MANAGING THE LIFE CYCLE REQUIREMENTS OF FACILITIES

Life cycle requirements of facilities

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Abstract

This paper describes a formal approach to manage the life cycle requirements of facilities. Two tools are used to support the performance approach and to make sure about the serviceability of the building. Firstly, Quality Function Deployment (QFD) is utilised to agree on project and design objectives. Secondly, a Requirements Management system (EcoProP) still under development and experimental implementation is applied to assure that the user requirements are met. These tools are used in two different research projects that have environment-friendly objectives as their common nominator.

Keywords: Life cycle design, performance approach, requirements management

1 Introduction

Construction is an old discipline and still very much practice-oriented. End products of construction, buildings, that have been traditionally considered to have value as such, may be today judged from a completely different view. Construction can be seen a process that provides, together with other processes, services to the users of facilities. In other words: to serve others' needs and expectations and not to produce something from its own aspirations. Or, construction may be seen as one of those processes that offer assets to investors and speculators. The owner's expertise is to rate the profitable life span for the investment. That is usually far shorter than the service life of the building, its materials and many of its components.

In both cases, the serviceability of the built facility is essential. More important than knowing how the building is constructed and which are the products used is to know how well it will perform during its service life. And how well it can adapt to the changing needs of its users and owners. The judgement of the serviceability of the facility must be obtainable at any given moment. It is a weak argument to justify a refurbishment investment or a heavy demolishing need by saying that the values were different at the time when the decision was made to construct the present performances. And that the investment was then considered advantageous.

Different tools and techniques can be applied to protect oneself against tedious surprises, such as performance prediction and risk assessment (Lounis et al. 1998). This paper discusses findings from implementing the performance concept and experiences from two tools that support the approach: Quality Function Deployment QFD (Akao 1990) and Requirements Management (Huovila and Serén 1998). Both of them have been experimentally piloted in building design processes aiming at serviceable facilities during their life span.

2 The performance approach

Some well-identified problems related with the design process can be listed:

- how to understand what the client really needs and what can be achieved
- how to interpret and to express the needs in a form of requirements
- how to verify that the design is conform with the requirements
- how to execute the design in a productive and qualitative way.

