resulted in equal or less queuing times

than the current prescriptive specifications of the acceptable solutions, then it could be argued that the proposed solution meets the performance requirements. It was also argued that concerns over legal liability could refrain designers and building officials from considering a solution for which clear evidence cannot be provided that it will offer a level of performance at least equivalent to that of the acceptable solutions.

One of the conclusions of the work of TG37 on this case study is that acceptable solutions can play an important role in a performance-based building regulatory system, more specifically in areas where performance requirements are not expressed in quantitative and measurable terms.

ACCEPTABLE SOLUTIONS

Traditionally the prescriptive approach was to write a code with a single method that had to be followed. Implicit in these prescriptions was the level of risk or performance, which was acceptable to society. These prescriptions would frequently be the first acceptable solutions.

What are Acceptable Solutions?

The term "acceptable solution" means many things to many people and is used indifferent ways around the world. From the perspective of the building regulatory structure, an acceptable solution is considered to be a set of provisions which when met will deliver the desired performance as intended by the goals/objectives and performance requirements. Acceptable solutions are examples of compliance with the regulation. In this paper, the term "acceptable solution" is used in a broad sense and shall include prescriptive solutions as well as those expressed in performance terms, including their verification methods. In most countries the body that develops the code usually establishes the acceptable solutions. The name given to acceptable solutions and their relationship to performance requirements vary from one country to another. Acceptable solutions are sometimes referred to as deemed-to-satisfy solutions and are often included in approved documents or guidance publications, which form an integral part of the building regulation. It is anticipated that over time the number of acceptable solutions will likely increase so that code users will have more ready-made options to choose from.

The different ways of "packaging" acceptable solutions can be cause for confusion. In at least one country, the body responsible for the development of the building codes will publish two building codes that are offered as equivalent alternatives: one is called the performance-based code, while the other contains a full set of essentially prescriptive specifications covering the same areas as the performance-based code. Although not specifically identified as such, the latter prescriptive code is equivalent to what is called "acceptable solutions" in other countries that do not have a dual code system. In another known case, a building code will contain one chapter describing the performance-based approach while the other chapters contain prescriptive specifications that are deemed to provide solutions equivalent to those that would be developed using the performance-based approach. Again, the packaging is different but the prescriptive chapters of this building code play the same role as acceptable solutions and are included in the term "acceptable solutions" for the purpose of this paper.

What are Innovative Designs?

An innovative design (also called alternative solution) is anything that differs completely or partially from what is described in the acceptable solutions. This concept does not exist in a performance-based design process with quantitative performance criteria. But, as shown earlier, many areas of building regulations do not benefit from sufficient knowledge to support the expression of performance requirements in quantitative terms. In those areas where performance requirements are expressed in qualitative and non-measurable terms, acceptable solutions may become a viable option for evaluating innovative designs. It is only in this context that the term "innovative designs" is used in this paper.

Innovative designs present ways of complying with the building regulations that differ from the specifications contained in the acceptable solutions. They can be a unique solution for a specific building or be a solution which represents a type of construction that is repeated in different buildings or locations. The solution can just meet the requirements or be significantly better than the minimum. In many countries, these solutions must be accepted by the local authorities or by some established organization acceptable to the building regulatory authority. This is where some confusion comes up because the solution would be "accepted" by a local authority as an alternative to

the corresponding acceptable solutions in the building regulations. That acceptance by one local authority is not legally binding on anyone else. That contrasts with the corresponding acceptable solutions, which is part of the building regulations and is binding on all local authorities administering the building code.

What is the Role of Acceptable Solutions?

1. Acceptable solutions have become an important part of the new performance-based regulatory systems. What has happened in the transition to performance-based regulations is a majority of the designers and builders continue to want to follow the acceptable solutions they have become more familiar with. Even though there is greater flexibility if a performance-based design is chosen, anything more than comparatively minor departures from the acceptable solutions is viewed as a higher risk or more costly approach and is only used in certain kinds of projects. Consequently, when looking at performance-based regulations today, most countries will have some form of a more prescriptive option available for their stakeholders.

2. As illustrated in the case study discussed earlier, many areas of building regulations rely on qualitative and non-measurable performance criteria to determine the acceptable level of performance of building solutions. It is recognized that acceptable solutions can play an important role in evaluating innovative designs in such areas of the regulations. The implicit level of performance of acceptable solutions can be used as a baseline against which innovative designs can be compared to determine equivalency. Unlike the efforts placed in the development of performance design tools, models and methods, little work has been done internationally towards the development of tools for the purpose of benchmarking the implicit expectation of performance of the acceptable solutions. In Canada, the Fire Risk Management program of National Research Council has developed computer-based decision-making tools in support of this role of acceptable solutions (see discussion below under Canadian Approach).

