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What Does Performance-Based Requirements Mean?

1.1 In General

The objective of a performance-based design is evaluating the quality of whole buildings and all building parts from a fit for purpose point of view. To clarify how this is done, first a few definitions are discussed, after which the array of performance requirements and metrics at the building and, derived from it, at the building part level is drafted. Then, the interaction between a consequent use of the building part array and building design and construction is discussed.

1.2 Definitions

The term 'performance' covers the physical properties and qualities of importance at the built environment, the whole building and the building part level. Related requirements must be expressible in an engineering way, predictable at the design stage and controllable during and after construction. The first and second feature presumes that tools allowing evaluation are available, while the third feature needs measuring methods applicable on site. Typical for a performance-based approach is a top-down structure, with the built environment, called level 0, ahead, followed by the building, called level 1, see Table 1.1, and the building parts, called level 2. A correct fit for purpose should start at level 0, then descend to level 1 and then to level 2.

This book mainly considers the level 2 performance requirements and metrics, which are based on a list of functional demands, such as structural adequacy, well-being, energy efficiency, durability, economics and sustainability, see Table 1.2. In several countries, some got a legal status with related enforcement guaranteeing application.

1.3 Advantages

The main advantage of a performance-based approach is the objectification of expected and delivered quality. For a too long time, designers juggled with the art

Performance-Based Building Design: From Below Grade to Floors, Walls, Roofs, Windows and Finishes, Second Edition. Hugo Hens.

Table 1.1 Level 1: whole buildings performance array.

Field	Performances
Functionality	Safety of use; adaptation to usage; flexibility
Structural adequacy	Global stability
	Strength and stiffness against vertical loads
	Strength and stiffness against horizontal loads
	Dynamic response
Comfort and health	Thermal comfort year-round, including avoiding overheating
	Acoustical, visual and olfactory comfort
	Indoor environmental quality
Heat and mass	Energy efficiency; moisture tolerance
Fire	Fire containment by compartmentalization and the right fire resistance of all enclosing floors and partitions; escape routing; active fire fighting
Durability	Functional, economic and technical service life
Maintenance	Accessibility; ease of cleaning
Costs	Total and net present value; life cycle costs
Sustainability	Life cycle inventory and assessment with less CO_2 as one of the requirements and zero carbon as the ultimate objective
	Global evaluation schemes

of construction axiom without defining what this meant. A rigorous performance approach lets principals know in advance the quality to be expected. In forensics, clear requirements and metrics facilitate the evaluation of unwanted problem and damage cases, which the art of construction axiom does not. A performance-based approach also stimulates building part assembly prefabrication and turned building engineering into a more research-based discipline.

1.4 Performance-based Design of Buildings and Building Parts

1.4.1 The Process

Designing buildings is a multiple undefined activity. At the start, information is so scarce that sketch designs mainly reflect the experience and creativity of the architect, though anyhow with respect for the program and all legal level 1 metrics mandated or requested by the client. This way, building form, spatiality, structure and envelope get shaped. Simultaneously, the facts and figures designer and client agreed on multiply. During the next stages, refinement alternates with engineered adjustment of the building structure, its envelope and the building services needed, using all level 1 and 2 metrics, resulting in a final high-performance design with sets of specifications that allow construction.

Table 1.2 Level 2: building parts performance array.

Field	Performance
Structural adequacy	Strength and stiffness against vertical loads Strength and stiffness against horizontal loads Resistance against buckling Dynamic response
Heat and mass	Air tightness Infiltration; exfiltration Wind washing; indoor air washing Venting and ventilation Air looping Thermal insulation Thermal transmittance (U) (inclusive thermal bridging) Thermal transmittance of transparent parts Average thermal transmittance of the envelope Transient response Dynamic thermal resistance, temperature damping; admittance Solar transmittance Moisture tolerance Construction moisture Rain-tightness Rising damp Hygroscopic loading Surface condensation Interstitial condensation Random leaks Thermal bridging Temperature factor Others (i.e. the contact coefficient)
Sound	Sound attenuation index Sound insulation of the envelope against noise from outside Sound absorption
Lighting	Light transmittance of transparent parts Glass percentage in the envelope
Fire	Fire reaction of the materials used Fire resistance
Durability	Resistance against physical attack (mechanical load, moisture, temperature, frost, UV radiation, salt, etc.) Resistance against chemical attack (corrosion, etc.) Resistance against biological attack (moss and algae growth)
Maintenance	Resistance against soiling; easiness of cleaning
Costs	Total and net present value
Sustainability	Life cycle profiles Carbon neutrality