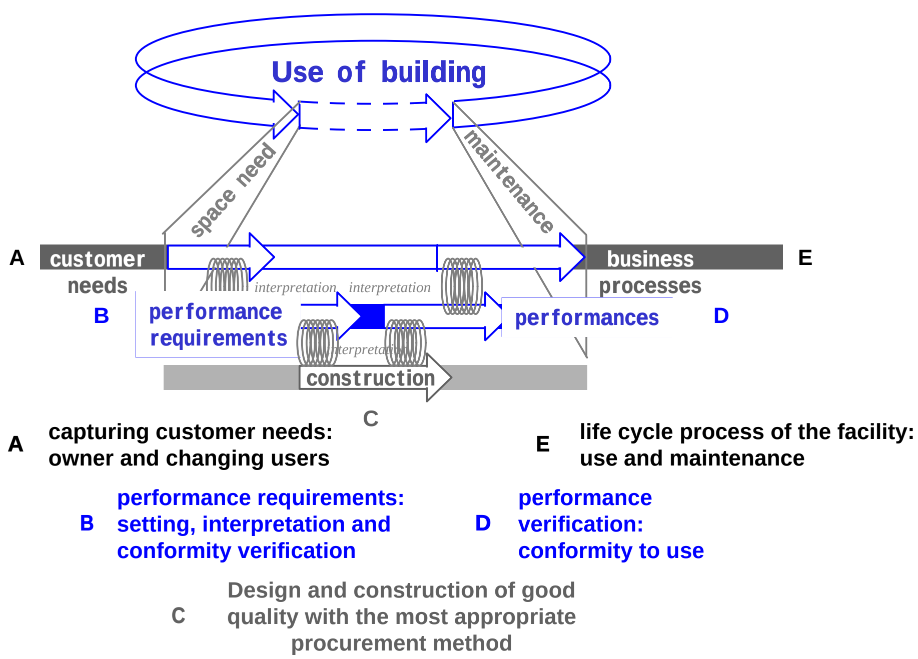

Fig. 1: The performance concept

Findings from a preliminary study in Finland were that the performance approach forces the clients to think what really is needed to support their business processes. The identified potential advantages of the approach were that it helps benefiting the suppliers' expertise, it moves the design emphasis earlier in the project, improves communication between different partners, enables competition between different technical solutions based on same performance specifications. It should also lead to profitable product development and facilitate the clients to obtain products that meet their needs. It also means that more effort is needed for the early phases of design. It may require changes to the traditional working procedures, new competition modes and agreements, maybe even definition for a new language and certainly increased communication along the design process.

3 Setting the objectives and achieving the team commitment

Quality Function Deployment (QFD) is a tool that has been successfully applied as a product development tool for consumer products. It offers a systematic approach to match the customer expectations with the features of the product, and to document the decisions in the design process. QFD can be seen as a team decision making tool to achieve common understanding and commitment to design objectives and prioritised characteristics of the design solutions. It is well known in the development of consumer products, but in the construction practice its known implementations (Huovila et al. 1995) are few.

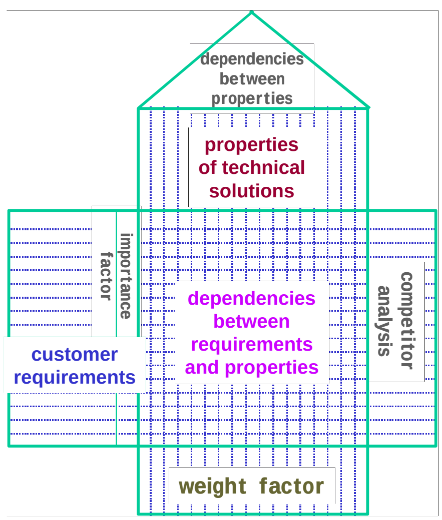

Fig. 2: The structure of the QFD house of quality matrix

QFD was recently experimented in an afternoon brainstorming session to set design guidelines together with ten experts of different backgrounds for a prototype building to be developed for a Housing Fair. That exercise had the following objectives:

- to share common understanding of the performance-based objectives
- to prioritise the project objectives
- to strive for innovative design solutions that meet the prioritised project objectives.

In this case, the tool was found useful to structure the meeting. In addition, it provided a way to document the decision path. It also enabled recording innovative solutions that were not selected for that project, but have potential to be further developed in other occasions.