3. Under prescriptive codes, policy makers were adopting solutions that were deemed to meet society's needs and expectations as they relate to building performance. Embedded within the prescriptive specifications are implicit levels of performance: adopting the solutions also meant adopting these implicit levels of performance. Seen from this angle, acceptable solutions of the building regulations contain society's performance expectations.

In performance-based regulatory systems, the goals/objectives and performance expectations are more explicit. Determining and quantifying the level of performance through measurable performance criteria should be the role of policy makers as an expression of society's expectations. One possible way of determining what level of risk or performance is acceptable to society is to examine the acceptable solutions with their past performance record. The implicit level of performance of acceptable solutions can be used by policy makers in developing acceptable performance criteria for performance-based systems. If policy makers do not play this role, the technical community (designers, manufacturers, builders, etc.) will be placed in the role of determining what is an acceptable level of performance to society.

CANADIAN APPROACH

During a strategic planning exercise that lead to the articulation in 1995 of the objective-based code concept in Canada[v], the Canadian Commission on Building and Fire Codes first examined the possibility of embarking in a performance-based building regulatory reform. The Commission quickly realized that sufficient knowledge is not available in several building regulation areas for the expression of performance expectations in quantitative, measurable and verifiable terms. The Commission considered that development of performance-based codes with qualitative and non-measurable performance criteria would be too disruptive to the construction process and was not acceptable for Canada. A transitional approach called objective-based was approved and is currently being developed. The first objective-based national building, fire and plumbing codes of Canada are scheduled to be published in 2004.

Objective-Based Codes

The fundamental concept behind objective-based codes in Canada is the recognition that the acceptable solutions represent an implicit expression of the levels of building performance that are acceptable to society. Objective-based codes are articulated around acceptable solutions[vi], which play all 3 roles described earlier in the discussion on the roles of acceptable solutions.

1. In objective-based codes acceptable solutions are maintained and represent one of the two compliance options. Following pertinent specifications of the acceptable solutions is deemed to meet the goals/objectives and performance expectations of the regulations. Acceptable solutions consist of essentially – but not exclusively – prescriptive specifications that have been developed over time under the code development system in place before the introduction of objective-based codes. Acceptable solutions will continue to be developed and updated under objective-based codes and will continue to offer to code users an easy way of complying with building regulations.

2. The second compliance option under objective-based codes is through the use of alternatives, i.e. innovative solutions that differ from the specifications of the acceptable solutions. To be acceptable, an alternative must however provide a level of performance at least equivalent to that of the acceptable solutions. This very important feature aims at preventing an unintentional reduction or increase in the level of performance and quality of construction that could result from the introduction of objective-based codes. This is a clear statement that the acceptable solutions (specifications developed over the years) do set out the level of performance deemed to be acceptable to society and that objective-based codes shall not inadvertently facilitate the use of building solutions with a lower performance level. A reduction or increase in the acceptable level of performance is possible under objective-based codes and can be achieved by the introduction or revision of acceptable solutions against which alternatives will be compared.

In preparation for the development of objective-based codes, the technical committees responsible for the development and updating of acceptable solutions have examined each and every code specification with the mandate of determining their goals/objectives and intents. In objective-based codes, each specification of the acceptable solutions is tied to well defined objectives and functional statements. When evaluating innovative solutions for compliance, the areas of performance to be examined are clearly identified by the objectives and functional statements attributed to each specification of the acceptable solutions.
Innovative solutions are not limited to "prescriptive" solutions. Both prescriptive and performance design options are permitted but their common denominator is that any alternative shall provide a level of performance at least equivalent to the acceptable solutions it replaces.

3. Objective-based codes may be perceived as a transitional approach towards the introduction of performance-based design criteria in building regulations. As more knowledge becomes available, areas of the codes may be developed into a performance path with quantitative, measurable and verifiable performance criteria, including their verification methods. This could become a third compliance option in addition to the two options described under points 1 and 2. One area of the current codes that appears to be a good candidate for such development into a performance option is structural design.

In developing performance criteria, the implicit level of performance embedded in the acceptable solutions and deemed to be acceptable to society shall be analyzed to ensure that a performance option will not inadvertently lead to a general reduction or increase of this accepted level of performance. Tools will need to be developed for the purpose of determining the implicit expectation of performance of the acceptable solutions and to transcribe it into quantitative and measurable performance criteria.

Decision-Making and Fire Risk Assessment Tools

FiRECAM™ and FIERAsystem are computer-based fire risk assessment tools that can be used to evaluate fire protection options and costs for office, apartment and light-industrial buildings. FiRECAM™ and FIERAsystem are developed by the Fire Risk Management group at the Institute for Research in Construction (IRC) of National Research Council Canada. These tools do not establish the level of performance in absolute terms but allow the benchmarking of current codes and can be used to determine if different fire protection options would have an impact (reduction or increase) - and the relative importance of such impact – on the overall level of fire safety performance of a building. These are decision-making tools that can be used to compare the impact of such features as sprinkler systems or smoke detectors on life safety and property preservation.

