

STANDARDS LINKAGES TO A PERFORMANCE-BASED REGULATORY FRAMEWORK

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ABSTRACT

Much of the world is developing or has in place, performance-based regulatory systems for the regulation of building safety. While the concept of performance-based regulation is not new, only in the last two decades has the development of engineering methods that can verify performance against goals, objectives and specific criteria provided the means for enforcement. Most of these systems follow a similar framework and cite common performance metrics and engineering methods.

The initial focus of the organizations developing performance-based regulatory systems has been the codes themselves, but now more attention is being paid to the infrastructure needed to administer such systems, and particularly on standards. In 1999 the Australian Buildings Codes Board published *Preparation of Standards Referenced in the Building Code of Australia*. ISO committees such as TC59 and TC92 are also turning their attention to the issue of performance-related standards and their linkages to performance-based codes.

This paper discusses the linkage between performance-based regulations and the standards that form a crucial part of the overall performance-based regulatory system (PBRS). There are many ways in which codes and standards may be linked, but generally performance-related standards should employ a structure that is complementary to that of the code. Traditionally codes have made direct references to standards that then provide a greater level of detail on how a function is to be accomplished or verified. In a PBRS that does not require specific approaches it is not clear if direct reference to standards in the regulation is appropriate or whether these would be in the "Acceptable Solutions." What then is the scope of a performance-related standard and would the standard be different if it supports the functional requirement or performance criterion as opposed to only acceptable solutions?

In the Performance Codes that have been developed by various countries there are many similar objectives, functional requirements, and performance requirements. To what extent will it be possible to develop and agree on common standards on a regional or international scale? And finally, how will the standards affect the development and application of the performance codes themselves? In particular, standards have a significant role in the regulatory acceptance of compliance with code provisions, and the same would be expected under a performance system.

These issues will be discussed from the international perspective of the authors and their direct involvement in the development and use of performance codes and standards in their own countries.

KEYWORDS

building regulations, building codes, performance evaluation, performance-based design, regulations, standards

INTRODUCTION

Many countries have in place or are developing performance-based building regulations that have replaced or supplemented prescriptive codes as the basis for their building regulatory systems. But the transition to a performance-based regulatory system (PBRs) requires that a consistent infrastructure be put in place that supports the specification and evaluation of buildings, their components and systems, in performance terms. This raises fundamental questions about the system of standards that exists to support codes, and how they are structured, developed, used, and linked to the codes. This is the primary subject of this paper.

REGULATIONS, CODES AND STANDARDS

In most of the world Building Regulations are developed by the National government and then may be promulgated nationally or adapted and adopted by a local jurisdiction. This direct development by the legislative bodies or their delegates is perhaps why most of the world uses the term *regulations*. The United States is unique in that the National government has no formal role in this process – private development bodies develop model codes that are adapted and adopted by states or smaller governmental bodies. But in every case the code is eventually adopted administratively or legislatively into law. Only after passing through this legislative adoption process do they become regulations, so this may be why the term *Codes* is more common in the U.S. But whether called regulations or codes, these documents contain mandatory requirements for what must be accomplished or provided under specific circumstances

Standards are developed by a broad range of public or private organizations, but not by legislatures or by their delegates. Standards generally deal with how things are to be done and often represent “best practice,” or the application of a family of products at a point in time. Standards are usually not adopted directly as mandatory requirements except where they are made mandatory references within regulations.

TYPES OF STANDARDS

There are various types of standards that may become a part of performance based building regulations or supporting materials such as approved documents, either by reference or other means. Such types include,

- Test or calculation method standards used to evaluate or measure the performance characteristics of designs, systems, or products;
- Product or system specification standards that provide requirements for product or system configuration (prescriptive specifications), or performance characteristics;
- Performance Statement Standards (PSS), which comprise user needs or objectives, qualitative descriptions of performance needed to fulfil the stated objectives, parameters to define necessary performance level, and methods for measuring achieved performance level.

While test or calculation method standards and product or system specification standards are already widely used in current regulatory systems, Performance Statement Standards are based on relatively new concepts and thus have different features. Therefore, the way to utilize this type of standard in the Performance-Based Regulatory System (PBRs) should be examined carefully.

