PeBBu

Performance Based Building

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EC 5th Framework

PERFORMANCE BASED BUILDING THEMATIC NETWORK 2001-2005

PERFORMANCE BASED DESIGN: Bringing Vitruvius up to Date

A PeBBu Domain 3 Report

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PERFORMANCE BASED DESIGN:
Bringing Vitruvius up to date
PeBBu DOMAIN 3

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Performance Based Building Network (PeBBu) is a thematic network funded under the European Commission's (EU) 5th framework – Competitive and Sustainable Growth and has been operational from October 2001 till September 2005. This project has been managed by CIBdf, The Netherlands. The PeBBu Network has been facilitating in enhancing the existing performance based building research and activities by networking with the main European stakeholders and other international stakeholders. The network has also been producing synergistic results for dissemination and adaptation of performance based building and construction. More than 70 organisations worldwide have been participating in the PeBBu Network.

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FOREWORD

This report of PeBBu Domain 3 ‘Design of Buildings’ is one of the results of an exiting period of four year’s work, in which some 60 Domain Members from 19 different countries participated. During this period the concept of Performance Based Design (PBD) was investigated and elaborated. We became convinced that PBD is a very important concept for the future, as it is essentially a client oriented way of thinking and working. Clients and end users more and more take positions in the centre of building process. They demand value for money, buildings that optimally facilitate their needs and operations. PBD is aimed at understanding and satisfying the real client needs (‘answering the question behind the question’) and leaves the design process open for creative and innovative solutions. The performance-based approach makes ‘integral design’, with parallel, interrelated contributions from all design disciplines imperative. This constitutes a challenging perspective for all design professionals. Although PBD has been put to practice in many countries to some extend, design practitioners appear to be hardly aware of it and it’s potential impact on the design profession. With this report the Domain 3 Members intend to contribute to a clearer picture. This report is especially aimed at design professionals in Europe.

I would like to thank the Domain 3 Members for their valuable and inspiring input, Mansi Jasuja for her managerial support and patience, Wim Bakens for his initiative to start PeBBu in the first place, and the European Commission for enabling so many of us to participate in this important international network.

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EXECUTIVE SUMMARY

Performance-based Design can best be described as a building design that is based on a set of dedicated performance requirements related to the intended use of the building, and that can be evaluated on the basis of performance specifications. However, Domain 3 is not only about the result of a design process, but also and primarily with that process itself. In that context a Performance-based design process is defined as follows: "a Performance-based design process is a process in which performance requirements are translated and integrated into a building design."

Designers have to deal with systematic interrelations between different performance specifications, which often relate to different fields of expertise. The performance of a building or a building part is always the result of the interaction between different solutions for different subsystems, like the architectural system, the structural system, the climate system and so on. Thus, the performance-based approach calls for integral design, with parallel, interrelated contributions from all design disciplines involved.

The main objective of Domain 3 "Design of Buildings" was to investigate and clarify the concept of Performance-based Design (PBD) for both the European R&D community and design professionals. The main drivers for PBD are user requirements (users demand better performance of buildings-in-use) and legislation that is becoming more and more performance-based (solution independent). In the context of PBD, the 'translation' and management of user and stakeholder requirements into performance requirements and the prediction of the building's performance in use on the basis of a design are very important.. An inventory of the state of the art shows that PDB is mainly an issue in research and education as yet. Design professionals (architects and engineers) are generally not very aware of PBD. In this respect a distinction should be made between two different approaches to PDB:

- designers and engineers have to meet with performance based client briefs and building regulations;
- designers define their work in a functional design plus a set of performance criteria, rather than work out the design traditionally in technical drawings and specifications.

The first approach can be recognised in most building projects in countries that apply performance based building regulations, mostly countries in the northern part of Europe. Applicants for building permits have to prove that the designs comply with the regulations, so every design professional is involved in PDB to some extend, consciously or unconsciously. Performance based building regulations and codes often include performance requirements for safety (structural safety, fire safety, earth quake resistance and so on), health, serviceability, energy efficiency and environmental impact.
The second approach is closely related to performance based procurement. Up to now, this approach has only been put to practice on a relatively small scale, mainly in the same northern countries. Mostly government building agencies take the lead; they organize pilot projects and/or experiments to set an example for innovation of the building process. The general idea is that the 'demand side' of the building process defines a functional design and a set or performance requirements, allowing the supply side to choose the most suitable technical solutions matching these requirements, availability and cost. This second approach to PBD has hardly been put into practice in non governmental projects as yet. One of the barriers is that many clients do not seem to trust this kind of procurement, that they experience as rather abstract and intangible and therefore too unsure and risky.

In general engineers and technical designers are more used to working with performance requirements than architects. The main design areas where performance based design and procurement is applied, are service engineering (acoustics, lighting conditions, indoor climate, air quality, and so on), energy consumption and maintenance.

Too often stakeholder requirements are not met in the final product. There are various reasons for this: cutting costs in some phase of the project, inability to find suitable design solutions to fulfil the requirements, forgetting the original requirements, and so on. To avoid this, early and continuous verification and assessments of design results have to take place in the design process. Assessment methods may vary from simple measuring (e.g. the amount of net square meters offered) via standardized calculating (e.g. the strength and stability of building structures or the energy loss) to simulating certain aspects of the behaviour of the building in-use (e.g. daylight penetration in different seasons and under different weather conditions). In some EU member states national building regulations are more and more performance-based. Also European regulations, that have to be implemented in the national building regulations of all EU member states, are as a rule performance-based. Performance-based regulations often refer to national standards, where not only performance levels for building parts and properties, but also the corresponding assessment methods are defined.

Assessment methods in European and national standards are mostly aimed at the testing of actual buildings or building products. However, one of the main problems in PBD is how to predict the performance of a building on the basis of a design. For many quality aspects the 'total building performance' depends on a complex interaction of many influences. On the one hand there are no validated, standardized assessment methods available to predict the total building performance, but on the other hand this performance will determine the client's perception of the quality delivered to a great extend. The only way to do it is by simulation of the building behaviour, using integrated data models. All over the world institutes and universities are in the process of developing simulation applications to facilitate this, using modern information and communication technology (ICT).

CONTENTS

Introduction & Reading Instruction

CHAPTER 1

1 Introduction & Reading Instruction

This report is one of the results of Domain 3 'Design of Buildings' of the PeBBu programme and is especially aimed at design professionals. The report introduces the concept of Performance-Based Design, a new way of thinking and working in design that responds to the need to satisfy client and user requirements and the need to comply with building codes and regulations, that are more and more performances based. The report is an excerpt from the Domain 3 Final Report., that was finished in October 2005 and that is available on the PeBBu website www.pebbu.nl.

First, in chapter 2 the Performance-based approach and the concept of Performance-based Building (PBB) are explained.
After that, Performance-based Design (PBD) is explained and elaborated in detail in chapter 3.
The following chapter 4 describes the world wide State of the Art of PBD.
As this State of the Art review shows that design professionals are quite relactant towards PBD as yet, ten good reasons for adopting this concept are given in chapter 5

For those who want to know more about Performance-based Building and Performance-based Design after reading this report, a list of references is given in the final chapter.

Background Information Performance Based Building

CHAPTER 2

2 Background information Performance-Based Building

2.1 The Performance concept

After many discussions, the consensus within PeBBu is that the simplest, most useful and clearest definition is contained in CIB Report # 64 'Working with the Performance Approach in Building':

"The Performance Approach is the practice of thinking and working in terms of **ends** rather than **means**. It is concerned with what a building or a building product is required to do, and not with prescribing how it is to be constructed." (Gibson 1982)

Performance Based Building focuses on the target performance required for the business processes and the needs of the users. It is about the defining of the requirements and fitness for purpose of a building, constructed asset or facility, or a building product, or a service, right from the outset (Szigeti and Davis, 2005). This is as opposed to the more traditional, prescriptive approach, which is concerned with describing type and quality of materials, method of construction, workmanship, etc.

2.2 Key Characteristics of the Performance Concept

Two key characteristics of the Performance concept are:

1. the use of two languages, one for the demand for the performance and the other for the supply of the performance;
2. the need for validation and verification of results against performance targets.

(Szigeti and Davis, 2005).

Both characteristics can be explained by use of the 'Hamburger Model', first used in the Netherlands by Ghieling (1986). This model distinguishes a 'Functional Concept' on the demand side and 'Solution Concepts' on the supply side of e.g. a built facility.

