OPERATIONAL METHODS FOR IMPLEMENTING DURABILITY IN SERVICE LIFE PLANNING FRAMEWORKS

ΕΠΙΧΕΙΡΗΣΙΑΚΕΣ ΜΕΘΟΔΟΙ ΓΙΑ ΕΝΣΩΜΑΤΩΣΗ ΤΗΣ ΕΝΝΟΙΑΣ ΤΗΣ ΑΝΘΕΚΤΙΚΟΤΗΤΑΣ ΣΤΟ ΣΧΕΔΙΑΣΜΟ ΤΟΥ ΧΡΟΝΟΥ ΖΩΗΣ

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ABSTRACT

Thanks to a significant European initiative, in 1993 the ISO 15686 set of standards has been undertaken, dealing with service life planning and including an integrated design framework for buildings, incorporating technical, economical and environmental aspects from the very early stages to detailed specification, construction and maintenance. It was aimed as a guiding concept regarding durability of building products.

Durability, that is sustained performance beyond an initial level, is a major parameter to guide that process. From the standard’s point of view, it is based on determination of a reference service life of the component at hand (RSLC) and of correction factors (A to G) to take into account the effect of process quality aspects on this initial estimation of service life.

While the general context of the building sector seems to consider with more interest the durability concerns, by demanding more relevant and reliable data on the working
life of the works, the ISO 15686 standard, (part 1 and 2 of which - General Principles and Service life prediction procedures - are already published), does not really provide ways to make use of all available service life data, and needs less arbitrary guidance to assess the values of the factors.

Therefore complementary tools are needed to help implement the standard’s requirements in practice. This paper shows that a more explicit and objective method can be achieved by using:

(a) a data fusion technique for assessing the Component’s Reference Service Life (RSLC) and
(b) a failure modes and effects analysis (FMEA), respectively. Both methods have been tested for innovative construction component technical performance assessment within CSTB.

The evaluation of a RSLC goes through several steps:
- accumulation of existing information on the product.
- Organisation of the data as a function of their source, production mode, and relevance.
- Combination of the data using a statistical technique, to provide a service life distribution.
- Assessment of a characteristic service life value(s) together with a global quality index.

The required computations are performed by dedicated software developed by CSTB.

FMEA is a qualitative technique for the evaluation of a system’s reliability. Although it was developed early in the 1960s in the aeronautical industry, and then to mechanical and electrical engineering, it is seldom used in construction, even though its concepts are generally familiar. This method can also be used as a basis for the diagnosis of pathologies in audited buildings and for the setting up of an optimised preventive maintenance scheme. A software tool for helping performance of FMEA is now being developed in CSTB.

Both methods and tools, results of research work performed in CSTB, provide
examples of contributions to a better implementation of durability concerns, which are now growing in all assessment and standardisation procedures at the European level such as Technical Approvals, product standards, harmonised standards, thus complying (with delay) with the wish already included in the European Construction Directive on Construction Products (CPD). The step of a general format for reference service life is the actual work item of TC 59/SC14 committee. The development of standards and assessment procedure addressing service life issues will be beneficial for a better communication on construction products durability, as a part of lifetime engineering, and towards sustainability in building construction.

ΠΕΡΙΛΗΨΗ

Οι αρχές της αειφόρου ανάπτυξης αποτελούν πλέον όλο και αυξανόμενες απαιτήσεις στην κατασκευή των νέων έργων και δεν μπορούν να εκτιμηθούν σωστά, αν η γνώση και το ενδιαφέρον που σχετίζεται με τη διάρκεια του λειτουργικού χρόνου ζωής και της συμπεριφοράς τους δε λαμβάνονται υπόψη.

Η εργασία αυτή παρουσιάζει το περιεχόμενο των διεθνών προτύπων τα οποία είναι σε εξέλιξη και την ανάπτυξη μεθόδων και εργαλείων για την αποτίμηση της ανθεκτικότητας των κτιριακών έργων σε περισσότερο επιστημονική βάση. Παρουσιάζεται η πρόσφατη έρευνα στο CSTB, με την περιγραφή δύο εργαλείων υπό ανάπτυξη για την καλύτερη αποτίμηση του λειτουργικού χρόνου ζωής και τα μοντέλα αστοχίας των κτιριακών στοιχείων. Τα πειραματικά αυτά εργαλεία συμβάλλουν γενικότερα στη μηχανική του χρόνου ζωής, όπως στις κατασκευές από σκυρόδεμα, ανταποκρινόμενα στις απαιτήσεις των Ευρωπαϊκών Οργανισμών για βελτιώσεις στο πεδίο αυτό.