The adoption of PBRs(s) is producing a demand for fundamental changes in the types of standards being developed. Older test methods that provide pass/fail or classification ratings (Class A, B, C) are being replaced by those that measure performance properties (heat release rate, species yields) and that feed directly into calculation methods such as limit state structural design methods. Technical committees developing national product or system specification standards such as those for fire alarm systems (NFPA 72 in the US and EN54 in Europe) are being challenged to in addition develop PSSs

that include the means to determine the performance level achieved by a specific design and installation as well as the reliability with which that performance is provided.

THE ROLE OF STANDARDS IN A PERFORMANCE-BASED REGULATORY SYSTEM

Within the framework of conventional regulatory system, standards are generally incorporated within the body of regulations by reference as parts of mandatory provisions, or as criteria to determine whether or not a regulatory requirement is met. However, with movement toward performance-based regulatory systems (PBRs), the status of these standards may change. The PBRs where regulatory requirements are described in generic terms, these standards are likely to give more practical evaluation tools or compliance methods to support specific requirements. In most recently developed PBRs, standards provide Acceptable Solutions, Deemed-to-satisfy Solutions, or certain parts of such solutions. For example, a test method for a certain material or product that was mandatory in the prescriptive system has become one (of possibly many) acceptable way(s) to determine the acceptable design involving that material or product. But many other test or calculation methods also may be accepted if they can demonstrate equivalent fitness-for-purpose characteristics of the component.

STANDARDS AS ACCEPTABLE SOLUTIONS

It should be noted that such standardized evaluation methods or compliance methods, even if they are technically justifiable or have already been used in one jurisdiction, would not necessarily be accepted automatically as Acceptable Methods/Solutions in other PBRs. Each PBR enforcing authority has the responsibility to ensure that the results of applying such methods or solutions are justifiable under the legal and regulatory system in effect. For example, it must be examined and ensured that the characteristics of proposed solutions applying to relevant standards satisfy the regulatory intent. The "enforceability" of evaluation methods, such as testing methods, also must be examined so that they can be applied in a fair and equitable manner. Where such test methods require specific proficiencies to be applied properly, it would be necessary to consider introducing such measures as accreditation of testing agencies. Thus, it should remain as the responsibility of the enforcing authority to examine the enforceability of such methods and to decide whether the standards that specify such methods may be adopted and/or approved as Acceptable Methods/Solutions in the PBR. Good coordination between the enforcing authority as the "approving body" of standards and standardization bodies is important to assure the compatibility of regulations and standards in a PBR. Consider the following examples of variations in how standards are adopted as Approved Documents within the PBR in some countries.

In Australia the State Governments adopt, with or without local amendments, the performance-based regulations issued by the Australian Building Codes Board (ABCB) and which cites or incorporates various Standards. Similar linkages operate in Canada (provincial governments) and the US (state and local governments). Each government is the approving body within its jurisdiction.

In England and Wales, Parliament or the Cabinet makes the performance-based regulations and the Minister for the Environment issues "Approved Documents" which in turn cite or incorporate various Standards. The Minister is the approving body.

In New Zealand, the Cabinet makes the performance-based regulations, and the Building Industry Authority, using powers delegated to it by Parliament, issues similar "Approved Documents".

Activities within the European Union (EU) to harmonize construction standards under the EU Construction Products Directive can be seen as an example of how standards for product approvals are evolving in support of multinational, and eventually global markets. Here, multinational standards bodies such as the European Organization for Technical Approvals (ETA) and the Commission for European Standardization (CEN) are working to harmonize standards and to designate compliance by a common mark (CE) that can be applied by any accredited testing laboratory using that standard.

The development of methods of assessment and testing and the ETA Guidelines embody the performance aspect of a specification. The development of such methods is well ahead of the development of performance standards. UK regulations are undergoing revision to acknowledge the role of CE marking in their Approved Documents where British Standards will gradually be replaced by European Standards (ENs) and ETAs as a method of indicating compliance. Similar changes are being made in other EU member countries.

Whoever formally approves Standards as acceptable solutions must have the power to approve subject to amendments. Otherwise, the Standards-writing body would have the power to make law, which is an illegal delegation of legislative power in most countries.