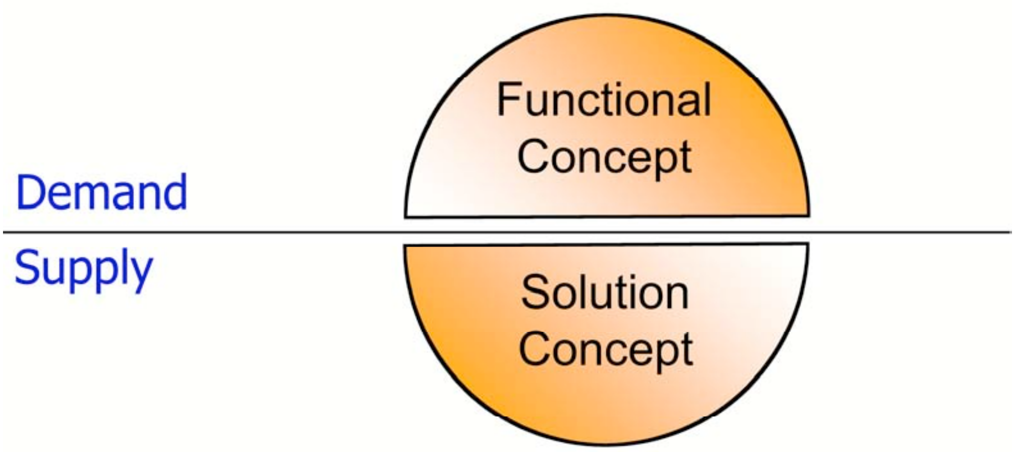
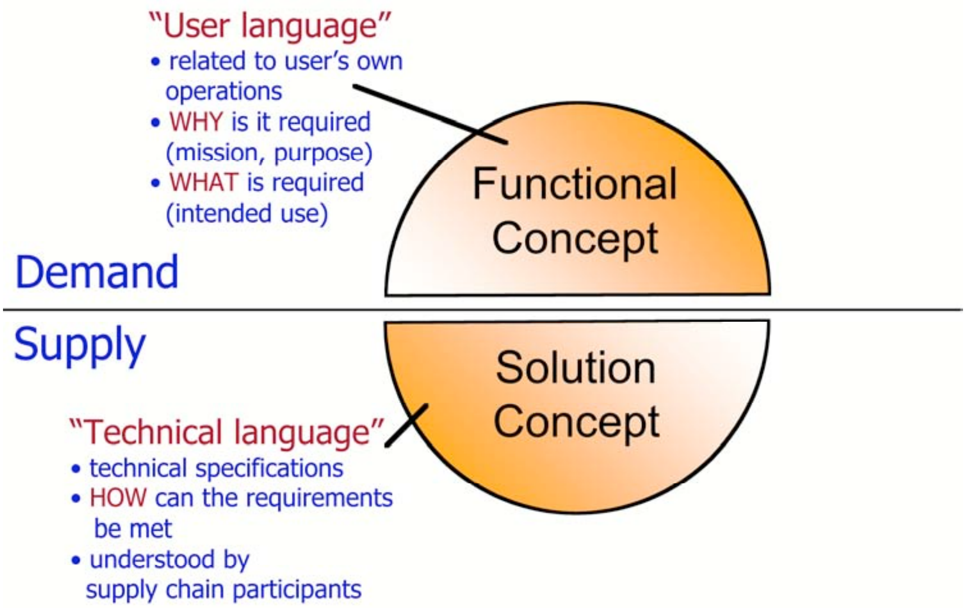


Figure 1: the 'Hamburger Model'

The Solution Concept has to comply with the Functional Concept, but a problem here is that the two concepts basically are expressed in two different languages, that make it difficult to match them.

The Functional Concept is primarily related to the intended use of the facility. It represents the users' functional needs and requirements, which derive from the users' own operations. In other words: the Functional Concept states in 'user language' WHAT is required and WHY it is required; it states what a facility should do for the users.

The Solution Concept states in terms of technical specifications HOW the requirements are supposed to be met.. This is done in 'technical language' that is understood by supply chain participants: the Solution Concept basically states how a facility could or should be constructed (Figure 2).



The Functional Concept and the Solution Concept represent two different viewpoints of the same facility. At the end of the day, clients and users need to be able to verify that what they get, at move in and over the life cycle of the facility, is what they asked for and paid for. Evaluations and reviews, as part of design, construction and commissioning, need to refer back to explicit statements of requirements, otherwise they are based on perceptions, intuitions and guess work (Szigeti and Davis, 2005). There is a need for making functional (user) needs and requirements more explicit and for linking those to the objectives for the project. Furthermore, there is a need for checking whether or not proposed solutions comply with the requirements. But, because of the different languages that are inherent to the different viewpoints mentioned above, this is quite a difficult thing to do

The Performance approach offers a solution here, using 'performance language' as an intermediate between functional needs and requirements and technical solutions. On the demand side functional needs are translated into performance requirements. These are facility or product related requirements, expressing what properties the built facility should have to facilitate the intended use. On the supply side the technical specifications are translated into performance specifications, expressing the measured or predicted properties of the offered solution. For this translation, validation and/or assessment methods and tools are needed. These may vary from simple measuring to (standardized) calculation methods en sophisticated IT-based simulation tools.

Once both the Functional and the Solution Concepts are translated into 'performance language', a sound comparison and matching between demand and supply are possible (Figure 3).

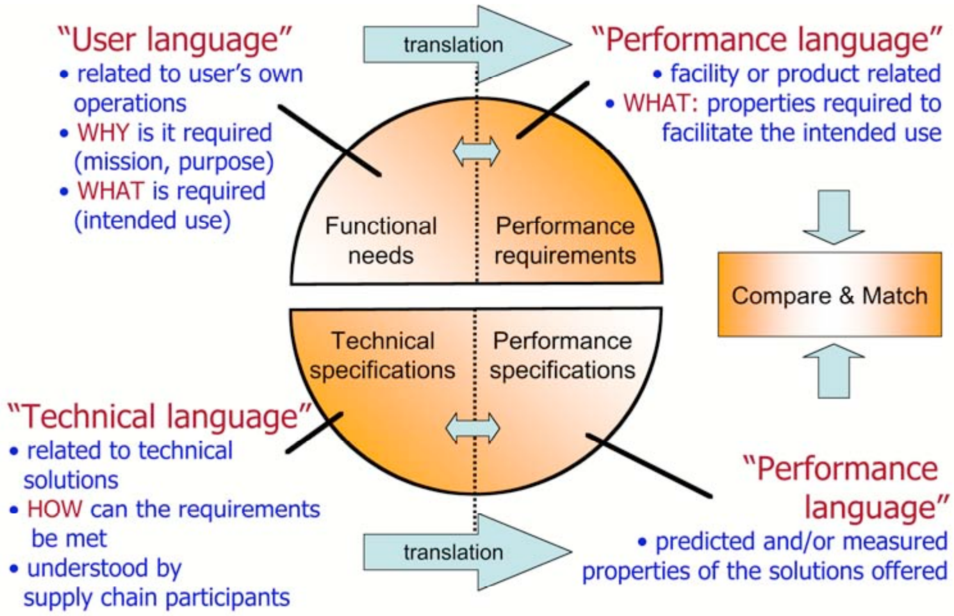


Figure 3: 'Performance language' as an in-between

2.3 The Performance concept is applicable on different levels

The performance concept as described in paragraph 2.2, is applicable on different levels of decomposition and aggregation of a built facility. This is shown in Figure 4. The need for a facility (Functional Concept on the facility level) expressed by the demand side, may provoke a Solution Concept on the whole building level by parties on the supply side. Once accepted, the Solution Concept for the building may be decomposed into building elements, for each of which functional needs and performance requirements can be formulated. The supply side may react to these 'Functional Concepts on building elements level' with Solution Concepts on the same level. Again these Solution concept may be further decomposed to next level, and so on.

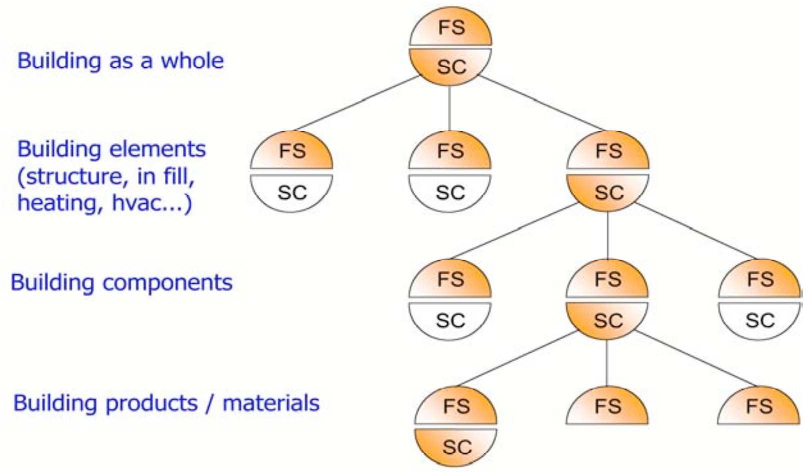


Figure 4: PBB applies to different levels of decomposition and/or aggregation of a built facility

2.4 It is not all one or the other

Using a Performance Based Approach does not exclude the use of prescriptive specifications. There is not yet very much experience with this approach in building. Therefore it is not likely that a facility will be planned, procured, delivered, maintained, renovated and used using solely Performance Based documents at each step of the way. Prescriptive specifications will probably still be applied when the use of such specifications is more effective, efficient, faster or less costly. They continue to be useful in many situations. Prescriptive codes, regulations and specifications are rooted in the experience of what has worked in the past – they are more or less the expression of the performance embedded in the chosen solution and of the knowledge and experience of those who use them. The down side of any prescriptive documents is that, unless they are regularly updated and take into account feedback from the field, they run the risk of codifying misunderstandings and mistakes, stifling change and innovation, freezing solutions and keeping the customer from benefiting form the knowledge of the provider.

Nevertheless, it is not either performance or prescription. Blending the two is often having best of both worlds (Szigeti and Davis, 2005).

2.5 Drivers for Performance Based Building

Why is Performance Based Building (PBB) important? The main drivers for PBB are performance requirements by clients and performance requirements in legislation.

Clients and users more and more demand value for money and expect the building industry to be customer focussed. There is an economic need for the industry to become more client oriented. In order to be able to meet the requirements of the clients, it is essential that:

a. the clients really know and understand what they require, why they require it and that they state their requirements clearly, explicitly and comprehensively;
b. building process participants understand what is required, can create optimal solutions that comply with these requirements and can prove compliance on beforehand.

Performance Based Building potentially provides for both the philosophy and the tools to accomplish this.

In the building and construction industry prescriptive codes, regulations, standards and specifications haven been perceived as getting in the way of innovation and creating technical restrictions to trade. These concerns have been the major drivers towards the use of a Performance Based Approach to codes, regulations and standards (Bergeron 2004, Ang at al, 2005, Meacham at al, 2005). In 1997 the World Trade Organization stated in Clause 2.8 of the Agreement on Technical Barriers on Trade that "… whenever appropriate, Members shall specify technical regulations based on product requirements in terms of performance rather than design or prescriptive characteristics." As a result e.g. in the US government, performance-based contracting is mandatory. In the European Union, European Directives that have to be implemented in the national legislation of the EU member states, are basically Performance Based. Very often these Directives refer to European standards, that are also basically Performance Based. In increasing number of EU member states, like the Netherlands and the Nordic countries, develop Performance Based Building Codes.