INTRODUCTION

The Sustainable Development principles, now increasingly present in the requirements for new building works, cannot be correctly respected if the knowledge and concern related to the service life duration and behaviour of products remain at the actual level of uncertainty and lack of interest.

If in the past, building works, considered as transmissible goods, were built up for generations, and actually some of these remained in use for centuries, thanks to some
retrofitting and often to change in purpose. More recently, in some countries, the only driving force for anticipating service life is insurance conditions, often limited (like in France) to 10 years.

With the new economical, environmental and social combined approaches: Private Funding Initiatives in UK (Bourke, 1998) Life Cycle Approach in Sweden (Soronis, 1998) High Environmental Quality in France (Nibel, 1998), Lifetime engineering in Finland (Sarja, 2002), a better documentation of the service life and durability anticipation is needed already during the design phase.

This paper presents successively the international standardisation context, which is in progress, and the development of methods and tools for a more scientifically based durability assessment of building products. We illustrate recent research developments in CSTB by describing in some details two tools under development for a better assessment of the reference service life, and the failure modes of the building components.

Finally these experimental tools are set back in the general context, as a contribution to the increasing movement towards lifetime engineering, made concrete for instance through the actual demands from the European bodies for improvements in this field.

CONTEXT

The ISO 15686 Standard

The activity developed within the ISO sub-Committee TC59/SC14 “Service Life Planning” since 5 years has now progressed to the stage where the first three parts of the developing standard, ISO 15686 Buildings and Constructed Assets – Service Life Planning, are approved, i.e. Part 1, General principles, Part 2, Service life prediction procedures, and Part 3, Performance audits and reviews.

Part 1 describes the principles and procedures that apply to design, when planning the service life of buildings and constructed assets. It is important that the design stage includes systematic consideration of local conditions to ensure, with a high degree of probability, that the service life will be no less than the design life. The standard is applicable to both new constructions and the refurbishment of existing structures. However, additional considerations may apply to existing buildings.
Part 2 of the standard series is mainly based on the Service Life Methodology (Masters and Brandt 1989). It describes a procedure that facilitates service life predictions of building components. The general framework, principles, and requirements for conducting and reporting such studies are given. It should be emphasised that the standard does not describe the techniques of service life prediction of building components in detail.

Part 3 is concerned with ensuring the effective implementation of service life planning. It describes the approach and procedures to be applied to pre-briefing, briefing, design, construction and, where required, the life care management and disposal of buildings and constructed assets to provide a reasonable assurance that measures necessary to achieve a satisfactory performance over time will be implemented. However, the cost implications of service life planning and the broader issues of sustainability (e.g. embodied energy, land use) are not addressed here.

Other parts on which work is in progress deal with “Data requirements”, “Life cycle costing” and “Guidelines for considering environmental impacts”. The first of these is intended to describe requirements of data in order to estimate the service life of a structure, building system, or building. However, at least in a first step, this part will be developed as a technical report rather than a standard. The second work item, “Life-cycle costing”, is to enable comparative assessment of the cost performance of buildings and constructed assets over an agreed period of time. The last work item which resulted in a CD 6 months ago, is to provide guidance on assessing the relative environmental impacts of alternate service life designs, and to identify the interface between environmental LCA and service life planning.

Another recently approved work item is “Maintenance and condition assessment protocols for buildings”, with the objective to develop guidance for improving the quality of durability and service life data derived from condition assessment of the existing building stock. Finally, the more recent work item, “Reference service life”, aiming to provide guidance on the provision of reference service life for use in the application of ISO 15686-1, has been approved some months ago.

Interesting to mention is that service life design applied to concrete structures is
under way in the hands of ISO/TC71, Concrete, Reinforced Concrete and Pre-Stressed Concrete. The recently established ISO/TC71/SC7, Service Life Design of Concrete Structures has the aim of developing a Code of practice on service life design of concrete structures. This would become the first international product standard addressing service life planning issues explicitly, simultaneously serving as an example or a template how to cope with other building products in this context.

