

DEVELOPMENTS IN THE APPLICATION OF THE PERFORMANCE CONCEPT IN BUILDING

James G. Gross
National Institute of Standards and Technology
Gaithersburg, MD, USA

ABSTRACT

The performance approach in building is not new; it is traced back thousands of years. The performance concept is widely acclaimed and is applicable to both building procurement (design and construction) and to regulation (control), but has not been widely applied worldwide. This presentation provides a summary of the history of the performance concept in building, identification of some problems and limitations to its application and how the performance concept is dependent upon the more traditional prescriptive approach for practical application. It is suggested that, now is the time for rapid increases in application because numerous nations of the world are committing to applying the performance concept to building regulation which will permit and encourage application to innovative building design and construction.

1. INTRODUCTION

The performance concept has been a subject of discussion for all of our professional lives. For some here today, that is a short time; for others of us, a rather long time as measured by technological advances. Unfortunately, except for a few surges of activity, it has received much philosophical discussion but less application than deserved.

Perhaps in the future, now will be viewed as a watershed time in the development and application of the performance concept in building--a time when the world moved from philosophical discussion and limited experimental application to broader and broader usage in both procurement of buildings and in their regulation and control. The performance concept as applied to both regulation and procurement is synergistic. For the first time, we are seeing many countries accelerating on both fronts. It is fitting that this symposium is organized to share practical application of the concept based upon experience, case studies and significant recent accomplishments.

Today I will briefly review the history and give some observations which hopefully will provide useful background for the discussion during the next few days.

2. DEVELOPMENT OF THE CONCEPT

The emphasis on performance as applied to buildings is not new. The performance approach is a way of thinking and communicating about building problems and solutions from the viewpoint of the end result rather than the ways and means of building.

Most of you who have worked in this field are familiar with the code of Hammurabi. King Hammurabi of Babylonia who reigned from 1955 BC to 1913 BC is credited with the first recorded building regulation. Nevertheless, for the benefit of those who do not know of Hammurabi and to refresh the memory of the rest of us, let me relate. In the Louvre, in Paris, there is on display an obelisk which has inscribed upon it, a quote from Hammurabi that originated nearly 4,000 years ago. This is part of what he said about building construction.

Article 229: The builder has built a house for a man and his work is not strong and if the house he has built falls in and kills a householder, that builder shall be slain.

This is a performance statement. Indeed it is incomplete in that it addresses only one aspect of user requirements of the house, but it clearly addresses structural safety . It doesn't say anything about the ways and means of building, e.g., the thickness of the walls, the size and spacing of the structural members or the material of which they are made, but it clearly addresses the end result in terms of user requirements.

About 2000 years later, the Roman architect Marcus Vitruvius Pollio in his Ten Books on Architecture addressed how buildings should perform to meet user requirements in Book I, Chapter II, Fundamental Principles, and Chapter III, The Departments of Architecture. The following books provide detailed prescriptive descriptions on how to build to fulfill these needs.

While the concern with in-use performance is very old, it is in this century that formal performance concept methodology was developed and applied. There are specific records of recommendation for performance-based building codes in 1925, and development of performance standards in the 30's and 40's. The 1925 publication, Recommended Practice for Arrangement of Building Codes, [1] prepared by a committee of the National Bureau of Standards, the predecessor organization to NIST, explicitly states:

“Whenever possible, requirements should be stated in terms of performance, based upon test results for service conditions, rather than in dimensions, detailed methods, or specific materials. Otherwise new materials, or new assemblies of common materials, which would meet construction demands satisfactorily and economically, might be restricted from use, thus obstructing progress in the industry.”

Certainly this statement is as true today as it was 70 years ago. But only recently have many countries actively moved to develop and apply performance based building codes.

During the 1960's and early 70's, there were numerous worldwide activities to develop and apply the performance concept in building. Major research efforts were undertaken to understand and develop methodologies and tools for application. Major building programs for housing, educational facilities and office buildings were carried out under the performance vernacular with varying degrees of success. This flurry of activity and interest in many countries led to the joint efforts of RILEM-ASTM-CIB to cooperate in the first international symposium on the Performance Concept in Buildings held in Philadelphia in May 1972, nearly 25 years ago. The proceedings were published in two volumes.