	PHASE 1 Properties / Requirements	adaptability	resale value	indoor conditions	attractiveness	economy	autonomy	friendliness to the environment	futurity	habitability	respond to the environment	dood indoor climate	constructability	identity	total ecology	architecture	helpot käyttöliittymät	recyclable fair house	transferability	dismountability		Importance/Weight factor (P1)
		M	T	S		T	Y	Y			S		TOT		Y	A	M	M				
functionality	**Utilisability**	**9**	**9**	**9**	9	**3**	9	**3**	0	9	0	9	**0**	1	1	**0**	9	3	1	0		**5**
	Adaptability	**9**	**3**	**0**	9	**3**	1	**9**	3	9	0	0	**1**	1	9	**0**	1	9	9	9		**2**
	Maintainability	**3**	**3**	**3**	3	**9**	9	**9**	0	9	0	3	**0**	0	9	**1**	3	1	1	1		**2**
environmental	Operation	**9**	**3**	**9**	3	**9**	9	**9**	1	1	9	9	**0**	0	9	**0**	0	0	0	0		**4**
loading	Construction	**0**	**0**	**0**	3	**3**	0	**9**	0	0	0	0	**9**	1	9	**1**	0	9	9	9		**2**
resource	**Energy**	**9**	**3**	**9**	3	**9**	9	**9**	9	0	9	9	**0**	3	9	**0**	0	1	1	1		**5**
use	*Water*	**9**	**1**	**0**	1	**3**	9	**9**	3	1	0	0	**0**	0	3	**0**	1	0	0	0		**1**
	Materials	**3**	**9**	**9**	3	**9**	1	**9**	9	9	0	9	**9**	9	9	**3**	0	9	9	9		**1**
life	Investment costs	**9**	**9**	**3**	3	**9**	3	**0**	0	0	3	3	**9**	1	0	**0**	1	3	3	3		**3**
cycle	Operating costs	**9**	**9**	**1**	3	**9**	9	**9**	3	0	3	1	**0**	3	3	**9**	9	3	3	3		**4**
cost	Maintenance cost	**9**	**9**	**3**	9	**9**	9	**9**	9	0	9	3	**0**	3	3	**9**	3	3	3	3		**2**
indoor	Acoustic comfort	**9**	**9**	**9**	9	**0**	0	**0**	9	9	0	0	**3**	3	0	**9**	0	0	0	0		**2**
quality	Thermal comfort	**9**	**9**	**9**	9	**0**	0	**3**	9	9	9	9	**3**	3	0	**9**	3	0	0	0		**3**
	Lighting	**9**	**9**	**9**	9	**3**	9	**3**	9	9	9	0	**3**	9	1	**9**	1	0	0	0		**4**
	Indoor climate	**3**	**9**	**9**	9	**0**	0	**3**	9	9	9	9	**9**	9	1	**0**	0	0	0	0		**5**
architecture	Architecture	**9**	**9**	**9**	9	**9**	3	**0**	9	9	3	0	**9**	9	0	**9**	1	3	3	3		**3**
	Weight factor (P1)	**393**	**355**	**322**	307	**285**	273	**258**	250	248	246	241	**182**	180	179	**169**	118	112	102	97	0	**4317**
	Weight factor %	**9 %**	**8 %**	**7 %**	7 %	**7 %**	6 %	**6 %**	6 %	6 %	6 %	6 %	**4 %**	4 %	4 %	**4 %**	3 %	3 %	2 %	2 %	0 %	**100 %**
	Votes	**4**	**1**	**3**		**2**	1	**3**			1		**2**		4	**4**	1	1				
	Selected	X		X		X		X					X			X						

Fig. 3: Prioritising the design objectives in a QFD process

In the QFD process different teamwork techniques can be used to identify the requirements (matrix rows) and their weighting (importance factor values 1...5). Correspondingly the product properties (matrix columns) and their dependencies to the requirements (matrix cell values 0, 1, 3, 9) are filled in the matrix. The next step is to take advantage of the calculated weight factors (at the bottom of the matrix) to facilitate the selection of the properties (x) that will be emphasised in that project.

The participants' feedback from the QFD experiment was positive. The half-day session resulted in two QFD House of Quality Matrices that were delivered to them as paper prints at the end of the day. The process led to identification of some new design objectives and innovative solutions. The results did not conflict with the earlier objectives. The selection was unsurprising as judged afterwards. On the other hand no one can tell where another kind of process would have led.

Later on Quality Function Deployment tool will be tested as a trade-off analysis tool in design process as a part of the ongoing in the IEA task 23.

4 Describing the properties of building

Managing the serviceability of buildings requires control over the properties of the building systems and building parts. Various master lists, checklists or classifications of requirements or properties of buildings have been developed by CIB (1993), ISO (1984), EC (1989) or GBC (Nilsson 1998).

ISO6241 User Requirements	CIB Master List of Properties	EC Essential Requirements	Green Building Challenge 98
• Stability • Fire safety • Safety in use • Tightness • Hygrothermal • Air purity • Acoustical • Visual • Tactile • Dynamic • Hygiene • Suitability of spaces • Durability • Economic	• Capacity, consumption • Structural, mechanical • Fire • Gaseous, liquid, solid • Biological • Thermal • Optical • Acoustic • Electric, magnetic • Resistance to attack • Service life, reliability	• Mechanical resistance, stability • Safety in case of fire • Hygiene, health and environment • Safety in use • Protection against noise • Energy economy and heat retention	• Resource consumption • Environmental loadings • Quality of indoor environment • Longevity • Process • Contextual factors

Fig. 4: Checklists of properties or requirements

5 Managing the requirements

A Requirements Management System, EcoProP, was developed to help the clients to express their sustainability objectives in a concrete and measurable way. The system is based on a list of generic properties that can be classified in three categories:

- performance characteristics: conformity to business processes, location, indoor conditions, service life and deterioration risk, adaptability, safety, comfort and loading to immediate surroundings
- characteristics of the properties: life cycle costs, environmental burdens in operation and embodied environmental loading in building parts
- process issues that do not relate with the building in use, but during the construction phase.