**The factors method**

**Part 2** of the above standard establishes that Service Life Prediction is based on the determination of:

- a reference service life of the component (RSLC) defined as “period in years that the component or assembly can normally be expected to last”
- correction factors (A to F) to take into account the quality of the product (materials quality) and the quality of the process (Construction site/execution, Indoor or Outdoor environment, Operating characteristics, Maintenance level).

On one hand, Reference Service Life assessment has to be “based on rigorous scientific prediction” (based on previous experience or observation of similar construction materials, provided by a manufacturer, given in building codes as typical service life for components,…). On the other hand, the assessment of each factor may also be based on previous experience.

Considering that the procedure described in the standard does not provide tools:

1. to make use of all service life data in a manner that is explicit, hence more open to quality assessment and certification, than the current usage relying solely on professional and expert judgement.
2. to perform relevant and objective calculation of the factors’ values.

The need is obvious for the development of new methods and tools in order to provide the standardisation procedure with more scientific basis, even if built up “a posteriori”

**Methods and tools**

Two complementary tools have been developed (Lair, 2000):

- a data fusion procedure (left part of Figure 1),
- a Failure Modes and Effects Analysis (right part of Figure 1).

![Figure 1: Durability assessment method and tools](image)

The first step of the approach is a common step called “system analysis” : the structure of the system (elements, materials, geometry...), its environment and the functions it has to fulfil are studied.

In this paper, the next steps of the proposed approach are detailed in the two next chapters, and illustrated with appropriate examples.

**FUSION PROCEDURE**

**Data collection**

Data collection means collection of all data, available on the product or its part, in its projected environment or one of its parts. We can look at the product, or “zoom in” on each of its parts and have to study the multi-scale aspect of environment (macro, meso, local and micro). (Haagenrud, 1998).

On a basic example: a reinforced concrete wall with external paint, we can collect data on:
- the system in its environment : reinforced concrete (RC) wall,
- the system in a part of its environment : RC wall towards the influence of mechanical loads,
- a part of the system in its environment : concrete in its environment (humidity, CO₂, freezing/thawing cycles, ...)
- a part of the system in a part of its environment : concrete facing to carbonation.

Data means either service life data (obtained with field tracking studies, natural or
artificial tests, knowledge expert etc) or degradation models (dose response functions, modelling, reliability analysis).

**Data organisation and modelling**

The following step is the data organisation. We want to model the behaviour of a product, but some data are only a partial representation of the real behaviour of the product: partial from a geometrical point of view and/or a phenomenological point of view. Data are more and more accurate in representing degradation phenomena. This accuracy is characterised with a parameter called granularity. Each data is defined by a geometrical granularity (representing : product $\rightarrow$ components $\rightarrow$ materials), a phenomenological granularity (taking into account : all phenomena $\rightarrow$ one phenomenon), and a temporal granularity (Service life $\rightarrow$ degradation model). Briefly, data organisation consists of grouping data of similar granularities at the same level.

Then, we have to construct various models (one for each level) representing the behaviour in time of the studied product: it is a modelling step. From the set of data of a level (partial views of the product), we build a global view of the product (Figure 2).

![Figure 2: RC wall multi-modelling](image)

For example, the phenomenological aggregation of carbonation, corrosion, freezing/thawing cycles, sulphates etc gives a degradation model of concrete. With geometrical aggregation of the three concrete, steel and paint degradation models, we obtain a degradation model of the system. Each model gives us a service life assessment, under an uncertain formalism: interval, fuzzy sets, probability density functions ...
Quality assessment

Before the Fusion procedure is executed, the obtained service lives are qualified, that is to say we assess the "confidence" we have in each service life estimation. It is a quality assessment step. In taking into account uncertainty and ignorance (parameters and modelling uncertainties and ignorance), we increase credibility of the results.

Based on the pedigree concept of NUSAP Method (Funtowicz & Ravetz, 1990), the quality assessment method, as a multi criteria analysis, consists of:
- identifying the relevant parameters characterising the quality of the data,
- assessing the parameters,
- aggregating these parameters in order to assess quality.

Six parameters have been defined. They represent the three aspects of data quality: quality of the data production mode, the format of the data, and the relevance of its use in our study. A procedure for the assessment (qualitative or quantitative assessment) and the aggregation (arithmetical mean) have also been defined (see (Lair, 2000) for more details).

We then have a set of couples (Service life, Quality mass) resulting from “multi-modelling” of the product. The quality mass (valued on [0, 1]) is thus defined. It will be used in the Fusion procedure as the weight in a weighted mean.

