Test Methods for Service Life Prediction: An International Status Report

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Abstract

It has been deeply investigated by various researchers how to predict service life of building materials and components both before and after that the ISO 15686-2 “Buildings and Constructed Assets - Service Life Planning - Part 2: Service Life Prediction Procedures” was first published in 2001. Although this standard clearly state a systematic methodology for service life prediction of building components, a review of most used service life procedures highlighted quite unexpected results.

This paper briefly presents the outcomes of the CIB W80 WG3 “test methods for service life prediction” state of the art report where eleven tests procedures for service life prediction of different building components or materials are analyzed in order to highlight differences and similarities among different test procedures and between each test procedure and the ISO 15686-2. The first result obtained is the evidence of two very different approaches to SLP:

- the first approach derives from studies on materials and usually provides for a test method that can be used on a single material, no matter how the material can be used in real project, and characterised by accelerated aging agents that aren’t always related to real climate agents and are often limited to one or two contemporary;

- the second approach is more related to the ISO method and is more used on building components then on materials. This second class of method usually has a performance approach to service life prediction and often gives information not only on the service life but also on performance decay over time.

An organic view of different test procedures may help to identify what are the steps to be done in order to come to a more pervasive use of the ISO service life prediction methodology.

Keywords: service life prediction, laboratory tests procedures, building components and materials

1. Service life prediction

Service life prediction is one of the most important parts of service life planning of building and building components. The knowledge of building components service life is crucial in many design phases, for example it is essential in operation and maintenance cost estimate, but strongly depends on the availability of durability and service life data on components and products, as requested in the European Construction Products Directive.

It has been deeply investigated by various researchers how to predict service life of building materials and components both before and after that the ISO 15686-2 "Buildings and Constructed Assets - Service Life Planning - Part 2: Service Life Prediction Procedures" was first published in 2001. Although this standard clearly state a systematic methodology for service life prediction of building components, an investigation of most used service life procedures highlighted quite unexpected results.

The following part of this paper will guide the reader though eleven different tests methods for service life prediction and allow him to acknowledge that:

- there still is a problem in identifying the difference between building material, component and assembly;

- the structure of the test procedure may be differ from the proposed ISO 15686-2 structure in many points;

- the duration of the tests are very different;

- the correlation between aging agent and climatic data is often weak

Conclusion will try to give some advice to researchers challenging service life prediction of building components.

1.1 Best practice

Although there is a well know standard on service life prediction methods, the ISO 15686-2 "Buildings and constructed assets - Service life planning - Part 2: Service life prediction procedures", the best practice all over the world does not always follow the standardized procedures.

An in-depth investigation of test methods used all over the world on different materials/building components highlighted two different approaches to service life prediction:

- the first approach derives from studies on materials and usually provides for a test method that can be used on a single material, no matter how the material can be used in real project, and characterised by accelerated aging agents that aren't always related to actual climate agents and are often limited to one or two at the same time;

- the second approach is more related to the ISO method and is more used on building components then on materials. This second class of method usually has a performance approach to service life prediction and often gives information not only on the service life but also on performance decay over time.

