Evalutation Criteria Of Durability Of New Materials In Buildings Components

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ABSTRACT

In the building sector innovative products and new construction systems have increased and diffused in an extraordinary way over the last decades.
In the European context the large increase of the construction rate, achieved both in the civil and in the industrial sector, led to the adoption of new construction systems and to the use of new materials; these new products have been developed in order to realise those innovative building components that have allowed to meet in part the global demand of new constructions.
The quick spread of applications using new materials and construction systems puts some questions to the operators of the sector:
what will be the durability of the new construction system with respect to what is already known and established for a corresponding traditional system?
in what way will the material replaced by the new product be compared with a traditional material of known durability?
The answers to the above questions become very important during the design phase, because durability globally resumes the main economic and technical factors that define the choices to be made for an effective use of new materials and systems.
But what evaluation criteria and methods are to be used for the assessment of durability? How have these methods developed over the time?
This work will try to give a first answer to these questions.

KEYWORDS

Ageing agent, building, durability, performance , service life, statistical approach, accelerated ageing test agent indicator, time factor, natural environment, artificial environment, statistical survey, real time,

INTRODUCTION

Durability is a fundamental attribute for most building materials and components; in this connection, the different international working groups have that took into account this subject with reference to the construction industry all agree in giving to the term "durability" the following meaning: "ability to maintain over the time the initial characteristics as evaluated in performance-related terms".

(The performance reference contained in the sentence means to express the need for building materials to maintain the performance granted by the material or the component above a threshold level that must be acceptable in order to ensure the required service life to the component).
On the subject of durability, two main aspects are distinguished: (a) durability with reference to environmental agents and (b) durability with reference to stresses deriving from utilization conditions imposed by the user.
Durability referred to environmental agents is basically the response of the product to ageing under the action of chemical, physical and biological agents from the environment.
For example: the action of ultra-violet radiation on a plastic external coating, the action of thermal radiation on plastic products, the action of ozone on a rubber-based product, the action of combustion products on synthetic material roofings.
Durability referred to stresses deriving from utilization conditions imposed by the user is the durability of an object or a component as a function of the intensity of strains resulting from service conditions of the building over the time. For example: resistance to wear stress due to pedestrian traffic on a thin flooring, wear resistance of window hinges, resistance to long term static indentation on a waterproof membrane.
It is advisable to distinguish such aspects of durability according to their relevance as to the methods used to assess it.

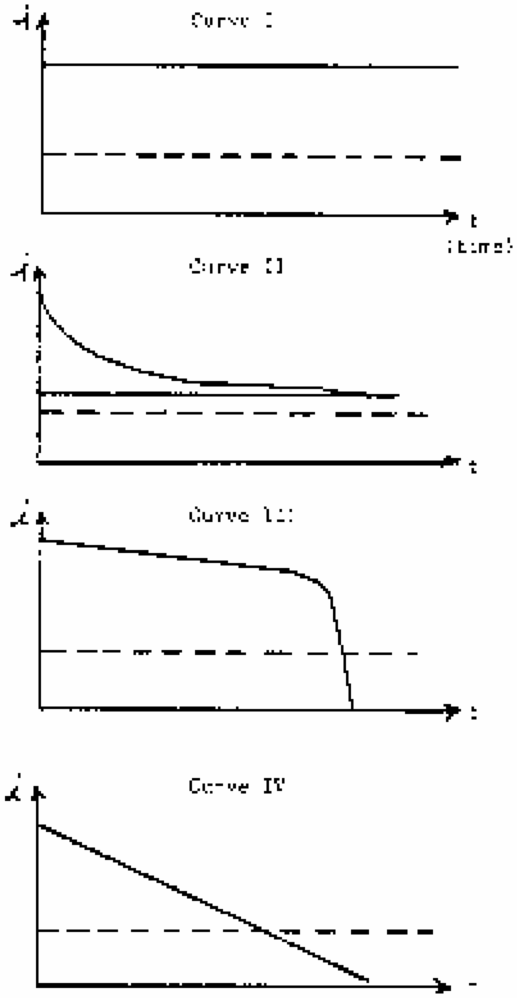
THE EVALUATION OF DURABILITY

The tools available to evaluate durability rely on two investigation methods :

1. the experimental approach through investigations carried out with laboratory methods and procedures
2. the statistical approach through the observation and survey of the actual behaviour of materials and components evaluated in probabilistic terms by analysing the structural and non-structural elements of parts of the building in use.