Volume 1 contains 82 papers published prior to the symposium [2], and Volume 2 contains opening addresses, rapporteur reports and discussion during the symposium [3]. Many of the performance leaders of the time were present. Emphasis was on research, concept development and major building procurement programs. Little attention was given to standards development and regulatory application. These proceedings deserve attention today. Much of what was said then is still applicable and very helpful in the implementation of the performance concept.

In 1977, RILEM-ASTM-CIB cosponsored a specialty conference on the Evaluation of the Performance of External Vertical Surfaces of Buildings, i.e., walls and fenestration. Also over the years, the same three organizations along with some others have sponsored seven international conferences addressing the important performance attributes. “Durability of Building Materials and Components,” the last of the series, was held in Stockholm last May.

The second broad-based Performance Concept in Building conference sponsored by the three organizations was held in Lisbon, Portugal, in the spring of 1982. Three topics were selected to receive indepth treatment:

- (1) methods of deriving performance requirements and criteria;
- (2) methods of evaluating performance against criteria;
- (3) application of performance concept to rehabilitation.

The third topic was in recognition of an increasing worldwide concern for preservation, rehabilitation and reuse of the existing building stock. As was true in the first cooperative symposium, limited attention was given to regulations. The proceedings were published in two volumes [4] and [5].

Today we begin the third broad-based conference on Application of the Performance Concept in Building cosponsored by CIB, ASTM and RILEM. ISO has joined as a cosponsor. Emphasis is on practical application, innovation and regulation as applied to the building design and construction process.

3. APPLICATION BARRIERS

The discussion and conclusions from these symposia raise a rhetorical question: “If the performance concept is so widely embraced philosophically, if the approach is so widely accepted intellectually, if the principles are easy to understand, if the methodology removes barriers to innovation, if the performance concept can aid in the production of buildings that perform better at less total cost, why isn’t it universally applied? While each of these “if’s” can be answered in the affirmative, let me share some observations about limitations which support the view that the devil is in the details.

Definitions and Terminology

There are definitions and terminology applicable to the performance concept, given in the ISO performance standards in building [6][7] and the CIB publication, Working with the Performance Approach in Building [8] which still is one of the best publications on the subject. Never the less, these terminology and definitions are not widely accepted by those who are attempting to apply the concept. The performance concept itself means different things to different people. To some, it is a concept of qualitative aspirations for buildings without a systematic methodology for analysis and verification. For others, is a concept which requires quantitative analysis and rigorous evaluation that at times discourages those who wish to use the concept when these tools are not available.

Performance and Prescriptive Approaches

Some see the performance concept as opposed to or a nonrelated alternate approach to prescriptive standards, regulations and specifications. In the minds of some these two ideas are not meant to work together, when in fact, the prescriptive approach is complementary to but subordinate to the performance approach. In order to implement the performance concept, prescriptive descriptions are needed, both for programs of regulation and procurement. In applying the performance concept, prescriptive solutions are evaluated against performance requirements for compliance with user needs. In preconstruction applications, the solution, be it a building or a part thereof, must be expressed in prescriptive terms in order for evaluation and construction to take place. In postconstruction situations, the construction itself provides the prescriptive solution for evaluation.

Framework and Taxonomy

The performance concept is applied to both building procurement and building regulation. In the case of innovative building production (an initiative action), more economical and better performing buildings are expected due to the freedom encouraged in design and construction. In the case of regulation (a permissive action), such as building codes and other control methods, the performance concept is intended to permit innovative construction while still protecting the health, safety and general welfare of society.

It is widely agreed that in the development of performance documents to meet either or both procurement and regulatory needs, three essential aspects must be considered in writing performance statements.

(1) *User Requirement* is a qualitative statement giving the user need or expectation for the item being addressed. It is a subjective statement of what the product or assembly is intended to do. (Other terms used include user needs, goals, objectives, intent, function, principles.)

(2) *Performance Requirement* is a quantitative statement giving the level of performance required to meet the user needs or expectations for the item being addressed. (Other terms used include criterion and function.)

(3) *Evaluation Methods* set forth the tests or other information upon which judgment of compliance with the performance requirement is based. It identifies the standards, inspection methods, engineering analysis, calculations, review procedures, historical documentation, test methods (be they laboratory or field, full-scale or less than full-scale, destructive or nondestructive) used in evaluating whether or not the performance requirement has been satisfied. (Other terms used for evaluation include verification, compliance, conformance and tests.)