EcoProP is currently piloted in four live projects emphasising at indoor conditions, service life and deterioration risks, adaptability and environmental burdens in operation. The objective is to express the higher level characteristics at a lower level in a form of concrete values or classes that are set as design objectives in environmentally friendly building projects. The requirements are documented and the corresponding verification methods are cited when possible.

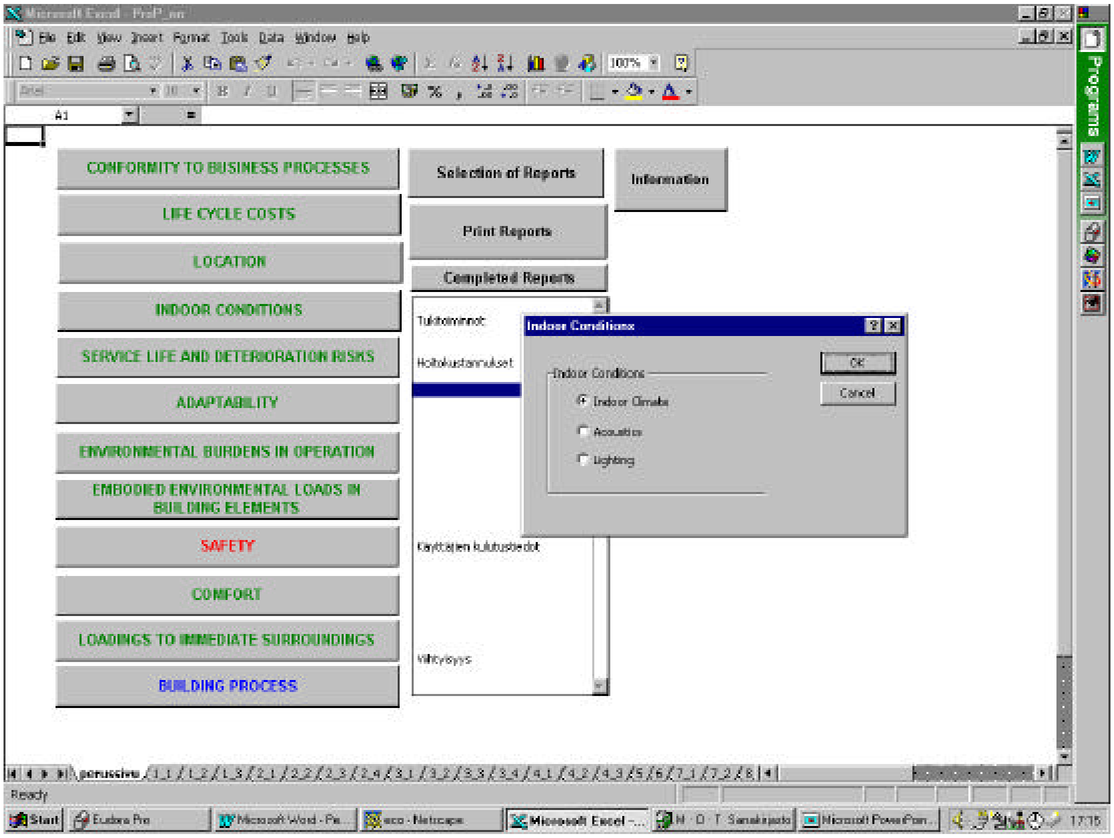

Fig. 5: The EcoProP user interface

6 Discussion

Formal methods and systematic procedures are still not everyday practice in construction. Most promising benefits of the described tools will most likely be achieved in cases where competition is emphasised at the qualities of the end product and innovation is encouraged. The customer-oriented approach may require some additional time compared to production-driven approach, but the gains from better serviceability of facilities, higher customer satisfaction and longer partnership relations should bring the balance.

7 References

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