Explaining Performance Based Design

CHAPTER 3

3 Explaining Performance Based Design

3.1 Towards a definition

The CIB report 64 "Working with the Performance Approach in Building" (1982) contains the following overall definition of 'the Performance-based approach':

- *The Performance-based (PB) approach is the practice of thinking and working in terms of ends rather than means.*

Performance-based building, with which the PeBBu project is concerned, is the application of the Performance-based approach to building. This leads to the following definition:

- *The Performance-based building (PBB) approach is the practice of thinking and working in terms of ends rather than means, as applied to building and constructing.*

Performance-based building is concerned with orientating activities around the performance in-use of built environment products and services and extending this approach as far back along the supply chain as is appropriate. PBB is about what a building should do for the client, the users and other stakeholders. The building must facilitate the intended use. The design stage is very important in this context, because in this stage most decisions are made that will determine the performance of the building in-use. In order to be able to design a 'well performing building', that is a building that is well fit for the intended use, it is crucial for designers to understand what the user organisation wants to do in the building, what it's operations and processes are, or in other words: what the 'user requirements' are. But that is not enough. Designers also have to understand what properties the building should have to meet with the user requirements. When these required properties are expressed in solution independent, measurable terms, we talk about 'performance requirements'. This leads to the next definition:

- *Performance requirements in building express in measurable, solution independent terms the properties of a building, space or building part, that are required to facilitate the intended use.*

One user requirement may lead to several performance requirements. This is illustrated in table 1, where the organisations need to be able to have meetings with 25 people, is translated into performance requirements for the facility.

Table 1: One user requirement may lead to several performance requirements

User requirement	Performance requirements
Have meetings with max. 25 people in different settings (theater and round table)	– Required space: 3 m2 per person – Space shape: ratio length : width ≤ 1,5 : 1 – Ventilation: min. 30 m^3 fresh air per person and per hour – Air temperature: 19º C < t < 21º C – Back ground noise (due to external sources): max. 35 dB(A) – Reverberation time: 0,8 – 1,0 sec – Lighting level on desktop level: min. 500 lux

Table I also illustrates an important difference between user requirements and performance requirements. User requirements are in language that a user understands very well, because it tells something about how the user organisation wants to operate. In fact the user organization is the only participant in a building project that can formulate these kinds of user requirements. Performance requirements on the other hand, are in a language that does not mean anything to the average user. It is specialist language; the translation of user requirements into performance requirements is specialist work, that has to be done by e.g. architects and/or consulting engineers.

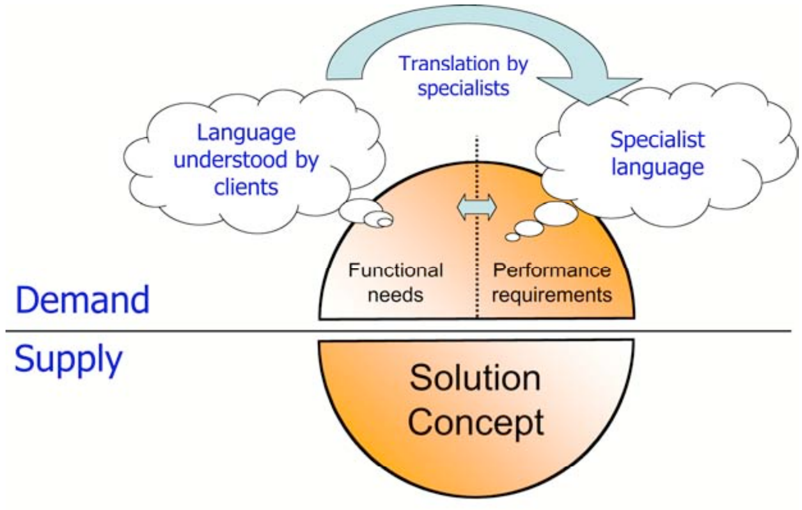


Figure 5: Formulating performance requirements is specialist work

Table I shows that performance requirements describe the required quality levels for different aspects of the building in-use, without suggesting any solutions. This leaves the design and engineering process open for creative, innovative solutions. To make sure that these solutions do meet with the performance requirements, they have to be assessed. This is done on the basis of 'performance indicators' (PI's) or performance specifications. These specifications can be deduced from the proposed design solutions (by measurement, calculation or simulation).

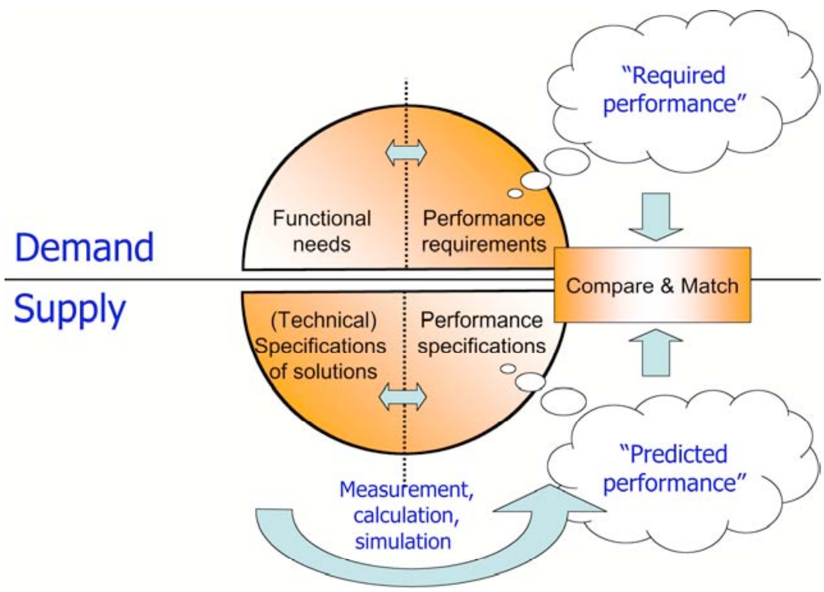


Figure 6: Translation of solutions into performance specifications by measuring, calculation and/or simulation

A distinction is made between 'performance requirements' and 'performance specifications':

- performance requirements represent the demand side: they describe the quality (performance in-use) that is required by stakeholders (owners, future users and others) and legislation;
- performance specifications represent the supply side: they specify the (expected) performance of specific design solutions and/or built assets.

Following these principles a Performance-based design (PBD) can be defined as follows:

- *A Performance-based design is a building design that is based on a set of dedicated performance requirements related to the intended use of the building, and that can be evaluated on the basis of performance specifications.*

However, Domain 3 'Design of Buildings' is not only about the result of a design process, but also and primarily about that process itself. A Performance-based design process can be defined as follows:

- *A Performance-based design process is a process in which performance requirements are translated and integrated into a building design.*

3.2 Performance-based Approach calls for Integral Design

Designers have to deal with systematic interrelations between different performance specifications, which often relate to different fields of expertise (as illustrated in table 1). Thus, the performance-based approach calls for integral design, with parallel, interrelated contributions from all design disciplines involved.

The performance of a building or a building part is always the result of the interaction between different solutions for different subsystems, like the architectural system, the structural system, the climate system and so on. This is depicted in figure 7.

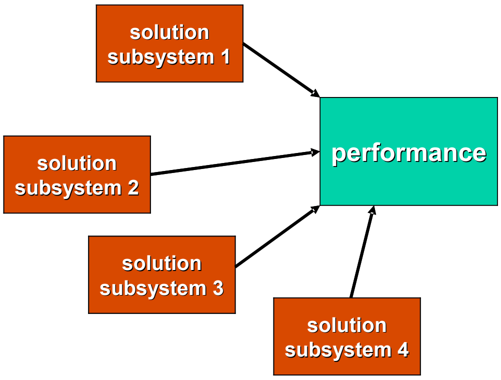


Figure 7: 'Performance' as the result of different solutions for different subsystems

In practice, the end user is not really interested in the performances of different subsystems; he experiences the performance of a built facility as a whole. The design disciplines will have to co-operate closely to create an integrated facility design. In some aspects also the expertise of the contractor and specialized subcontractors will be needed to get optimal performance (figure 8).

As the Performance-based approach is the practice of thinking and working in terms of ends rather than means, it provides for openness to the infill of the design process. It provides suppliers (both designers and contractors) with the opportunity to come up with creative solutions. Therefore, in principle all requirements should be performance-based and measurable. Requirements and solutions (prescriptive specifications) should be mixed up as little as possible, as solutions will essentially always be compromises.