In addition, there are some useful components but not necessarily essential parts that aid in the implementation of the performance concept and include:

(1) *Commentary* provides background for the reader and presents the rationale behind the selection of specific user requirements , performance requirements, and the evaluation sections. The commentary is provided for informational purposes.

(2) *Deemed to Satisfy Documents* supply information on traditional solutions which are deemed to comply with the performance requirement. Deemed to satisfy documents are very helpful in implementing the performance concept, particularly in regulations when traditional solutions have been shown to satisfy the performance requirement and thus

should not be subjected to detailed repetitive evaluation and analysis. (Other terms used for these documents include Approved Documents, Codes of Practice, Manuals of Acceptable Practice and Prescriptive Codes.)

(3) *Quality Control Manuals* are documents that set forth quality control and quality assurance procedures for building products and construction practices. Laboratory accreditation and product certification programs may be included.

(4) *Post-occupancy Evaluation* outline procedures for evaluation of the actual performance of the building in use. Post-occupancy evaluation provides a means of assessing actual performance as compared to predicted performance and feedback for future work. Unfortunately such evaluation is seldom carried out unless performance problems have been identified. Otherwise, post occupancy evaluation is often considered a nonessential expenditure of resources, particularly when the evaluation does not directly benefit the building owner.

Confusion arises when writers of performance statements use different terms for the same meaning and when these essential parts and implementation aids are further broken down or combined in a variety of ways.

Knowledge Deficiencies

Unfortunately, in many cases, user needs or user requirements are not well understood. Different people have different requirements. Cultures, economic capabilities and expectations vary from country to country. The building industry worldwide has neglected human factors research which would assist in filling these gaps.

One of the most difficult technical problems in applying the performance concept has to do with the issue of performance over time. Traditional prescriptive solutions have implied acceptable performance, but the reliability and associated risk with innovation cannot draw upon history to assure performance over time. This matter is being addressed . In the work of CIB, RILEM and ISO, researchers from around the world are cooperating in an attempt to quantify and standardize performance of whole buildings and components.

Another problem relates to the lack of authoritative information on the economic benefit of innovation both as related to productivity in the workplace and the health and well being of building occupants. There is an increasing awareness, and efforts are under way to quantify these benefits, particularly as they relate to productivity in the workplace. Last month (November 1996), a high level conference, the National Summit on Building Performance, was held in Washington, D.C., to examine the influence of buildings and facilities on workplace productivity. Speakers included Dr. John Gibbons, Assistant to the President of the U.S. for Science and Technology, who said “better constructed and renovated facilities could improve employee productivity 30 percent by the year 2003.” Also, a keynote speaker was Lee Iacocca, who was CEO of the Chrysler Corporation when it invested \$1 billion to construct the most advanced automobile technology center in the world which led to major increases in worker productivity.

The report from this conference will be delivered to the U.S. Congress and widely circulated to the U.S. business community.

Need for Standards

Standards are needed to facilitate communication and application of the performance concept. We need performance standards and prescriptive standards. Performance test methods are most often expressed as prescriptive standards which simulate the environment in which the building component will be subjected. Evaluation test standards are most often a detailed prescription of the test method and the specimen to be tested. The detailed prescription is necessary in order to obtain precision and accuracy required for ready comparability and acceptance of the test results.

To aid innovators and evaluators alike there is need for standardization of the performance requirements for various systems, e.g., wall systems and components of buildings, in order to encourage innovation and to set forth evaluation guides. Such standards should be produced on an international basis to obtain consistent and comparable results.

Needs for Education

Except for conferences and symposia, insufficient attention is given to both formal and informal education of design professionals, manufacturers, standards writers, regulators and owners on the benefit and methods of application of the performance concept. Many educational institutions introduce students to the philosophy of the performance concept but provide little instruction in its application to real problems and real building solutions.

4. RECENT DEVELOPMENTS

Several recent developments have brought about increased activities in the application of the performance concept.

Construction Products Directive

The Construction Products Directive issued by the European Union in December 1988, explicitly calls for application of the performance concept in the development of European standards for all construction products that are intended to be permanent parts of buildings and civil engineering structures. The six essential performance requirements for construction products include (1) mechanical resistance and stability, (2) safety in case of fire, (3) health hygiene and the environment, (4) safety and use, (5) protection against noise, (6) energy economy and heat retention.