FiRECAM™ and FIERAsystem are examples of the research that IRC is conducting to support Canada's move from a prescriptive to an objective-based system of construction codes. IRC is planning to extend its modeling capabilities to evaluate fire protection systems in other types of buildings, such as industrial plants, arenas and shopping malls.

CONCLUSION

A lot of efforts has been invested internationally in support of the introduction in several countries of performance-based building regulatory systems. A performance-based system relies on clearly expressed goals/objectives and functional requirements, which are generally expressed in qualitative terms. Key to a performance-based system is a set of quantitative and measurable performance criteria appropriately linked to the qualitative portion of the system. Some areas of building regulations such as energy conservation, structural design, sound insulation, and some aspects of fire safety currently benefit from sufficient knowledge to support the expression of performance criteria in quantitative and measurable terms.

Several areas however do not benefit from such knowledge, namely those areas of building regulations related to personal hygiene, comfort and well-being of people, access and movement of people - including people with disabilities, safety of people from injury, aspects of fire safety - more particularly those related to prevention of fires and human behavior in fire emergencies. The absence of quantitative and measurable performance criteria is these areas creates a need for alternate methods and tools to determine – and verify - the acceptable level of performance in order to satisfy society's expectations as expressed in the goals/objectives and performance requirements of the regulations. Several methods and tools have been developed and their use varies from one country to another. Expert judgment, historical in-service performance, statistical evidence, approved calculations, test methods, models and simulations are examples of such methods and tools that may be used to determine and verify performance of a building design. Another method relies on comparison of a proposed building design with acceptable solutions, those solutions (essentially - but not exclusively - prescriptive specifications) that are deemed to comply with building regulations. This is the method privileged by Canada in developing its objective-based codes concept.

Canada will publish in 2004 objective-based national building, fire and plumbing codes. Canada's objective-based approach is articulated around the fundamental principle that acceptable solutions do reflect the level of performance acceptable to society. Based on this principle, acceptable solutions will continue to be developed and updated and will play the following roles in an objective-based building regulatory system:

1. As one of the compliance options, acceptable solutions will offer to the construction community an easy and cost-effective way of meeting the goals/objectives and performance expectations of building regulations;
2. Acting as a benchmark for determining the level of performance that is acceptable to society, acceptable solutions provide excellent guidance for assessing equivalency of innovative solutions. Computer-based fire risk assessment models FiRECAM™ and FIERAsystem are developed at National Research Council of Canada in support of this role of acceptable solutions in objective-based codes;
3. The implicit level of performance embedded in the acceptable solutions can be viewed as representing society's expectations of building performance. Converting this implicit level of performance into quantitative terms can help in the development of measurable and verifiable performance criteria that would closely reflect society's expectations. This is an area where research is needed to develop tools and methods that would allow to quantify the implicit level of performance of acceptable solutions.

TG37 recognizes the dependence of important areas of building regulations on the prescriptive methods and will continue its work in studying these issues and questions.

ACKNOWLEDGEMENTS

This paper was developed by a member of CIB TG37 as one of a set of papers related to the implementation of performance based regulatory systems. While the words are the author's the ideas have sprung from detailed discussions at several meetings and from the cumulative experiences of the members, many of whom are authorities who are directly involved in the enforcement of performance based regulatory systems in their own countries. It is important to mention the contribution of the members of the Inter-jurisdictional Regulatory Collaboration Committee (IRCC) to these discussions.

---

[i] Inter-jurisdictional Regulatory Collaboration Committee, "Guidelines for the Introduction of Performance Based Building Regulations (Discussion Paper)," May 1998

[ii] Bergeron, D., Bowen, B., Tubbs, B., Rackliffe, T., "Acceptable Solutions," *Proceedings, CIB World Building Congress 2001, Performance in Product and Practice*, Wellington, NZ

[iii] Meacham, B., Tubbs, B., Bergeron. D., Szigeti, F. (2002), "Performance System Model – A Framework for Describing the Totality of Building Performance," 4th International Conference on Performance-Based Codes and Fire Safety Design Methods.
[iv] CIB Publication 206, "Final Report of CIB Task Group 11 Performance-based Building Codes," April 1997
[v] Canadian Commission on Building and Fire Codes, "Building the Future – The Strategic Plan of the Canadian Commission on Building and Fire Codes 1995-2000," Institute for Research in Construction, National Research Council Canada, 1995
[vi] Canadian Commission on Building and Fire Codes, "Objective-Based Codes: A Consultation on the Proposed Objectives, Structure and Cycle of the National Building Code," October 2000