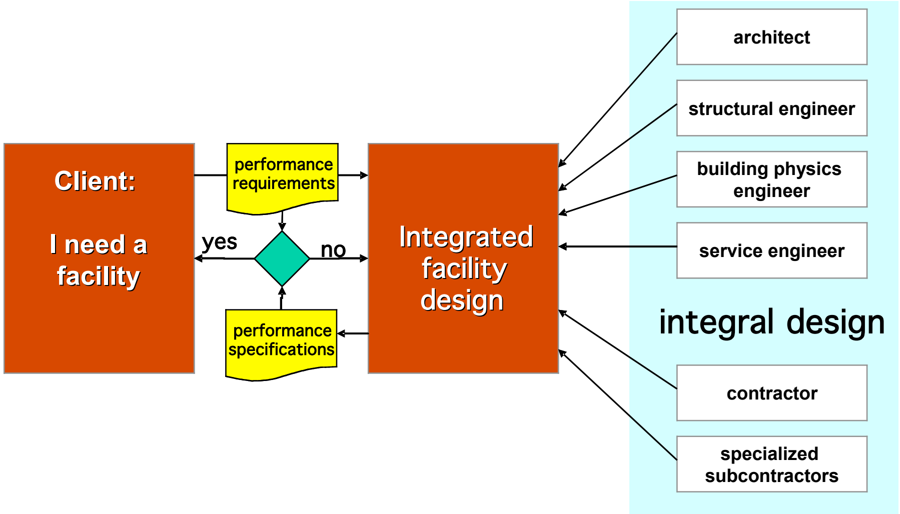


Figure 8: PBD calls for integral design

3.3 In practice it's not a 100% performance-based

However, some essential aspects of design, such as architectural and cultural value, cannot be expressed in 'hard' measurable performance requirements. Nevertheless these aspects may be quite an important component in a stakeholder's general appreciation of a built asset. This means that also in a performance-based design process, these aspects should be fully taken into account. Also a client should be free to choose a specific solution or product, if he really wants that. In other words: in practice it will be unwise to be too fundamental in following a performance-based design approach; a design process will always be hybrid to some extend. This is also (more or less) illustrated in a diagram by professor Graham Winch of UMIST (figures 9 to 11). Figure 9 represents the building process from inception to completion. In the beginning no information about the end result is available; there is much uncertainty about the end result. At completion all information is available and there is complete certainty about the end result. The dotted line represents the growth of the amount of information in an 'average' building process. In the area above the line there is uncertainty, in the area underneath there is certainty about the end result.

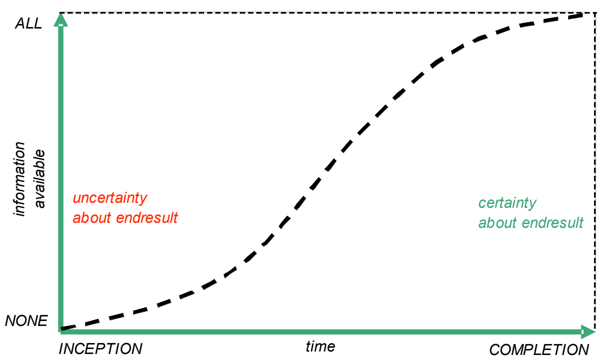


Figure 9: information development in the building process

On the one hand clients may gain earlier certainty by giving a brief in terms of prescriptive requirements (figure 10). On the other hand, by doing so, there is a fair chance that they 'jump to conclusions' too early and cut off unexpected and innovative solutions. They don't make optimum use of the creativity and expertise of the supply side.

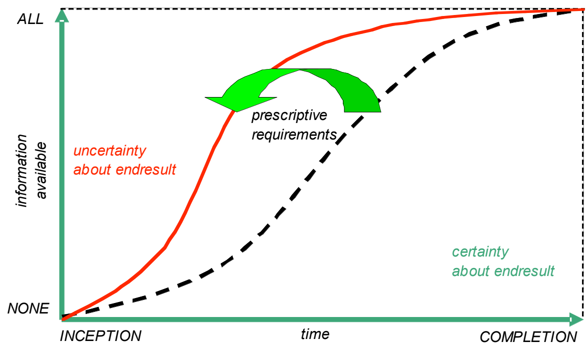


Figure 10: the effect of prescriptive requirements

By giving a performance based brief, clients may on the one hand postpone certainty about the end result it's true, but on the other hand keep the design process open for change and growing insight (figure 11). Performance specifications offer the opportunity to postpone the decision for detailed prescriptive specifications. They give clients the opportunity to 'grow' into the project, allowing them to think better about what their real needs ('the question behind the question') and allowing designers and suppliers to come up with the best solutions.

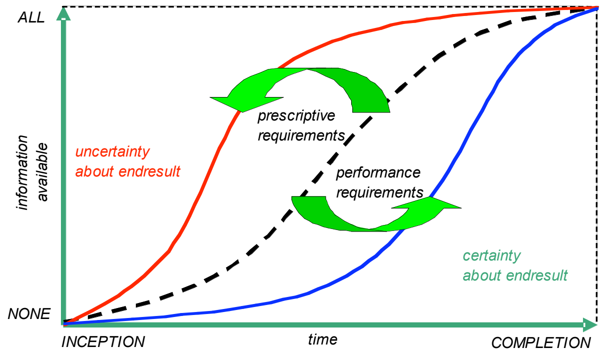


Figure 11 effect of performance requirements

At some time in a project performance requirements need to be translated into prescriptive solutions; on a project level you need both. For some aspects the translation may be done by the client or the architect, for other aspects it may be done by the one that is instructing the carpenter. This may differ per project or even per subsystem in a project. Moreover, PBD does not end with the completion of the building, as only in the in-use stage of a building it becomes apparent in how far the real client and user needs are fulfilled.

State of the Art of Performance Based Design

CHAPTER 4

4 State of the Art of Performance Based Design

4.1 Performance based Design in general

The inventory of the state of the art in Domain 3 shows that PDB is mainly an issue in research and education. Design professionals (architects and engineers) are generally not very aware of PBD. In this respect a distinction should be made between two different approaches to PDB:

1. designers and engineers have to meet with performance based client briefs and building regulations;
2. designers define their work in a functional design plus a set of performance criteria, rather than work out the design traditionally in technical drawings and specifications.

The first approach can be recognised in most building projects in countries that apply performance based building regulations. Applicants for building permits have to prove that the designs comply with the regulations, so every design professional is involved in PDB to some extend, consciously or unconsciously. Performance based building regulations and codes often include performance requirements for safety (structural safety, fire safety, earth quake resistance and so on), health, serviceability, energy efficiency and environmental impact.

The second approach is closely related to performance based procurement. Up to now, this approach has only been put into practice on a relatively small scale, mainly in the same northern countries. Mostly, government building agencies take the lead; they organize pilot projects and/or experiments to set an example for innovation of the building process. The general idea is that the 'demand side' of the building process defines a functional design and a set or performance requirements, allowing the supply side to choose the most suitable technical solutions matching these requirements, availability and cost. This second approach to PBD has hardly been put into practice in non governmental projects as yet. One of the barriers is that clients, apart from a few very professional clients, do not trust this kind of procurement, that they experience as rather abstract and intangible and therefore too unsure and risky. They often prefer to be able to control the whole design and building process. Another drawback is the reluctance or even the opposition of design professionals. Many of them consider PDB as a further degradation of their positions and interests in the building process. In general engineers and technical designers are more used to working with performance requirements than architects. The main design areas where performance based design and procurement is applied, are service engineering (acoustics, lighting conditions, indoor climate, air quality, and so on), energy consumption and maintenance.

4.2 Translation of client and user needs into assessable performance specifications

Interesting methods for the matching of user needs and performance requirements and/or specifications are found in e.g. the Netherlands, Canada and Finland. The Dutch Government Building Agency (GBA) e.g. is developing a computer aided interview technique for (future) users of office buildings. The questions that users have to answer, are formulated in 'user language'. To give an example: users are not asked what the air refreshment rate per hour should be in a certain area, but they are asked to give any reasons why the ventilation of a room should deviate from the standard value of 'good ventilation'. Dependent on the combination of answers that are given to predefined questions ('question tree'), the computer generates a set of specialist performance requirements. It is more or less an 'expert system', based on fifteen years of experience with the performance-based briefing and procurement and assessment of design solutions. Figure 12 shows the 'top of the question tree', where potential users are asked to indicate the relative importance of different performance or quality issues. In a brief a lot of performance requirements will be described. Some requirements are very general, while others are very detailed. Through this sheet future users are asked to indicate how important they consider different performance issues to be for their organization and processes. When "standard" is filled in, a standard performance level is sufficient and the system will automatically generate a corresponding set of performance requirements.

User needs	Importance		
Functionality	**Standard**	**Medium**	**High**
Space requirements building	○	○	●
Flexibility / adaptability building and building lay out	○	○	●
Relations / logistics	○	○	●
Communication and telematics	○	○	●
Comfort	**Standard**	**Medium**	**High**
Thermal comfort	○	●	○
Air quality	○	●	○
Acoustical comfort	○	●	○
Visual comfort	○	●	○
Hygiene	○	●	○
Security / Safety	**Standard**	**Medium**	**High**
Safety with calamaties	●	○	○
Occupants' safety	●	○	○
Social safety	●	○	○
Operational reliability	●	○	○
Anti burglary safety	●	○	○
Safety as regards to harmful influences	●	○	○
Architecture	**Standard**	**Medium**	**High**
Town planning	○	○	●
Architecture	○	○	●
Interior	○	○	●
Environment	**Standard**	**Medium**	**High**
Sustainability	○	○	●
Energy consumption	○	○	●
Materials	○	○	●
Waste	○	○	●
Soil pollution	○	○	●
Water consumption	○	○	●
Air pollution	○	○	●
Internal constraints	**Standard**	**Medium**	**High**
Investment costs	○	○	●
Operational costs	○	○	●
Planning / delivery time	○	○	●

Figure 12: sample sheet from a briefing system by
the Dutch Government Building Agency (in development)

When "medium" or "high" is filled in, extra attention must be paid to the subjects concerned. This is done in follow-up sheets. In this way, the performance-based brief is built up and detailed gradually, without bothering the user with difficult specialist 'performance language' too much.

In Canada, the International Centre for Facilities (ICF) developed the 'ST&M-approach' ('Serviceability Tools & Methods'). The method comprises a set of standard tools for measuring in broad terms what is needed and what is provided; it compares what functionality the occupant groups require and how well assets support those needs. Scales are used, giving a range of standard levels, so that stakeholders can choose how much of each topic is needed. For every topic there are two scales. The first is a functionality requirement scale giving levels of functionality from 0 to 9 (demand). The second is a serviceability scale for assets, also ranging from 0 to 9 (supply). Each couple of scales is calibrated. There are scales for some 200 topics. This is probably the most elaborated and easy to use example of how performance specifications (of design solutions offered) can be matched with user requirements (and the other way around). The ST&M approach was standardized by ASTM and in 1996 became a set of American National Standards and is presently an ISO Committee Draft as well (reference number: ISO/TC59/SC3N474).