The question with the laboratory experimentation is: "how to predict the durability of a material or a component merely on the basis of an experimentation carried out with laboratory tests".
For many years, but still today, many approaches of the following type have been developed: when can a product (material or component) enduring without any alteration one or more specific cycles of tests, be characterised with the assignment of a 10, 20-year or more durability?"
That was the question after performing a cycle of accelerated ageing tests where the action of UV rays, water, heat, etc. was alternatively applied to the components under investigation.
But to actually foresee the durability of building materials and components merely on the basis of a single cycle of conventional accelerated ageing tests, seldom leads to explicit results; in fact, the so called accelerated ageing tests are not fully convincing, neither from a theoretical nor from a practical point of view.
Theoretically, because there is nothing that could lead to believe that the accelerated cycles employed produce the same effects on the normal circumstances that generate the ageing effect, but on the contrary; practically, it was observed that materials behave and are classified in a different way according to whether ageing is natural or artificial. (Blachère,1971)
The approach of cause/effect simulation on materials was adopted to assess durability both experimentally and statistically.
The adoption of such method of experimental simulation may not be hindered but it becomes progressively neglected to make room for procedures resorting to "ageing agents" and "ageing indicators".
In this sphere, for what concerns durability referred to environmental agents, the method consist of: 1) establishment of a list to control the most meaningful ageing agents (e.g.: UV, heat, water, etc.) and 2) subsequent expression of the most meaningful characteristics of ageing considered as "ageing

indicators", or in other words, this means constructing the variation curves of physical/chemical characteristics as a function of time in order to allow acceptable forecasts.
The variation curves of "ageing indicators" assumed as a function of the time factor, from which the ageing agents depend, may assume particular shapes; more expressively, the curves of chemical and/or physical characteristics, assumed each time as ageing indicators, expressed as a function of time, may be represented by the following curves typologies:



Figures 1- 4. The curves I – IV showing change in the indicator of aging as a function of the time factor.

The curve of figure 1, synthesized with the trend of the “ageing indicator i”, means that the material did not have any modification over the time as to the ageing agent, in this case the durability as to the ageing agent is unlimited.
The curve of figure 2 represents the measurable value of the ageing indicator decreasing at first from an initial value to an asymptotic value that is greater than the value that characterizes the minimum acceptable performance. Under these conditions, we have an initial modification of the product which is not followed by any other modification; therefore, being the chemical and/or physical characteristics greater than the requested performance, the durability of the material as to the ageing agent may be estimated as being excellent.
The curve of figure 3 corresponds to products whose durability decreases in a regular way. In this case, there will be a limited but predictable durability. In order to predict durability, the “time” parameter defined by the abscissa of the point of intersection of the ageing indicator value with the reference line corresponding to the acceptable threshold of the requested performance must be transformed in “real time”.
The curve of figure 4, synthesizes the most undetermined case for what concerns the prediction of durability: in general, this typology of curves describes materials whose durability is not predictable and limited over the time. (Farhi, 1980)
In this connection it can be extremely interesting to know the exact moment when the sudden decrease of the ageing indicator value takes place, and to know whether the inflection occurs over a more or less short period of time or whether it takes place after a long period of time.
In choosing the ageing indicators to be used during the experimental phase, it is important to have a good knowledge of the ageing mechanism of the products to be examined; in this way it is possible to select the most suitable chemical-physical characteristics to describe the ageing phenomenon generated in natural environments (natural ageing) and in artificial environments (accelerated ageing).
For certain products or materials the ageing indicator may be very easily identified, for example; the elongation at break of polyester fibres spunbonded reinforcements used as a support and impregnated into bituminous membranes, compared with elongations obtained through accelerated thermal ageing of the same type of membranes.
While, for a rigid PVC related to external ageing agents, the ageing indicator may be represented by the DHC index or by the impact force.
Most of the times the ageing indicator does not represent the product’s “performance” in restrictive terms, but it more simply expresses a conventional characteristic to be used in the subsequent evaluation phases.
In this connection, it is useful to define the evaluation criteria that are usually assumed to measure the durability of building products and/or materials in utilitarian terms.
A construction element is no more lasting or it has failed when it has completely or partially lost one or more of its characteristics, so that it is no more suited to the use it was destined to when manufactured.
The characteristics it must maintain are of a geometric, physical, chemical and aesthetic nature, while the factors that cause the deterioration of the construction element can have a physical, chemical or time-related nature.
The duration of a construction element is identified with its “service life”.
Ageing is the irreversible alteration, in a generally pejorative meaning, caused by the passing of time on materials.
Ageing resistance is an index of the aptitude of each material to maintain its characteristics over the time, in a real environment, but in stand-by conditions, that is to say without any mechanical stress.
The durability of each material is a characteristic deriving from objective observations about the predictable behaviour of the material over the time, under real-conditions stresses.
Anyway, having defined the evaluation parameters, a certain number of observations are needed to identify ageing agents in order to perform laboratory experiments; in fact, the purpose of the experimentation is to shorten as far as possible the tests, without “distorting” the ageing phenomenon.