CIB TG 11 - Performance-Based Building Codes

Recently CIB, recognizing the need for work in the application of the performance concept to building regulations, formed Technical Group 11 (TG 11), to facilitate the exchange of knowledge and the development of recommendations to aid nations wishing to pursue this direction. TG 11 held its first meeting in 1994 and now has held 4 meetings, the latest in September 1996 in Ottawa, Canada. England and Wales implemented a performance-based building regulatory system in 1984 and since that time other nations including Sweden, New Zealand, Australia, and the Netherlands have implemented this approach with varying degrees of success. Canada has developments underway to implement the performance concept in the form of an Objective Based National Building Code in the year 2000. Japan too has a mandate to implement a performance based building regulatory system. In the U.S. the organizations which have promulgate three sets of regional model building codes

have joined to produce one set for the entire country. A study is underway to develop a performance-based set of model building codes for the country.

Standards Development

ISO TC 59, Building Construction, SC 3 on Functional-user Requirements on Performance in Building Construction, has several working groups developing performance standards. Particularly notable is the development of standards addressing design life of buildings, under Working Group 9. Working Group 10 was established this year to explicitly develop Performance Standards for One- and Two-Family Dwellings. Counterpart activities on dwellings have been established by Standards Australia and in the U.S. by ASTM Committee E-6 on Building Performance with a new subcommittee E6.66, Performance Standards for Dwellings. Also noteworthy is the establishment and work of Subcommittee 4 of ISO TC92, Fire Safety. Working Group 1 of Subcommittee 4 is explicitly devoted to the application of fire safety performance concepts to design objectives.

WFTAO Formation

Most if not all industrialized countries of the world have technical approval organizations for the performance evaluation of innovative building products. In most cases, these organizations evaluate nonstandard products, those for which there are no prescriptive standards or specifications. Since 1994, these organizations have met in an International Forum in Brazil, France and South Africa. This past September the World Federation of Technical Assessment Organizations was formed to foster information exchange, cooperation and eventually mutual recognition. We will learn more about this significant development under theme 3.

5. SUMMARY

Much progress has been made since the first joint conference in 1972. In the intervening time, there have been periods when the development of the performance concept and its application has not received much attention. Today we see a resurgence and much progress toward implementation, particularly in the building regulatory systems of the world. Lack of acceptance of the performance concept by the world's building regulatory interests has been a severe constraint to those wishing to apply the concept to the design and

construction of buildings. When designers and builders wish to take advantage of the concept in order to apply innovation, they are discouraged by a building regulatory systems which prohibit or at a minimum make it very difficult to apply. Today, we see this situation changing rapidly. The emphasis on the development of performance standards in national and international standards organizations also facilitate the application of the concept in both building production and regulation. It is recognized that test standards which simulate performance in a given environment are particularly important to permit regulatory application and to encourage trade even when the test values required in one part of the world are different than in another part of the world. Although progress is excellent, there remain many problems with the application of the performance concept. We look to this Symposium to shed light on many of these so that we might move into the next century with the performance concept better understood and more widely applied to the design, construction and regulation of buildings.

6. REFERENCES

- [1] "Recommended Practice for Arrangement of Building Codes," Bureau of Standards, U.S. Government Printing Office, July 1985.
- [2] "Performance Concept in Buildings," Vol. 1, Joint RILEM/ASTM/CIB Symposium Proceedings, NBS Special Publication 361, February 1972.
- [3] "Performance Concept in Buildings," Vol. 2, Joint RILEM/ASTM/CIB Symposium Proceedings, NBS Special Publication 361, February 1972.
- [4] "Performance Concept in Building," Vol. 1, Advances in the Development of the Concept and Its Application in Rehabilitation, Laboratorio Nacional de Engenharia Civil, Lisbon, Portugal, 1982.
- [5] "Performance Concept in Building," Vol. 2, Advances in the Development of the Concept and Its Application in Rehabilitation, Laboratorio Nacional de Engenharia Civil, Lisbon, Portugal, 1982.
- [6] "Performance Standards in Building - Contents and Presentation," ISO 6240.
- [7] "Performance Standards in Building - Principles for their Preparation and Factors to be Considered," ISO 6241.
- [8] "Working with the Performance Approach in Building," CIB Publication 64, January 1982.