Figure 3 presents the results of data collection, organisation and modelling steps for the study of a roofing system.

<table>
<thead>
<tr>
<th>Data n°</th>
<th>Model (Granularity)</th>
<th>Level</th>
<th>Service life and Source</th>
<th>Quality mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Service life of roofing system</td>
<td>1</td>
<td>25 years [OFC, 1985]</td>
<td>0.30</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td>15-20 years [OPAC, 1993]</td>
<td>0.36</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td>15-45 years [EPFL, 1996] (1)</td>
<td>0.47</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>15-25 years [GUMPERTZ, 1996]</td>
<td>0.39</td>
</tr>
<tr>
<td>5</td>
<td>Degradation of waterproofing layer</td>
<td>2</td>
<td>22-32 years [AMMAR, 1980]</td>
<td>0.39</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td>20-40 years [EPFL, 1995] (2)</td>
<td>0.41</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td>20 years [PERRET, 1995]</td>
<td>0.34</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td>(25, 40, 55) years [PIHLAJAVAAARA, 1980]</td>
<td>0.33</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td>Normal dist. (μ=21.5 ; σ=7) [KYLE, 1997]</td>
<td>0.64</td>
</tr>
<tr>
<td>10</td>
<td>Loss of elasticity of waterproofing layer</td>
<td>3</td>
<td>24 years [WYPYCH, 1990]</td>
<td>0.26</td>
</tr>
</tbody>
</table>

Figure 3: Data modelling and quality assessment (roofing system example)
**Fusion procedure**

Fusion procedure is a statistical technique based on “Evidence theory” (Shafer, 1976). From the set of initial service lives, we extract a "consensual service life", that is to say we extract synthetic information of the current knowledge. Each model is called “evidence” (it is a way to assess service life). Each model focuses on a set of service lives. We keep the “right to be wrong”, then service life is included in the set “ignorance”.

Evidence 1 is translated into a belief function: a mass $m_a$ is associated to $A$, a mass $(1-m_a)$ is associated to the set “ignorance”. By analogy, evidence 2 is translated.

The consensus is obtained by the product of the masses associated to the considered set: for example, $m(A) = m_a(1-m_b)$

Data fusion of two evidences (1 and 2 focusing on $A$ and $B$ with respective quality mass $m_a$ and $m_b$) is illustrated in Figure 4):

<table>
<thead>
<tr>
<th>Evidence 1</th>
<th>$m_a$</th>
<th>$m_b$</th>
<th>$(1-m_b)$</th>
<th>$(1-m_b)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evidence 2</td>
<td>$(1-m_b)$</td>
<td>$m_b$</td>
<td>$m_b$</td>
<td>$(1-m_b)$</td>
</tr>
<tr>
<td>Consensus</td>
<td>$m_a(1-m_b)$</td>
<td>$m_b$</td>
<td>$(1-m_b)$</td>
<td>$(1-m_b)$</td>
</tr>
</tbody>
</table>

**Figure 4: Fusion principle**

This example is the basic case of the fusion of two “heterogeneous data” ($A \cap B \neq \emptyset$). But first, in the building domain, we frequently have conflicting viewpoints ($A \cap B \neq \emptyset$) or weakly coherent viewpoints ($A \cap B$ nearly $\emptyset$). We then propose adaptations to the basic rule. Second, viewpoints could be vague. An expert says “service life is probably [30, 40] but could also be [20, 30] or [40, 50]”. This evidence focuses on several service life sets $A_i$; they are called “separable support functions”. The basic rules have to be generalised to this type of evidences (Dempster rule):

$$m(\emptyset) = k \sum_{A_i \cap B_j \neq \emptyset} m_i(A_i).m_j(B_j)$$

Third, when we want the fusion of several data, we have to fuse two sets of evidence, then we fuse the result with the third, because of problems of conflict and weak
coherence, because of the non-associativity of some rules, there is no universal rule allowing the fusion of any set of data. This fact compels us to propose a fusion strategy, intended to choose the most relevant rule for a given set of data. We will not detail further data fusion and fusion strategy. Interested readers could refer to (Lair, 2000).