The principle of the ST&M-method is shown in figure 13.

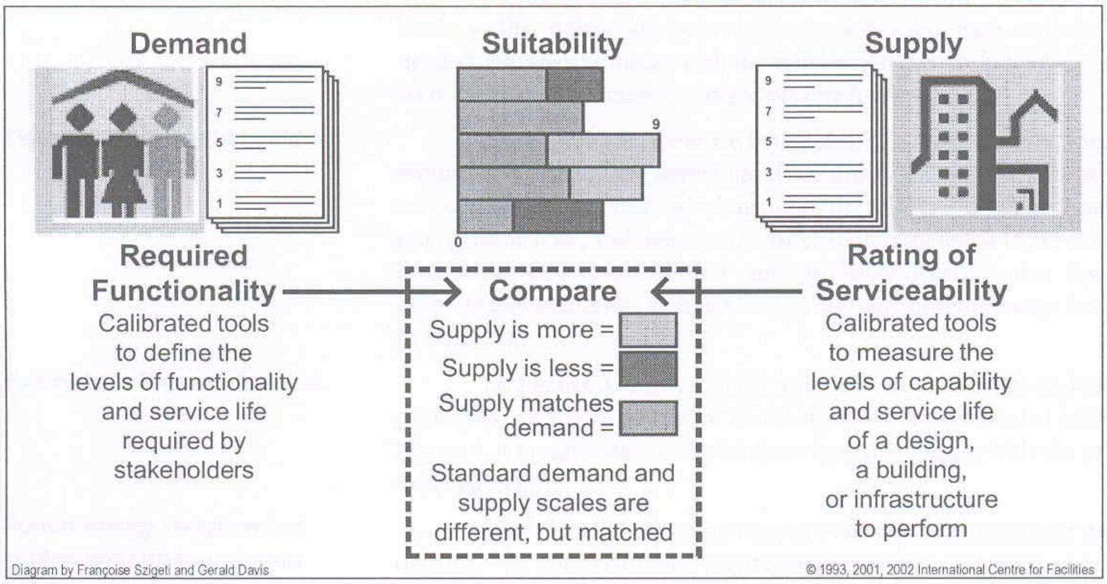


Figure 13: The core elements of the ST&M approach

In many countries client briefs are usually solution oriented. They often contain technical and space solutions, that belong to the domain of the building industry. These are hard for clients and end users to understand, because they are not involved in that domain. Research by VTT in Finland shows that performance based briefs turn out to be easier for the end users to understand, because they appeal more to the end users' own domains and processes. Moreover, performance based requirements in briefs give designers possibilities to fully exploit their knowledge accomplishing creative and flexible solutions.

Probably one of the best examples of the performance-based approach is represented by the 'European Concept for Accessibility' (European Center for Accessibility, 1996, website: www.eca.lu). The concept serves as a reference work for the harmonisation of the concept of accessibility in Europe and provides a basic foundation for a European standard of accessibility. With this in mind, the document can also be used as a reference for the development or revision of nationally oriented manuals and design directives. Therefore, the document is primarily intended for policy-makers and legislators and internationally and nationally oriented consumer organisations that wish to represent their interests in a European

perspective. The author is professor Maarten Wijk, architect/researcher from the Netherlands, with the support of some 40 experts in the field of accessibility from various European countries.
Usually, accessibility provisions in buildings are associated with disabled persons and are very often treated as add-ons to the 'normal' building (design). This often stigmatizes people with disabilities. Moreover, provisions are often aimed at certain categories of disabled (e.g. wheelchair users), not taking other categories into account. The 'European Concept for Accessibility' provides the principles and criteria for 'universal design'; it contains performance requirements to make the built environment accessible for all people in a natural and independent way, regardless of size, age, circumstances, abilities or disabilities. As such, the concept is fully performance-based[1].

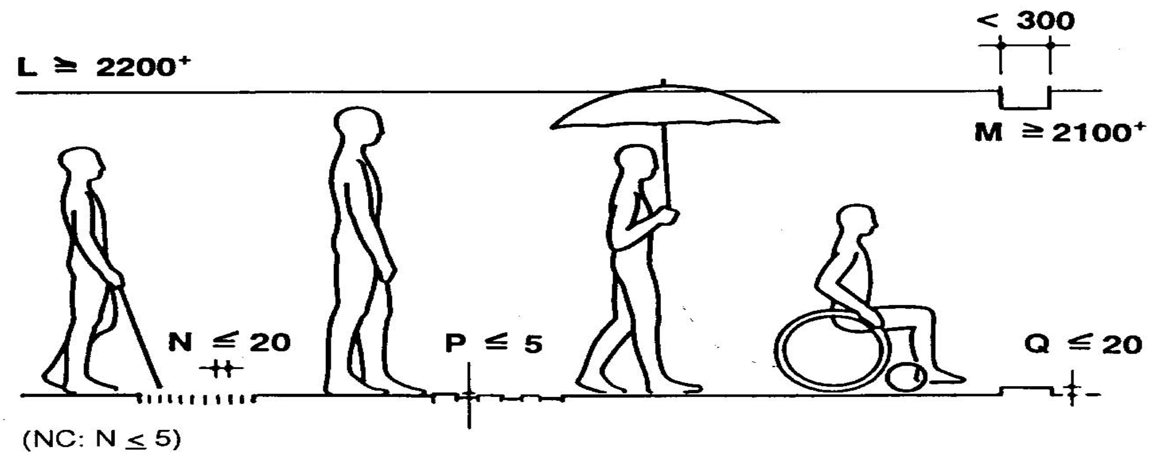


Figure 14: illustration of some performance requirements from the 'European Concept for Accessibility'

4.3 Classifications and formats for performance specifications

A survey of material from only a few countries already shows a wide variety of 'classifications' that are used for arranging performance specifications in briefing methods. Even on a national level (and sometimes even within one client organisation) we encounter several different classification methods.
Figure 15 shows the Finnish building property classification as used in the EcoProp system.

K CONFORMITY	A PERFORMANCE	B COST AND ENVIRONMENTAL PROPERTIES	C BUILDING PROCESS
K1 LOCATION K1 Site characteristics K2 Transportation K3 Services K4 Impact on immediate surroundings **K2 SPACES** **K3 SERVICES**	A1 INDOOR CONDITIONS A1.1 Indoor climate A1.2 Acoustics A1.3 Illumination **A2 SERVICE LIFE** A2.1 Service life A2.2 Deterioration risks	B1 LIFE CYCLE COSTS B1.1 Investment costs B1.2 Service costs B1.3 Maintenance costs B1.4 Disposal and value	**C1 Design** **C2 Site operations** **D OPERATION** **D1 Usability** **D2 Maintainablity**

[1] The 'European Concept for Accessibility' is presently being revised by another author. Unfortunately is lookes like if the performance-based approach is not maintained as consistently as in the 1996 edition.

K CONFORMITY	A PERFORMANCE	B COST AND ENVIRONMENTAL PROPERTIES	C BUILDING PROCESS
	A3 ADAPTABILITY A3.1 Adaptability in design and use A3.2 Space systems and pathways **A4 SAFETY** A4.1 Structural safety A4.2 Fire safety A4.3 Safety in use A4.4 Intrusion safety A4.5 Natural catastrophes **A5 COMFORT** **A6 ACCESSIBILITY** **A7 USABILITY**	**B2 ENVIRONMENTAL PRESSURE** B2.1 Land use B2.2 Embodied environmental pressure B2.3 Recycling B2.4 Environmental pressure from use of building B2.5 Environmental pressure because of users	

Figure 15: VTT EcoProp Building property classification

This resembles, but is not quite the same as the classification that is used in the Dutch publication 'The materials for the clients' brief', issued by the Dutch Building Research Institute (SBR), which is shown in figure 16.

Location	Performance	Building Identity	Internal Constraints	External Constraints
• Accessibility • Facilities and services • Social and cultural identity • Constraints	**USE** • Net floor space • Interrelations (between spaces) • Accessibility • Usability • Adaptability **INDOOR CONDITIONS** • Indoor climate • Air quality • Acoustical comfort • Vibrations • Visual comfort • Hygiene **SAFETY** • Safety in use • Safety in operation • Social safety • Resistance to natural catastrophes	**EXTERIOR** • Cultural value • Representativeness • Perception value **INTERIOR** • Cultural value • Representativeness • Perception value	**COSTS** • Investment costs • Operation costs • Maintenance costs **ENVIRONMENT** • Energy consumption • Water consumption • Materials consumption (natural resources) • Nature **SITE OPERATIONS** • Planning, date of delivery • Labour conditions	**LEGISLATION** • General legislation • Sectoral legislation • Local legislation **STAKEHOLDERS** • Stakeholder (management) **FINANCIAL** • Subsidies • Taxes • Insurance **TIME ASPECTS** • Terms for acquiring official permits • EC guidelines • Appeal procedures

Figure 16: classification used in SBR publication "The materials for the clients' brief"

There are more examples like this. A completely different classification is used in the Canadian ST&M approach, as shown in Figure 17, stemming from the ASTM Standard on Whole Building Functionality and Serviceability (second edition, Davis & Szigeti, 2000).