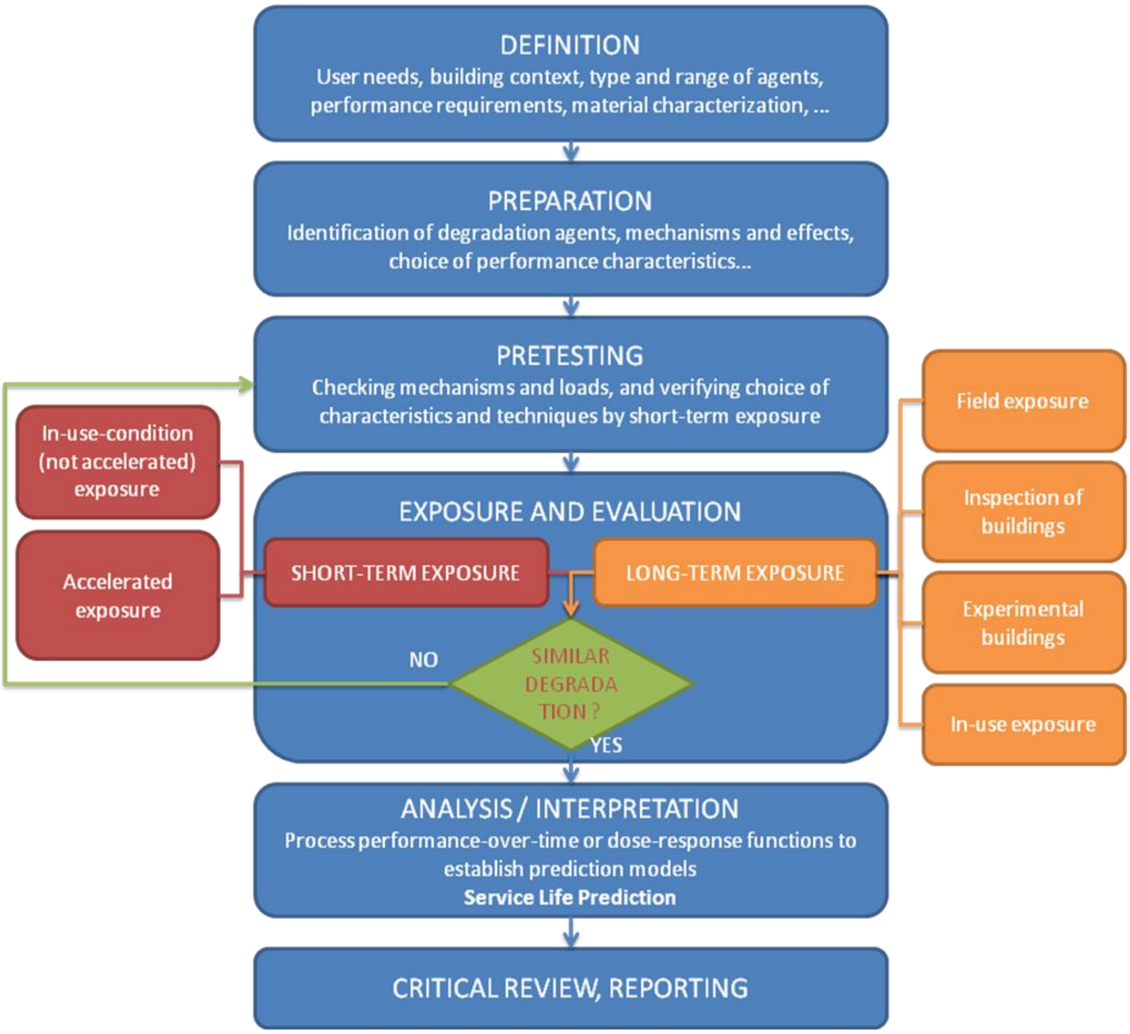

Figure 1: Service life prediction procedure (ISO 15686-2)

Examples of the first type of test methods are the ones used to test concrete (Raado 2003, CEN/TR 15177), woods (Östman 2005, Gjelsvik 1986) and metals (ISO 11997-1, ISO 11997-2, ASTM STP 1238), while the second approach is most common for building components and examples can be found for masonry (Daniotti 2005), ETICS claddings (ETAG 004, Sahal 2004, Daniotti 2008), cementitious façade renderings (Flores-Colen 2008), pitched roof (Annex B of EN 14509, Alaimo 2005, Alaimo 2006), flat roof (Nicolella 2008), external load bearing wall (Ciribini 2007).

A synopsis of the best practice found during the investigation of over one hundred papers or standards can be made and it is also possible to compare different approaches used for each components/materials in a table that will be useful in order to point out some conclusions. This is done in Table 1 for building materials and in Table 2 for components, in these tables it is possible to compare every test methods in term of aims, procedures and outcomes

Table 1: Synopsis of all testing methods presented for building materials M. C = Component, CS = Composition of more phases within the cycle, CDA = Climate Data Analysis, EE = Extended Exposure to the same agent, Y = Yes, M = Material, N = No, NS = not specifie