In some jurisdictions, the approving body will come to an agreement with the standardization body as to what can and what cannot be included in an acceptable solution. This has been achieved in Australia by the ABCB publication *Preparation of Standards Referenced in the Building Code of Australia*. In New Zealand, the BIA and Standards New Zealand are working on a similar agreement of their own.

However, such an agreement will not necessarily be interpreted correctly and followed by the standardization body. That body is likely to be under pressure from its technical committees to include good-practice provisions that are not necessary for compliance with the regulations. Ideally, therefore, the approving body will have sufficient technical expertise to nominate members to technical committees and to check that any particular Standard does in fact comply with the agreement. Nevertheless, in practice, the approving body must inevitably rely to some extent on the standardization body.

In jurisdictions where there are many approving authorities, some of them will have limited technical expertise. However, most of them will be looking to adopt the same performance-based regulations and accompanying acceptable solutions. In such jurisdictions, there are unlikely to be formal agreements of any kind and the approving authorities must rely heavily on the standardization body. In effect, the standardization body in such jurisdictions comes very close to having the power to make laws simply because its Standards are likely to be uncritically accepted by numerous approving authorities. In such jurisdictions, it is essential that the standardization bodies understand and are committed to the principle of performance-based regulations.

THE NEED FOR MULTIPLE TYPES OF STANDARDS

In a PBRS there is a need for several types of standards to satisfy fully the regulatory function. For example, in designing a fire alarm system for a performance-based building the designer would use a test or calculation method standard as a means of qualifying the performance of the detectors, audible and visible devices, and the system monitoring capabilities in terms of the design objectives. A system specification standard would be used to provide the details of the installation, maintenance, testing, and use of the system to obtain the desired performance and reliability. Where a performance statement standard (PSS) is available it could be used to address the performance needs of the design and the other standards would become measurement methods or acceptable solutions. Thus, it is easy to envision the use of all three types of standards in the PBRS.

A current problem is that many of the world's standardization bodies have not yet begun to develop performance statement standards needed to support PBRSs. In this fire alarm system example, organizations like CEN in Europe, Underwriters Laboratories and the National Fire Protection Association in the U.S., and ISO TC21 continue to develop system specification standards and test method standards that employ pass/fail and classification criteria.

Calculation standards, or at least accepted methods to predict performance in a specific, end use configuration are needed, along with test methods to measure the data that characterize the performance parameters of specific products as inputs to the calculation. In the building materials

area these have been developed by industry associations and engineering societies. Such organizations might also be the best suited to develop the needed performance statement standards.

Performance Statement Standards

The concept of Performance Statement Standards (PSS) is relatively new. A PSS typically consists of four elements, User Needs/Objectives, Qualitative Performance Description, Parameter(s) to indicate Performance Levels, and Measurement Method(s). This composition is very similar to performance-based regulations, as well as performance specifications for products. This implies that PSSs have the potential to be referenced in performance regulations and specifications, and to provide mandatory requirements or acceptance criteria.

A PSS may be developed for any type of material, product or system that might be used throughout a building or in only part of the building. Such applications can become quite complex when attempting to understand the interrelationships among numerous building components and their impact on the range of performance characteristics that are considered. One of the challenges in the application of complete performance designs is the potential for conflicts between the needed performance characteristics of a material or product to meet different user needs or qualitative performance descriptions.

For the purpose of regulating building performance, in PBRs and performance specifications for building projects, building related performance may be addressed at three different levels, *i.e.*, the building as a whole, building elements or components, and materials or products to be used in a particular manner.

The essential purpose of the PBRs applied to a building project would be to control the performance characteristics of the building itself, *i.e.*, the performance of "building as a whole" level. At this level, however, it is often difficult to define explicitly all four elements of the Performance Statement, especially measurement method(s). Practically, the measurement method for the "building as a whole" level can be substituted by combination of Performance Statements of individual elements or components, such as walls, columns, etc. Certain assumptions about "system configurations" of whole buildings, such as necessary capacity and arrangement of load bearing walls in the structural system, would usually underlie such substitutions. In the same manner, Measurement Method(s) at the element or component level can be substituted by a combination of performance statements for materials or products incorporated in the element in question. Again, "element configurations" would be underlying the substitutions.