A. GROUP AND INDIVIDUAL EFFECTIVENESS

A.1 Support for Office Work (E 1660)
A.1.1 Photocopying and office printers
A.1.2 Training rooms, general
A.1.3 Training rooms for computer skills
A.1.4 Interview rooms
A.1.5 Storage and floor loading
A.1.6 Shipping and receiving

A.2 Meetings and Group Effectiveness (E1661)
A.2.1 Meeting and conference rooms
A.2.2 Informal meetings and interaction
A.2.3 Group layout and territory
A.2.4 Group workrooms

A.3 Sound and Visual Environment (E1662)
A.3.1 Privacy and speech intelligibility
A.3.2 Distraction and disturbance
A.3.3 Vibration
A.3.4 Lighting and glare
A.3.5 Adjustment of lighting by occupants
A.3.6 Distant and outside views

A.4 Thermal Environment and Indoor Air
A.4.1 Temperature and humidity
A.4.2 Indoor air quality
A.4.3 Ventilation air (supply)
A.4.4 Local adjustment by occupants
A.4.5 Ventilation with openable windows

A.5 Typical Office Information Technology (E1663)
A.5.1 Office computers and related equipment
A.5.2 Power at workplace
A.5.3 Building power
A.5.4 Telecommunications core
A.5.5 Cable plant
A.5.6 Cooling

A.6 Change and Churn by Occupants (E1692)
A.6.1 Disruption due to physical change
A.6.2 Illumination, HVAC and sprinklers
A.6.3 Minor changes to layout
A.6.4 Partition wall relocations
A.6.5 Lead time for facilities group

A.7 Layout and Building Features (E1664)
A.7.1 Influence of HVAC on layout
A.7.2 Influence of sound and visual features on layout
A.7.3 Influence of building loss features on space needs

A.8 Protection of Occupant Assets (E 1693)
A.8.1 Control of access from building public zone to occupant reception zone
A.8.2 Interior zones of security
A.8.3 Vaults and secure rooms
A.8.4 Security of cleaning service systems
A.8.5 Security of maintenance service systems
A.8.6 Security of renovations outside active hours
A.8.7 Systems for secure garbage
A.8.8 Security of key and card control systems

A.9 Facility Protection (E 1665)
A.9.1 Protection around building
A.9.2 Protection from unauthorized access to site and parking
A.9.3 Protective surveillance of site
A.9.4 Perimeter of building
A.9.5 Public zone of building
A.9.6 Facility protection services

A.10 Work Outside Normal Hours or Conditions (E 1666)
A.10.1 Operation outside normal hours
A.10.2 Support after-hours
A.10.3 Temporary loss of external services
A.10.4 Continuity of work (during breakdowns)

A.11 Image to Public and Occupants (E 1667)
A.11.1 Exterior appearance
A.11.2 Public lobby of building
A.11.3 Public spaces within building
A.11.4 Appearance and spaciousness of office spaces
A.11.5 Finishes and materials in office spaces
A.11.6 Identity outside building
A.11.7 Neighborhood and site
A.11.8 Historic significance

A.12 Amenities to Attract and Retain Staff (E 1668)
A.12.1 Food
A.12.2 Shops
A.12.3 Day care
A.12.4 Exercise room
A.12.5 Bicycle racks for staff
A.12.6 Seating away from work areas

A.13 Special Facilities and Technologies (E 1694)
A.13.1 Group or shared conference centre
A.13.2 Video teleconference facilities
A.13.3 Simultaneous translation
A.13.4 Satellite and microwave links
A.13.5 Mainframe computer centre
A.13.6 Telecommunications centre

A.14 Location, Access and Wayfinding (E 1669)
A.14.1 Public transportation (urban sites)
A.14.2 Staff visits to other offices
A.14.3 Vehicular entry and parking
A.14.4 Wayfinding to building and lobby
A.14.5 Capacity of internal movement systems
A.14.6 Public circulation and wayfinding in building

B. THE PROPERTY AND ITS MANAGEMENT

B.1 Structure, Envelope and Grounds (E 1700)
B.1.1 Typical office floors
B.1.2 External walls and projections
B.1.3 External windows and doors
B.1.4 Roof
B.1.5 Basement
B.1.6 Grounds

B.2 Manageability (E 1701)
B.2.1 Reliability of external supply
B.2.2 Anticipated remaining service life
B.2.3 Ease of operation
B.2.4 Ease of maintenance
B.2.5 Ease of cleaning
B.2.6 Janitors' facilities
B.2.7 Energy consumption
B.2.8 Energy management and controls

B.3 Management of Operations and Maintenance (E 1670)
B.3.1 Strategy and program for operations and maintenance
B.3.2 Competences of in-house staff
B.3.3 Occupant satisfaction
B.3.4 Information on unit costs and consumption

B.4 Cleanliness (E 1671)
B.4.1 Exterior and public areas
B.4.2 Office areas (interior)
B.4.3 Toilets and washrooms
B.4.4 Special cleaning
B.4.5 Waste disposal for building

Figure 17: Topics of the Serviceablity Scales (ST&M approach, ICF, Canada)

4.4 The management of client and user involvement throughout the design process

As this is quite a new topic, there is little information available about the state of the art in this field. The best examples probably come from project developers who open project websites, which allow future users to follow the development process online. Some developers offer future users the opportunity to give input and choose from options during the development process by means of these project websites. These project developers experience that, when they offer these opportunities (and end users more and more will demand them), they have to make the processes very transparent. Not only for the clients, but certainly also for themselves and their project partners. It has to be very clear for all parties involved until which moments which decisions (e.g. of end users) may be postponed, in order to prevent frustration of the process and extra costs. Several market parties in Western European countries struggle with this. In general we may conclude that the building industry is not a very user oriented industry as yet.

In several countries we see large scale programmes aimed at structural changes in the building industry. Examples are ‘Rethinking Construction’ in the UK, ‘Process and Systems Innovation in the Building Sector’ (PSIB) in the Netherlands, the ‘SARA’ programme in Finland and ‘Project Hus’ in Denmark. One of the common goals of these programmes is to change construction into a more consumer oriented industry, where incentives for change and innovation should come from clients. Further development of the performance concept can strongly contribute to that goal, as this concept is user oriented by nature. The management of user involvement throughout the process is one of the aspects that needs to be developed further.

Already in 1992 the Dutch Building Research Institute (SBR) issued a report about a new system of briefing that allows clients to develop the brief in interaction with the design. This should be done in a controlled process, in which briefing and designing are, though parallel, separate processes. According to this system, after each formally concluded design stage the brief should be updated and further completed with the information that is necessary for decision making in the next design stage. This process is depicted in figure 18 (‘ass.’ means assessment).

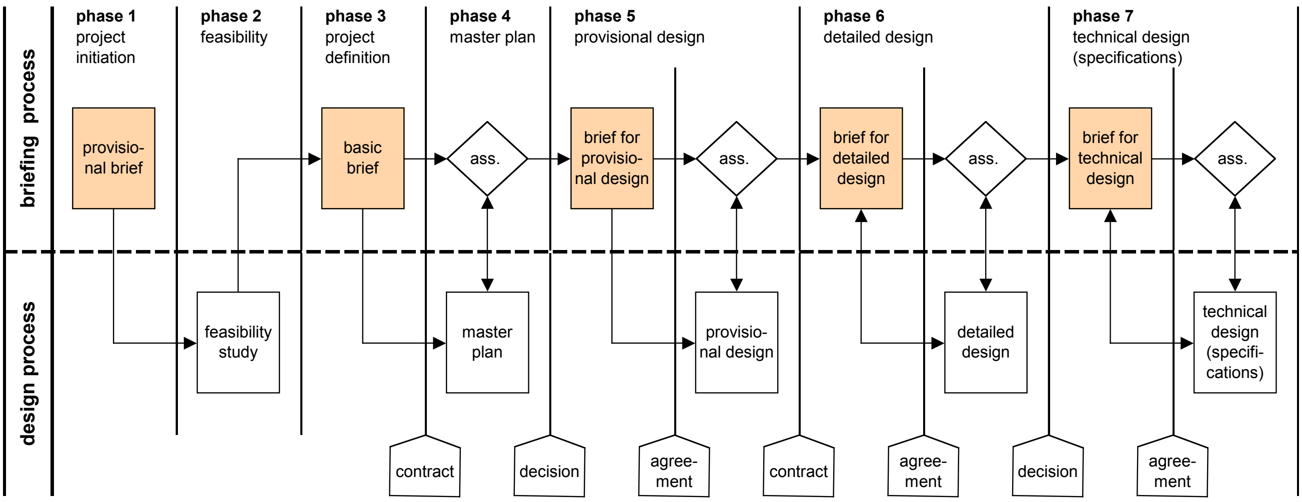


Figure 18: overlapping of the briefing process and the design process (source: SBR publication nr. 258, Rotterdam, 1992)

This principle is taken over by the Royal Institute of Dutch Architects (BNA) and the Dutch Association of consulting Engineers (ONRI), who will issue a common ‘Standard Task Description’ (STD) for designing buildings in 2004. This STD is basically a breakdown of the design process into interrelated tasks per phase for all disciplines involved (commissioning, architecture, building physics, interior design, structural engineering, service engineering, landscape design, projectmanagement). In this system, that will be the basis in the Netherlands for contracts between clients on the one side and architects and consulting engineers on the other, each new design phase starts with an evaluation, update and further elaboration of the brief.

In the **UK** Barrett and Stanley also make a plea for empowering the client and developing the brief in interaction with the design in their book "Better Construction Briefing" (2001). Based on research findings, the authors present a briefing method that – among other issues – include these two starting points. It is the result of a three years' research project that started in 1997. The method was tested in several pilot projects. Best practices and recommendations deriving from these pilot project, are described in the book. The authors conclude that the briefing method may improve the clients' position and the process and product quality considerably, but that it will be a hard job making it common practice.

4.5 Assessment methods for design results

Too often also important basic (performance-based) requirements are not met in the final product. There are various reasons for this, e.g. cutting costs in some phase of the project, inability to find suitable design solutions to fulfil the requirements, 'forgetting' the original requirements due to several translations and modifications in the course of the design process ('growing insight' that obscures the original objectives and demands), and so on. To avoid this, an early and continuous verification has to take place in the design process (Ang et. al, 1999, Becker 1999). The user has to be sure that the desired performance targets will be fulfilled. And if this is not possible, the user has to know this on beforehand. This is already shown in figure 18, but also in figure 19 (Wyatt and Ang, CIB 2000).