**Presentation of the results**

Final results are not exploitable on their own. We have to present them in an understandable and easily usable format. A classical distribution of failure seems to be the best solution. We draw a cumulative probability function. The a-priori probability that product failure occurs in time interval \([0, t]\) is assessed thanks to Smets probability (Dubois, 1990):

\[
P([0, t]) = \frac{\sum m([x_i, y_i])}{m([x, y])}
\]

\([x_i, y_i]\) are the resulting intervals of fusion.

Evidence theory allows us to draw two complementary curves:

- **Belief (BEL)** is the measure of the belief we have that the failure of the product will occur in \([0, t]\).
  
  \[
  \text{Bel}([0, t]) = \sum_{[x_i, y_i] \subseteq [0, t]} m([x_i, y_i])
  \]

- **Plausibility (PL)** is the measure of how much we believe that the failure of the product will occur in \([0, t]\) assuming that all unknown parameters are supportive of a failure superior than \(t\).
  
  \[
  \text{PL}([0, t]) = \sum_{[x_i, y_i] \cap [0, t] \neq \emptyset} m([x_i, y_i])
  \]

In some way, BEL and PL represent pessimistic and optimistic values of the probability of failure; they draw a zone we call “Uncertainty zone” (grey zone on Figure 5).

We can estimate characteristic service lives. For an acceptable risk \(k\), we assess the characteristic service life \(SL_k\) with :

\[
\frac{\text{DDV}_k}{P(\text{DDV} \leq \text{DDV}_k)} \leq k
\]

For example, we could say that \(SL_{10\%} = 21\) years with an uncertainty interval \([15, 26]\) years.
Finally, we want to keep the good sense on what we do.

As Lao Tsu said:

"Knowing ignorance is strength,
Ignoring knowledge is sickness"

Bad input only gives bad results, so we want to “measure” the quality of the approach (quality of the data and results as well as quality of the method).

Additional information are then associated to this assessment. First, we want to qualify the chosen data fusion rule. According to parameters characterising each rules, we assess the quality of the rule with a note between A and F. Second, we want to qualify the informative content of the results (note between A and F): the wider the uncertainty zone is, the poorer the result.

Interest and perspectives

We propose a procedure for service life assessment. Based on the use of every available information, it is possible to assess the Reference Service Life, required in the Factor Method. Expert judgement, manufacturer judgement, weathering tests, modelling and all other durability sources can be used. The quality assessment principle appears as an essential step, allowing the reduction or increasing of the influence of any data on the result, according to its quality. The existence of “ignorance response” (equivalent to “I don’t know” in an opinion poll) increases the belief in the results.

Currently, we propose an operational method for durability assessment. Tested on some building products (roofing system, wooden window …). It gives interesting results. In the case of innovative products (innovative cladding system), it shows its limits (lack
of data). Bad results (in the sense of informative content) are obtained but we point out the studies which are required:

- further thoughts on degradation modelling have to be developed,
- durability and service life data bases have to be developed to make easy the search of information, to capitalise knowledge.

As a start towards these aims:

- the construction of such a database was commenced at CSTB,
- dedicated software was developed by CSTB, to provide guidelines for data quality assessment, make the data fusion and the presentation of results.

**FMEA : FAILURE MODES AND EFFECTS ANALYSIS**

**Generalities**

Used from the 1960s in the aeronautical and car industries, FMEA is a convenient tool for the safety studies of industrial systems. FMEA is intended for the verification of the product ability to satisfy client’s needs (reliability, maintainability, disposability, safety). Commonly used in these industrial domains, it targets and checks weak points before mass-production in order to define preventive measures (Modarres, 1993).

**Method and originalities**

We want to apply a similar approach for building products. With adaptations due to building specificities, we have then developed a “risk assessment” approach currently used in certification procedures.

The proposed approach relies, on one hand, on the precise description of the system, the identification of its functions and the definition of its environment (common part of the method). On the other hand, we also consider the building process of the product (design, manufacturing, transport, storage, setting up ...). A FMEA Process gives a list of necessary conditions at each step to achieve a good quality product.

We then lead a FMEA Product (Figure 6). Briefly, thanks to system analysis, we identify functions ensured by the product, and elements involved in the “success” of each function. FMEA consists of the identification of all failure modes for each function,
then the search for causes, and finally the identification of effects. The novelty of the approach concerns the search of causes and effects. The behaviour towards solicitations of an element, its degradation or failure can change the environment of neighbouring elements. For example, dimensional variations of insulation panels of a roofing system under thermal solicitations can involve stresses in the waterproofing layer. We propose to note direct effects (influence of the degradation or failure on the considered element) as well as indirect effects (influence on other elements or on system).