Building physics-related performances (applies to rows Heat and mass through Fire)

1.4.2 Integrating the Approach

A performance-based approach normally moves from the whole building to the building part level and from more general to specific thanks to an ever-deeper analysis of the performance metrics to be guaranteed. At the start, level 1 metrics receive most attention, with the decisions taken fixing a bunch of final qualities (see Table 1.1). Then, level 2 metrics receive attention, as they help translating form and spatiality in how to construct (see Table 1.2). As more data become available, the evaluations refine. The load-bearing system takes its final form, the envelope gets its shape and the first finishing choices are made. Each step of course requires accountability as well from a structural as from a building physics, safety, durability, maintainability, cost and sustainability point of view.

Detailing, analysing, calculating, comparing, correcting and deciding about materials, layer thicknesses, beam, column and wall dimensions and concrete reinforcement, all evaluated using the performance metrics imposed or agreed on, characterize the final stage. Details must comply with the level 2 metrics, when needed with feedback to level 1. This way, performances generate solutions with buildability, reliability and redundancy as important assets. Inclusion of all this in the specifications allows contractors to propose alternatives at a same or a lower cost on condition that they perform equally or better then what is proposed.

1.5 Impact

For decades, the triad client/architect/contractor dominated the building process. The client formulated a demand. He engaged an architectural firm that produced the design, all construction drawings and the specifications usually with the help of structural, building and mechanical engineers. The cheapest contractor then got the order and constructed the building under the supervision of the architectural firm.

Such triad has its drawbacks. Often, the architect is saddled with duties beyond her or his education and experience. Soil mechanics, foundation techniques, structural mechanics, building physics and building services are procured by consultants, but their involvement mostly just starts when the pre-design is finished and related key decisions are taken. Too often, such a split between design and consultancy prohibited buildability to be embedded in the drawings. ‘How to do?’ so was often left to the contractor with sometimes unwanted consequences.

Surely for large projects, a performance-based rationale may help turning this triad into a demand/bidder model. The demand comes from the client, who is proposing the intents that concern site planning and all functional requirements at the building and, if needed, the room level. Based on that, several building teams, including the architect, the consulting engineers, and sometimes the contractor, are invited to translate the client’s intents into a sketch design, so as to fix the form, the architectural expression and the overall spatiality of the building. The building team advancing the best proposal, possibly after an evaluation by an independent jury, then gets the contract and elaborates the final design and, when demanded, a rating using

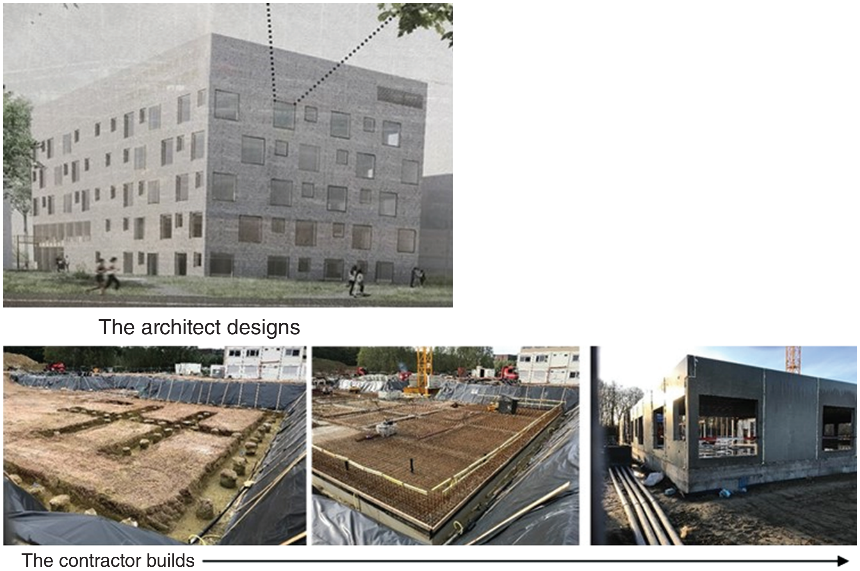

Figure 1.1 From design to construction.

LEED, BREAM or other LCIA-schemes, while the other teams are paid for their work. If the contractor is part of the team, then the winners have to construct and decommission the building, see Figure 1.1. Otherwise, as contractor among the subscribers is assigned the construction company whose bid guarantees the lowest price to required quality ratio.

Further Reading

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