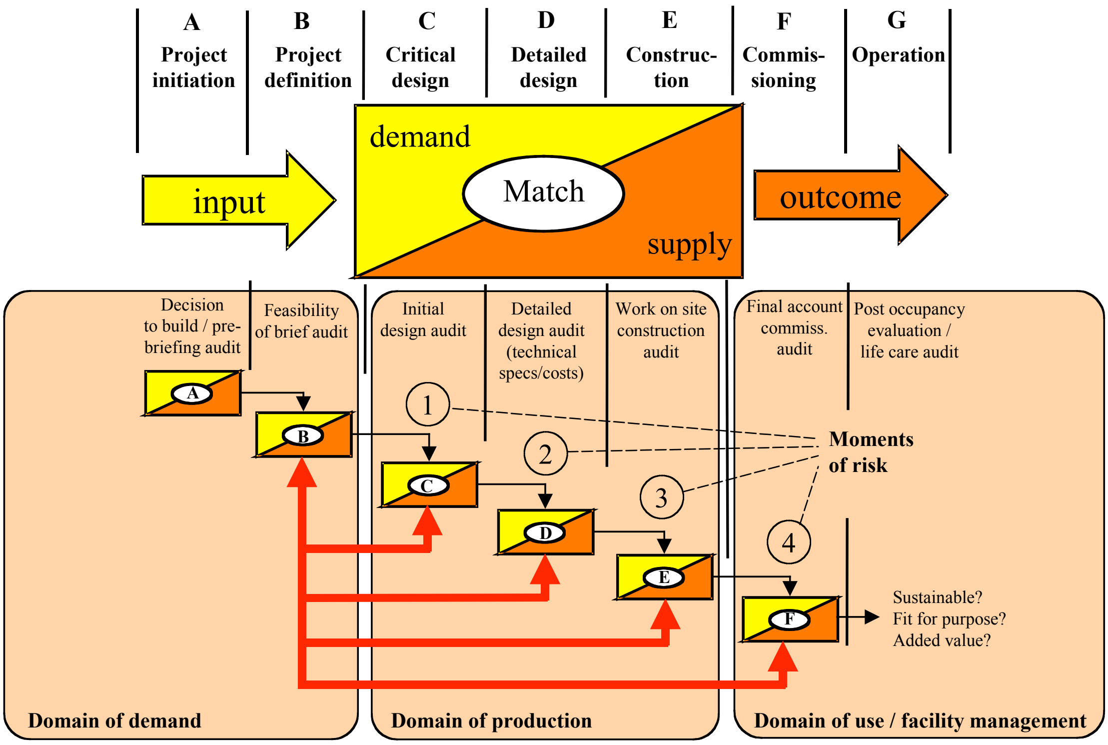


Figure 19: Project assessment loop in the case of performance based procurement (Wyatt and Ang, CIB 2000)

The diagram in figure 19 was developed in the context of performance-based procurement and is based on the experience of the Dutch Government Building Agency with this type of procurement [2]. This experience taught that – from the client's point of view – there is too much risk for non-conformity when interim results of the design & build process are not assessed properly, also (or rather: especially) after signing the contract with a project supplier.

Assessment methods may vary from simple measuring (e.g. the amount of net square meters offered) via standardized calculating (e.g. the strength and stability of building structures or the energy loss) to simulating certain aspects of the behaviour of the building in-use (e.g. daylight penetration in different seasons and under different weather conditions). In some EU member states national building regulations are more and more performance-based. One of the examples is the Dutch National Building Decree, laying out the technical requirements for all building works, which is completely performance-based. The Dutch National Building Decree often refers to national standards, where not only performance levels for building parts and properties but also the corresponding assessment methods are defined. This often concerns the 'hard', elemental properties and performances of building parts and certain aspects of the total building performance. Aspects for which standardized calculation methods are available.

Also European regulations, that have to be implemented in the national building regulations of all EU member states, are as a rule performance-based. Very well known of course is the Construction Products Directive (CPD). European building regulations as a rule refer to European standards, in which both performance levels and assessment methods are defined.

A recent overview of the State of the Art of the assessment of building performance is given in the book "Assessing Building Performance" edited by Wolfgang F.E. Preiser and Jacqueline C. Vischer (2005).

Assessment methods in European and national standard are mostly aimed at the testing of actual buildings or building products. However, one of the main problems in performance-based design is how to predict the performance of a building on the basis of a design. For many quality aspects the 'total building performance' depends on a complex interaction of many influences. On the one hand there are no validated, standardized assessment methods available to predict the total building performance, but on the other hand this performance will determine the client's perception of the quality delivered to a great extend. The only way to do it is by simulation of the building behaviour, using integrated data models. All over the world institutes and universities are in the process of developing simulation applications to facilitate this. An example of such a development is the <Virtual Environment>. The <Virtual Environment> software uses one integrated data model to carry out a range of analyses, which includes energy performance, value engineering, life cycle analysis, thermal analysis, cost planning, airflow analysis, lighting and occupant safety. The software system is capable of assessing many aspects of building performance, allowing the design team to 'test drive' the building. It is developed by Integrated Environmental Solutions Ltd (IES). IES specialises in advanced computer technology to assist with the design and operation of buildings. Established in 1994 in UK, it is a rapidly expanding company that offers an integrated software system known as the <Virtual Environment>. It consists of a range of software products that enable architects, consulting engineers and developers to evaluate the performance of a building at any stage during the design process. With this software it is possible to evaluate performance of a building throughout the design process:

- Predict comfort conditions
- Examine the visual impact
- Satisfy safety standards
- Design services quickly and accurately
- Optimise energy efficiency

[2] 'Performance-based procurement' is defined here as procurement on the bases of a performance-based brief (e.g. Design & Build) or on the basis of a functional and aesthetic design plus a set of performance requirements. In principle the procurement can take place after the stages B, C or D in diagram 11.

- Control cost

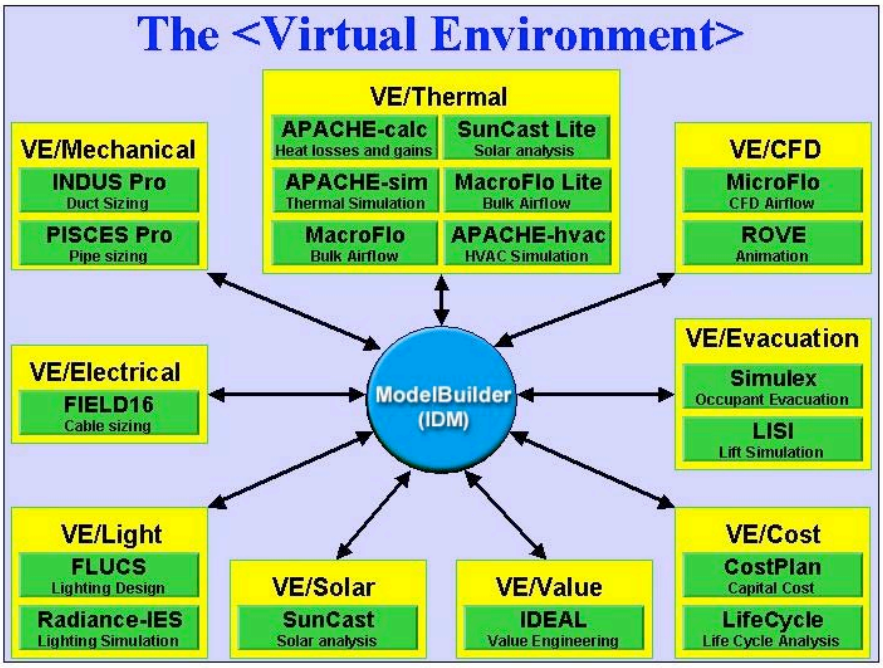


Figure 20: a summary of the products within <Virtual Environment>

The IES <Virtual Environment> consists of integrated software in ten product groups as follows (figure 20):

- VE/ModelBuilder: software capable of creating and modifying the Integrated Data Model from initial concept or by using CAD data.
- VE/Thermal: software for the thermal analysis of a building from heat loss and gains, to thermal simulation and HVAC plant and controls.
- VE/Solar: software to investigate solar shading and insolation as produced by the building and site obstructions.
- VE/Light: software to simulate and design natural and electric lighting systems.
- VE/Value: software to enable Value Engineering analyses to be performed at any stage of the building life cycle/design process.
- VE/Cost: software to perform capital cost and life cycle cost analysis.
- VE/Mechanical: duct and pipe sizing and drafting software.
- VE/Electrical: electrical cable sizing software.
- VE/Evacuation: occupant evacuation and lift simulation software.
- VE/CFD: software to simulate 3D internal and external air flow using computational fluid dynamics techniques.