	Test name	*Wood*	*Metals: condensation*	*Metals: spray salt tests*	*Metals: sulphure dioxide*	*Metals: ISO 14993*	*Metals: ISO 11997-1*	*Metals: ISO 11997-2*	*Concrete: carbonation*	*Concrete: chloride penetration*	*Concrete: sulphates*	*Concrete: freeze -thaw*
Aims	*1. SLP based*	*Y*	*N*	*N*	*N*	*Y*	*Y*	*Y*	*N*	*Y*	*N*	*N*
	2. Material/ Component	*M/C*	*M*	*M*	*M*	*M*	*M*	*M*	*C*	*C*	*M*	*M/C*
	3. Agents	*4*	*2*	*1*	*1*	*3*	*3-4*	*5*	*1*	*1*	*1*	*1-2*
Procedure	*4. Refining SLPP*	*Y*	*N*	*N*	*N*	*N*	*N*	*Y*	*Y*	*N*	*N*	*N*
	5. Lab exposure	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*
	6. Ageing cycle (Simple / Composed)	*SC*	*SC*	*EE*	*EE*	*SC*	*SC*	*SC*	*EE*	*EE*	*EE*	*SC*
	8. Outdoor exposure	*R*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*Y*	*NS*
	9. Rescaling	*Y*	*NS*	*NS*	*NS*	*Y*	*Y*	*Y*	*N*	*N*	*N*	*N*
Outcomes	*10. Link to ESL method*	*Y*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*Y*
	11. Performance(s) over time	*Y*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*Y*	*N*	*N*
	12. RSL	*Y*	*N*	*N*	*N*	*Y*	*Y*	*Y*	*N*	*Y*	*N*	*N*
Standards for ageing procedure	*13. Standards*	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*

	14. Fully adopted	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*
Performances evaluation	*15. Standards*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*Y*	*NS*	*NS*	*NS*

Table 2: Synopsis of all testing methods presented for building components. C = Component, CS = Composition of more phases within the cycle, CDA = Climate Data Analysis, EE = Extended Exposure to the same agent, Y = Yes, M = Material, N = No, NS = not specified

	Test name	*Masonry walls*	*ETICS*	*Renders*	*Pitched roofs*	*Flat roofs*	*Load bearing walls*
Aims	*1. SLP based*	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*
	2. Material/ Component	*C*	*C*	*M/C*	*C*	*C*	*C*
	3. Agents	*4*	*4*	*5*	*4*	*4*	*3*
Procedure	*4. Refining SLPP*	*Y*	*Y*	*Y*	*Y*	*Y*	*N*
	5. Lab exposure	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*
	6. Ageing cycle (Simple / Composed)	*SC*	*CS*	*SC*	*SC*	*SC*	*SC*
	7. Outdoor exposure	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*
	8. Rescaling	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*
Outcomes	*9. Link to ESL method*	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*
	10. Performance(s) over time	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*
	11. RSL	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*

Standards for ageing procedure	*12. Standards*	*N*	*Y*	*Y*	*Y*	*NS*	*Y*
	13. Fully adopted	-	*N*	*N*	*N*	*NS*	*NS*
Performances evaluation	*14. Standards*	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*

2. Conclusions

Even if the aim of the best practice investigation was not to cover every building materials or components, some general conclusions can be pointed out. It appears clearly form item n.1 "SLP based" of both table 1 and 2 that most of accelerated tests for materials are simply a pass or fail durability test, while the test method for building components are mainly meant for providing information regarding Service Life, representing then innovative performance based test methods.

This is also evident when considering outcomes (item n.9,10 and 11 of tables 1 and 2): test procedures for building components are usually linked to some method for Service Life Estimation (i.e. Factor Methods, Engineering Methods, Stochastic Methods), allowing to evaluate performances over time and/or Reference Service Life; on the other side a few test methods for building materials have such kind of outputs. Related with the pass or fail durability test approach, it may be highlighted that in general such tests take into account the effects produced by only one or two agents, while of course the service life evaluation purpose implies to consider different agents synergic effects as it is in the actual service life (see item n.3: agents).

All considered tests are based on laboratory ageing procedures (see item n. 5), most of them using the iteration of the same ageing cycle composed by different stages (SC), especially the already mentioned innovative test methods, developed for service life prediction (see item n. 1,6), thus simulating different agents; on the other hand some traditional test methods used for single material (for example: metals or concrete) uses extended exposure (EE) to the same agent (see item n. 3).

Test methods developed for service life prediction of building components aims at estimating service life through the comparison between laboratory results and outdoor exposure through time rescaling, i.e. finding the proportion factor between accelerated and natural ageing (see item. 7, 8). Traditional materials testing procedures seem not to make clear reference to outdoor exposure (see item. 7), but refer to some proportion factor, based on "experience" or data from different industrial sectors (like automotive industries for metals).

Despite a big effort by scientists and researchers, future developments, both on vertical objectives (for example: ETICS-EIFS, external renderings, roofing, concrete metals etc) and on horizontal objectives (for example: the methodology to define accelerated ageing cycle using statistical climatic data, the method to compare lab ageing results with outdoor exposure or building condition assessment data, the method to elaborate experimental data in order to define RSL and performance decay data) seem to be needed.

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