Three types of causes could then be identified:
① a classical cause as the action of an environmental agent on an element.

② an unexpected behaviour due to a defect in building process (potential defects listed in FMEA Process).

③ the influence of a neighbouring element on the considered element (iterative FMEA: a cause could come from the effects of behaviour, degradation or failure of another element).

<table>
<thead>
<tr>
<th>FUNCTIONS</th>
<th>ELEMENTS</th>
<th>MODES</th>
<th>CAUSES</th>
<th>EFFECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waterproof</td>
<td>Waterproofing layer</td>
<td>Piercing</td>
<td>① Vegetation</td>
<td>Water penetration (→ insulation)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>② Setting-up</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>③ Movements of insulation panels</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>...</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tear</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stream breaking</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>membrane</td>
<td></td>
<td>...</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thermal insulation</td>
<td></td>
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<td>...</td>
<td></td>
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</tr>
</tbody>
</table>

*Figure 6: FMEA product*

We thus have a list of potential failure modes, the causes and effects.

As an example, we propose an abstract of an innovative product FMEA (natural stone facing on aluminium honeycomb structure).
Interest and perspectives

Though it is seldom used in construction, FMEA is a promising method that could be used in various places in the standard. A more extensive presentation can be found in a recent paper (Lair, 2002). FMEA is a familiar tool which could be used as a guideline in the assessment of factors. An exhaustive search and knowledge capitalisation are the main interests of such approach. In accordance with occurrence probability, gravity of consequences, detectability ..., a criticality indicator is assessed: it allows the ranking and the selection of some “dangerous” failure modes requiring preventive actions. FMEA could give guidelines to improve the reliability and the quality of innovative products. Conclusive FMEA applications on innovative weatherboarding products have revealed the efficiency of this tool. Some failure modes were identified; the designer needed to make adaptations in order to improve the quality of its product, to enrich the certification files.

CONCLUSION, BACK TO THE CONTEXT

In 1988 the EU Council adopted The Construction Products Directive (Council of the European Communities 1988), adopted in 1988, with the aim of removing the barriers to trade in the construction sector, fixes the six essential requirements that the performance of products have to confer to the construction works (Mechanical resistance...
and stability, Safety in case of fire, Hygiene, health and the environment, Safety in use, Protection against noise, Energy economy and heat retention). Durability is not a requirement but a general concern expressed through the following sentence: “Such requirements must, subject to normal maintenance, be satisfied for an economically reasonable working life”. (Sjöström, 2001)

- Maintenance is defined as “a set of preventive and other measures that are applied to the works in order to enable the works to fulfil all its functions during its working life”.

- Normal maintenance “includes inspections and occurs at a time when the costs of the intervention which has to be made are not disproportionate to the value of the part of the works concerned, consequential costs being taken into account”.

- The Working life is defined as “the period of time during which the performance of the works will be maintained at a level compatible with the fulfilment of the Essential Requirements”.

- Economically reasonable working life “presumes that all relevant aspects are taken into account such as: costs of design, construction and use; costs arising from hindrance of use; risks and consequences of failure of the works during its working life and costs of insurance covering these risks; planned partial renewal; costs of inspections, maintenance, care and repair; costs of operation and administration; disposal; environmental aspects”.

The CPD specifies that a construction product is fitted for its intended use if it conforms to an harmonised European standard (drafted by CEN), a European Technical Approval (issued by an EOTA member), or a non-harmonised technical specification (e.g. a national technical specification) recognised at Community level.

It appeared therefore quite obvious that some day, both CEN and EOTA should undertake the durability concern as a response to an economic and political conjunction of circumstances. These conditions are apparently fulfilled in the present situation, where sustainability is a political and social requirement while new economy rules call for more precise costs anticipation.
We have now reached the step where the experts working in CEN (especially within the Construction Sector Network) and EOTA are asking for more detailed information and data about durability and service life. In some specific sectors, the deficiency of standards regarding durability is clearly stated, and inside these instances, working groups and specific meeting are organised for that purpose, and basic documents are drafted and circulated.

So we are now very close to the point where standardisation work, research development and construction actors needs may be focused on the same goal, and then the principles of integrated design and lifetime engineering will actually come into practice.

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