It should be remembered that such "system configuration" or "element configuration" would usually be the ones reflecting specific construction methods and local design conventions. Therefore, such substitutions must be regarded as "context-specific" as they are the outcome of a specific design process. Solutions developed by the substitution of performance statements for materials or components cannot be used as general solutions because in some other context they might not satisfy the higher level performance requirement for the building as a whole. Further, it is not desirable for the performance-based regulations to be "context-specific", as the most important aspect of the PBRs is the flexibility to address as many different design contexts as possible.

A Performance Statement Standard (PSS) itself may be "context-specific". Therefore, because such "context-specific" PSSs represent only specific design contexts or design conventions, they would not be suitable to be incorporated into the mandatory requirements of the regulations. They may be suitable for Acceptable Solutions or Acceptable (Compliance) Methods.

PSSs may be developed for generic elements or components such as a kind of wall, and also for a material or product such as gypsum board. In these cases, the implications of these standards would differ from that of PSSs for the building as a whole. User Needs or Objectives for an element or component would be different from that for the building as a whole. The former may vary depending

on the intended use given to the element or component in the applied design policy. PSSs at the element or component level or material or product level would be usually given specific User Needs or Objectives, and this implies that certain specific design contexts be assumed at the standardization stage. Therefore, such PSSs at the element or component, or material or product level can be approved as parts of an Acceptable Solution, only when the design contexts being applied to the solution and assumed at the standardization stage are deemed equivalent.

Again, it is the enforcing authority of each PBRS that has the responsibility to examine the suitability of established or proposed PSSs for the purpose of their own PBRS, and to approve or disapprove them as a part of an Acceptable Solution.

Identifying impacts on multiple objectives

In a PBRS it is important to recognize that the performance characteristics of materials, products, or systems can affect the performance objectives for multiple building attributes or user needs. For example, a more flexible structural frame intended to improve seismic performance can have negative implications on the durability of finish systems that are not equally flexible. Thus, when developing standards and especially PSSs that might be designated as Acceptable Solutions it is important to understand these potential interrelationships.

One way to address this issue is to develop a matrix of building components against user needs or attributes that will identify multiple intersections. Then any standard for those components would need to address all of the applicable performance characteristics. One such matrix was developed by the National Bureau of Standards (US) as the *Systems Approach* in the early 1970's [Hattis and Ware, 1972, NBS 1972] and was subsequently applied in Iran [TCSB 1975] and in Israel [Jaegerman et al, 1976]. The system was presented at CIB Symposia on the performance concept in 1972, 1982, and 1996 [Ware 1972, Hattis 1982, Gross 1996, Hattis 1996].

A paper by Hattis and Becker [in press] proposes that this approach is consistent with performance codes following the so-called Nordic Model and that the matrix can be helpful in relating performance statements to the individual parts of a building by use of a hierarchy of built elements. A number of such hierarchies can be constructed and one used within ASTM E06 is provided as an example:

Subsystems

1. Spaces
2. Structure
3. Exterior Enclosure
4. Interior Space Division
5. Plumbing
6. HVAC
7. Fire Protection Systems
8. Electrical
9. Communication & Security Systems
10. Fuel Networks
11. Fittings Furnishings & Equipment

Another use of this matrix would be to identify multiple intersections of user needs and building elements, or elements that affect more than one function. In this way it is possible to identify the potential for conflicting performance requirements to be applied to any single element.

IMPLICATIONS FOR INTERNATIONAL STANDARDS

As mentioned above, to apply performance related standards to the acceptance of performance solutions, it is necessary to consider both the enforceability and compatibility of those solutions within the design context as applied to the standards and regulations.

When the standards are adopted at local level, it is rather easy to satisfy these criteria because both PBRs enforcing authorities and standardization bodies can work closely to establish the necessary coordination.

In addition, standards are usually regarded as voluntary or advisory in most nations. Therefore, the standardization bodies may develop specific standards even if their application is limited to specific context, while PBRs enforcing authorities have the ability to approve proposed standards as Acceptable Solutions. However, in the case of International Standards, the situation can be quite different.