With regard to this, for example, if materials are subjected to a higher temperature as to the “critical” temperature of the product or to higher temperatures than “service” temperatures, unreliable results are obtained.
This is why it is very important to carry out natural ageing tests simultaneously, and to record during this phase of natural life the variations of ageing indicators and to compare the obtained variations with those obtained with the ageing indicators of accelerated ageing as obtained in laboratory.
This procedure serves two purposes: a) it verifies that the variations of laboratory ageing indicators are basically the same as obtained through the exposure to natural atmospheric agents and, b) it attempts to express a relationship between the “time” factor measured in laboratory related to “real time”, in order to make it possible to extrapolate the results obtained with the estimation of the predictable life of materials.

VERIFICATION OF DURABILITY ON EXISTING WORKS

It is possible to examine the durability of materials, components and structural parts of buildings simply going by the observation of in service elements without having to resort to laboratory experimentation.
Under these conditions, attention should be drawn to characteristic points and elements of the observations that have been made, or otherwise carry out a statistical survey.
In any case the survey implies that the examined material or component be well identified through the observation since the results of the observation can only be applied to well identified materials or components.
To make this kind of investigation usable, it is necessary to rely on a wide statistical sample that, to the purpose of the survey, must be sufficiently representative of a given phenomenon to be investigated.
Anyway, by verifying the behaviour of in service materials, it will be possible to obtain the data needed to “detect” durability rather than to “predict” it. This method can be applied to materials or systems that are practically subjected to no design development. The method is not suitable for those innovative materials and elements where the person in charge of the survey has no background experience.
Such materials and elements are in fact progressing fast. (Over the early phases of development and formulation of a product, several components are varied. These components may regard the product’s composition, assembling methods or the installation of a particular element).
In other words, this investigation methodology is extremely useful and provides results when used as a complementary addition to the laboratory experimentation, since the behaviour verification made through observation allows laboratory experimentation to calibrate the instruments and makes it easier to adapt them to the needs of correlation of data gathered with the in-situ behaviour of the observed materials and elements. (Sjostrom , 1987)
Moreover, the verification of the behaviour through statistical observation is often applied to check the technical assessment rules as concerns many elements and components of the building, in order to assess durability related to environmental agents and also to assess durability related to the stresses caused by users. Materials can be considered ready to enter the standardisation field only after it has been established that the in-situ verification of the behaviour of materials and products can be achieved by going through the statistical observation of characteristic parameters.
This can not be done rapidly in building because when it comes to durability, building materials and structural elements are expected to provide better performances if compared to other consumer goods.

CONCLUSIONS

A better understanding of durability is to be expected only when the information it must provide are expressed in quantitative terms. For example, this means that the expectations about service life, the deterioration process and the maintenance schedule should be expressed in years. State-of-the-art

applied technology based on new-materials science makes this kind of investigation possible. Generally speaking, everybody agrees upon the purposes to be attained by this kind of activity, namely the design and construction of durable buildings. But durability is frequently taken into account without a strict and serious technical or scientific logical basis.
The approach to be adopted when dealing with the durability of structural elements and products used in building should clearly refer to a logical and utilitarian methodology of durability assessment.
The adoption of such a criterion implies lengthy and onerous investigations. This is the tribute innovations must pay to permanently establish themselves in the building field.

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