The <Virtual Environment> software is built around the concept of a single Integrated Data Model (figure 21). Most of the applications use the single building model as much as possible. More information can be found at following website: http://www.ies4d.com/

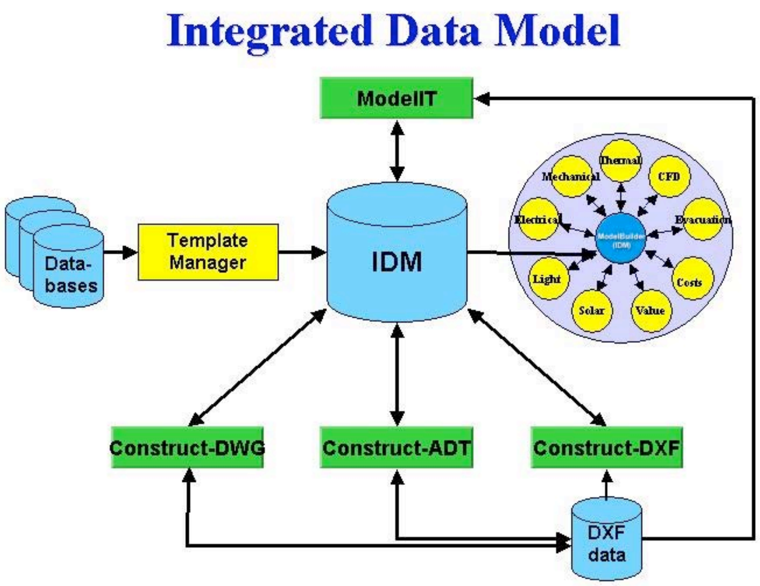


Figure 21: representation of <Virtual Environment> software built around Integrated Data Model

This is just an example; more software companies like IES develop integrated software products similar to <Virtual Environment> or have those products already available. The technology is available, the IES software proves that adequately. The problem is that all these integrated software systems are so called 'closed systems'. As a rule it is not possible to exchange data between different systems.
That means that it will only work, when all participants in a design project use applications of the same integrated software system. In practice however, the participants in a project use different software applications stemming from different sources. Often an important part of their internal operations is based

on the software they use. Most project participants will not be ready to invest in an expensive, integrated software system (and as a consequence in training and their internal operations also) on a project level only. After all they can never be sure that they will be able to use it again in the next project, where a different coalition of participants with yet different software systems will be active….

The reason why it is often impossible to exchange digital information between different software systems is that the developers use different definitions for the same 'objects'. As a consequence a door that is defined with certain properties in one application, is not recognized as that door with those properties by another application from a different software house (and the other way around). In several countries organizations have emerged that strive to develop system independent 'object libraries'. An object library is a collection of standardized definitions of building objects and their possible properties. When these system independent libraries are consistently applied in different software systems, it will be possible to exchange digital information between those systems. In other words: object libraries will enable all participants in the building industry to speak a common (digital) language. Examples of object libraries for the building industry are the STABU LexiCon (www.stabu-lexicon.com) and the Industrial Foundation Classes (IFC's) of the International Alliance for Interoperability (IAI) (www.iai-international.org or www.iai-na.org). These are examples of 'standards for interoperability', that definitely need to be developed further and deserve wide support.

The STABU foundation is the Dutch organisation that developed, maintains and exploits the national system of standardized project specifications. All partners in the building industry are represented in the foundation board and the whole Dutch building industry supporting this national standardisation activity.

The IAI is a global standards-setting organization representing widely diverse constituencies—from architects and engineers, to research scientists, to commercial building owners and contractors, to government officials and academia, to facility managers, and to software companies and building product manufacturers. Alliance members are committed to promoting effective means of exchanging information among all software platforms and applications serving the AEC+FM community by adopting a single Building Information Model (BIM). This mission is accomplished by defining, promoting and publishing specifications for Industry Foundation Classes (IFC) as BIM and as a basis for AEC project information sharing through the project life cycle, globally, across disciplines and technical applications.

Most of the organizations that are involved in the development of object libraries, including STABU and IAI, cooperate under the banner of ISO and also within the recently established International Framework for Dictionaries (IFD: www.ifd-international.org). A first result of that is the draft international standard ISO-DIS12006-3, which contains a 'meta data model' for object libraries. This is an indirect, but important and necessary step towards the development of comprehensive, advanced and internationally accepted and applicable simulation software for the assessment of building performance.

Ten reasons for Performance Based Design

CHAPTER 5

5 Ten reasons for Performance Based Design

5.1 Introduction

Performance-based design is not a goal in itself. It is a means to reach 'higher' goals. The Performance-based approach requires a different attitude, a different way of thinking about designing buildings than in the traditional design process. Implementing the Performance-based approach in the design process means a change of culture. Experience teaches that cultural changes do not occur overnight; it takes a lot of effort and a lot of time. Much active and/or passive resistance of professionals in the trade has to be overcome.

So why do we do it? Why is Performance-based design better than traditional design; what are the 'higher' goals? Why should design professionals be convinced that the performance-based approach is important and a worthwhile cause to put effort in?

5.2 Ten reasons for Performance-based design (PBD)

1. PBD provides for a more client oriented way of thinking and working in the design process.
2. Performance-based thinking helps clients and designers to gain better knowledge about how a building operates or should operate.
3. PBD leads to cost effectiveness, better quality and better client and user satisfaction.
4. European and national building regulations are more and more performance-based.
5. PBD prevents designers from tumbling into solutions from the very beginning without proper understanding of the real client and user needs.
6. PBD provides architects with the tools to be the integrator in the design process again.
7. PBD offers better conditions for creativity and for generating added value.
8. PBD offers the opportunity to make better use of knowledge and expertise of contractors and suppliers, allowing them to come up with innovative, cost effective solutions.
9. PBD helps to fill in the building industry's responsibility for the environment.
10. PBD is common practice to some extend already.

These reasons are elaborated into more detail as follows.

1. *PBD provides for a more client oriented way of thinking and working in the design process.*
   'The' end user becomes more and more important and he demands quality from his own perspective. During the last few years it has become more and more clear that it is an economic necessity for the building industry as a whole to pay more attention to meeting with user requirements. The performance-based approach is basically a client orientated way of thinking and working, especially in the design process.

2. *Performance-based thinking helps clients and designers to gain better knowledge about how a building operates or should operate.*
   As already was stated in chapter 2, performance-based building primarily has to do with what a building should do for the owners and users (and other stakeholders), rather than with how it should be constructed. This enhances the awareness of how a building-in-use operates or should operate.

3. *PBD leads to cost effectiveness, better quality and better client and user satisfaction.*
   Quality, in client oriented way of working, can be defined as the extend to which a product or service meets with the client's and end users' needs, wishes and expectations. Performance requirements intend to express clients' and users' needs explicitly. A performance-based approach in design offers better conditions for meeting with those needs and – as a result - for better quality and better client and user satisfaction.

4. *European and national building regulations are more and more performance-based.*
   European and national building codes will be more and more performance-oriented (as opposed to prescriptive codes), allowing designers to come up with multiple solutions. Already the European Building Products Directive, that must be implemented in the national building codes of all EU member states, is completely performance-based. Designers will have to prove that their design solutions meet with the legislative requirements. Therefore it is imperative that design professionals adopt the performance-based way of thinking and working.

5. *PBD prevents designers from tumbling into solutions from the very beginning without proper understanding of the real client and user needs.*
   In practice designers often start to develop solutions immediately, without proper understanding of the real questions ('what should the building do for the owner and users?').
   Also owner and user requirements in briefs often seem to be recipes for solutions, rather than descriptions of the performance of the building in-use. This may obscure the real needs behind the owner and user requirements. Moreover it may rule out unexpected creative, innovative and/or cost effective solutions on beforehand. PBD stimulates thinking about 'the question behind the question' before jumping to conclusions.

6. *PBD provides architects with the tools to be the integrator in the design process.*
   Vitruvius already stated ten centuries ago, that architecture is the fusion of functionality, solidity and beauty. With this definition, Vitruvius made a strong plea for integral design. PBD is also all about integral design. Someone has to do the integration of contributions of all parties involved and the architect is best positioned for that. In many countries the architect lost his integrating role in the building process, because he was not able to cope with all the technical systems. The PBD concept provides him with the tools to be the integrator again. Thus, PBD may give the architect back his lost position.
   It has to be taken into account though that there are different legal traditions in the European countries, leading to different positions for architects and different approaches as to who is the integrator. E.g. in Spain, Germany and Belgium architects have a strong legal responsibility for the building design. The building process in the UK is more and more moving towards Design & Build, which causes a shift in the responsibilities of parties involved. In Slovakia a main engineer is appointed for each project (not the architect). Nevertheless, under all circumstances there has to be someone who is responsible for combining all specialist contributions in a design process into one, comprehensive and integrated design. That is essentially the architect's job, irrespective of his legal position. **It's like bringing Vitruvius up to date in a modern setting.**

7. *PBD offers better conditions for creativity and for generating added value*
   As performance-based building codes and requirements allow designers, to come up with a variety of solutions, the performance-based approach will enhance creativity and innovation in the design and building process, with more added value for clients and end users as a result..

8. *PBD offers the opportunity to make better use of knowledge and expertise of contractors and suppliers, allowing them to come up with innovative, cost effective solutions.*
   Multitudes of building concepts, techniques and products are available for the building industry and more are added every day. It is impossible for designers to have knowledge of all available concepts, techniques, products and new developments. Contractors (and suppliers) often have better knowledge of the market, but also they cannot possibly have mastery of all available concepts and techniques. They have to specialize. But when they are confronted with building designs that are specified in detail, they will often not be able to use their own specializations.
   When architects and other designers refrain from giving detailed prescriptive specifications for every building part and complete the functional and aesthetic design with a set of performance specifications for building parts instead, allowing contractors to use their own techniques and market knowledge, that might lead to more cost effective solutions, better quality and more value for money for the owners and users.

9. *PBD helps to fill in the building industry's responsibility for the environment*
   The building sector has a responsibility for the environment; future generations also have the right to live in a healthy and sound environment. Legislation in this field is mainly performance-based, leaving the responsibility for how to meet with the legal requirements to the designers to a great extend.

10. *PBD is common practice to some extend already*
   In practice most designers already do PBD to some extend, consciously or unconsciously, e.g. in relation to meeting with energy consumption and other environmental requirements. So to most designers PBD is not a completely new concept. Besides that it's important to understand that total systems of performance-based building or design do not exist. PBD can be applied in a more or less extensive form, depending on the circumstances of a project (also see chapter 2). This means that designers do not need to change their 'normal' way of working from one day to another in order to implement PBD.

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