The first concern is the potential difficulty in assuring compatibility among proposed technical or engineering methods, such as test methods or calculation methods, as well as reconciling these with local design conventions that are the basis of both regulations and standards. If sufficient compatibility cannot be assured, the ability to accept and approve such international standards as Acceptable Solutions in the PBRs may be seriously restricted.

The second concern is with the voluntary status of standards in local regulation. This issue is quite important for performance related standards, and especially for Performance Statement Standards (PSSs). The potential problem is that both PSSs and Performance-based regulations incorporate User Needs or Objectives. If the regulation and the PSS incorporate the same User Needs or Objectives but the details such as the performance descriptions are different, confusion will occur. Should the PSS be regarded as mandatory by considering that the specific PSS is the only way to fulfil the stated User Needs or Objectives, serious conflicts with the PBRs will occur. Therefore, it is essential for the PSSs to keep their voluntary nature in order to maintain a flexible relationship with mandatory requirements and Acceptable Solutions within the PBRs. However, current WTO/TBT rules require local governments to accept international standards where such exist as the basis of regulations. Under such circumstances, any "context-specific" performance statement cannot be regarded as suitable for the objective of international standardization.

CONCLUSION

Performance based regulatory systems (PBRs) are being adopted by many countries as a means to rationalize building regulations and to allow more functional buildings at lower cost without sacrificing safety. This change from prescriptive regulation carries with it the need for many other changes to the regulatory infrastructure, not the least of which is in the area of standards. The strong linkages between standards and regulations are even stronger in PBRs, especially where standards are cited in acceptable solutions. However when these are developed as international standards that are required to take precedence over local standards in order to prevent non-tariff barriers to trade, conflicts may occur with long-established local expectations, convention and/or building practice. Thus there must be some allowance for cultural and national norms even if there is some impact on trade.

Further there are implications for the standardization bodies working in both the national and international arenas to develop standards that measure the performance characteristics of materials, products, and systems in their context of use. In a PBRs it is no longer acceptable to assume that a material, product, or system is always appropriate if it meets any single set of criteria. This is especially true if the applicability of these criteria is subject to cultural variation.

Finally, there needs to be a mechanism for considering the interrelationships of the performance characteristics of materials, products, and systems against objectives and user needs at the component or subsystem level and when viewed at the "building as a whole" level. In a large and complex building it is not difficult to envision a solution to one performance objective that has a detrimental effect on the performance of that or another component against another objective or even on the whole building performance. The use of a matrix relationship between a standard set of building

components and attributes was identified as one possible approach to identify materials, products, or systems whose performance effects multiple attributes.

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REFERENCES

- Gross, James G., National Institute of Standards and Technology *Developments in the Application of the Performance Concept in Building*, Tel Aviv, 1996.
- Hattis, David B and Ware, Thomas E., *The PBS Performance Specification for Office Buildings*, NBS Report 10 527, U.S. Department of Commerce, 1971.
- Hattis, David B., Building Technology Inc., *The Performance Specification for Procurement and Evaluation of Housing for the Tehran Region*, Lisbon, 1982.
- Hattis, David B., Building Technology Inc., *Role and Significance of Human Requirements and Architecture in Application of the Performance Concept in Building*, Tel Aviv, 1996.
- Hattis, David B. and Becker, Rachel, Comparison of the Systems Approach and the Nordic Model and their Melded Application in the Development of Performance Based Building Codes and Standards, submitted to the ASTM Journal of Testing and Evaluation 2000.
- Jaegerman, Ch., Becker, Rachel, et al., *Performance Specifications for Housing*, Building Research Station, Technion, Haifa, Israel, 1976.
- NBS *Operation Breakthrough (OBT) Guide Criteria for the Design and Evaluation of Innovative Housing Systems*, National Bureau of Standards/U.S. Department of Housing and Urban Development, 1972.
- TCSB, *The Performance Specification for Procurement and Evaluation of Housing for the Tehran Region*, 1975.
- Ware, Thomas E., Building Research Division, National Bureau of Standards, *Performance Specifications for Office Space Interiors*, Philadelphia, 1972.