SERVICE LIFE ESTIMATION AND MAINTENANCE IN EXISTING BUILDING. A PRACTICAL VIEW.

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Abstract

The control of the main factors affecting service life, and the management of feedback of data from practice are central in defining Maintenance strategies and operational tools too.
Analysis, interpretation and comparison of data from practice permits improving quality and control of building performance in a life cycle perspective, reducing performance breakdown and helping in management of maintenance interventions.
The research work, which application field is existing building assets, is set in compliance with the international R&D and standardization activities on the concept of Service Life Planning of building. In particular it deals with a methodological proposal for building failures survey and Service Life performance evaluation, providing guidance for planning, documentation and inspection phases according to ISOs 15686 and via Italian normative procedure and operational instruments for Maintenance.
Keywords: Maintenance - Service Life Planning – Collecting data.

1 Introduction

The principles of sustainable development in the construction sector has modified the traditional building process involving considerations on the whole life cycle and on service life evaluation.
The matter, still open, concerns how much the design process has to be modified and what procedures are to be applied so that requirements claimed to the new sustainable building process would be satisfied.
Any systematic approach for service life evaluation, individualizes two essential phases. [1]
The first introduces requirements and performance criterions definition: a systematic classification of requirements, a check-list useful to be translated in technical specifications at the design phase. The second introduces analysis of degradation symptoms and mechanisms and understanding of their interactions with the specific environmental context to which building, each component and material are exposed.
At now however the increasing interest towards service life and potentialities connected with all operational procedures for its forecasting and estimation, an intrinsic limit emerges. It is connected with an evident lack of data opportunely structured to be applied for a reliable evaluation of service life.
The general objective of research comes down from these premises. It deals with the international R&D and normative efforts on the concept of Service Life Planning and on application of Factor Method by ISO 15686 [2] It is aimed with implementation of the aforesaid Method and in particular with the refining of one of the seven factors introduced: the Factor G – maintenance level.
The work presents the early results of a PhD research activity [3] shared with a more general and ongoing work developed by research group, STOA, at DASTEC, finalized to the definition of a guideline to operate on existing building in the whole Region. [4] The paper introduces two steps: a methodological approach and an experimental phase, which deal, respectively, with the characterization of Factor G and a study case.

2 Characterization of Factor G - Maintenance Level and assignment of a value

The strategies individualized for approaching this aspect deal with the need of connoting and contemporarily "filling" a "container" that is not yet sufficiently defined. In particular they concern:
- a rereading of Factor G together: an hypothesis of data for its characterization;
- the gathering and systematic organization of such data (according to ISO/DIS 15686-7)
- the assignment of the range of weight.

The terms connected with Factor G are three, as introduced in the ISO 15686 - 1 Annex E [5]: quality, frequency and accessibility. They all are pre-fundamental requirements for an effective management of maintenance phase.
Quality interests all phases in the building process, assuming specific connotations in maintenance process, also introducing some aspects connected with qualification and certification.
Frequency makes reference to the choice of more appropriate maintenance strategies, introducing costs in life cycle and the most general issue of sustainability in the construction sector connected with coherent use of resources.

Accessibility introduces maintainability and its importance as essential requirement in the design phase. It is tightly connected in-use phase with inspection and diagnostic procedures; as well as with the most general aspect of flexibility.

Starting from these premises the work traces back the "data characterizing" the Factor G to the "ways of breakdown" of building systems and components in a specific context.
This suggested simplification is one of many possible hypothesis. Clearly it has some limits but however it seems congruent with the objectives to characterize Factor G.
The steps are simple. With reference, for instance, to a certain component, we have:

- Definition of component
- Definition of functions and conditions of component
- Definition of relative ways of breakdown

from which come down some specific analyses for detection of:

- Possible causes of every way of breakdown
- Possible effects on functionality of component and/or of systems
- Possible effects on other connected elements

And, therefore, for detection of:
- Ways and procedures for breakdowns surveys.

The proposal allows a first attempt of management of manifold variables involved in the characterization of the Factor G through considering building system in its components and defining for each one their specific requirements and relative performances, also handled from available bibliography if necessary.
Future objective is connected with defining a list, that will consider, together with the degradation aspects, both obsolescence and costs aspects. In fact both these issues address more and more often the politics and therefore the maintenance strategies.

The principle of gradualness and progressive refinement is one of fundamental reference for data gathering and structuring proposed. It allows using all data already available making them more and more reliable according both to increasing knowledge and both to new data in manifold forms. The need is to transfer and make useful all the available information, structuring a system of information on behaviour of components and/or system in use in a specific context,.
Specifically it would be functional at the maintenance level both as "intervention on the existing building" in order to remove actual breakdowns; and both at the design phase as "forecast and control of possible breakdowns through the predisposition of a sequence of opportune actions during the time (inspections, surveys, etc). According to this it would be possible defining a "list of requirements" such that to be introduced at the design phase through which operating forecasts on the possible breakdowns and on the relative ways of intervention in that specific context.
Particularly data gathering and structuring referred to the ways of breakdown observed in a specific context, shapes the possibility (in the future) to structure a data-base useful for estimation of Reference Service Life according to the contents of ISO/DIS 15686-8. [6]

With reference to the assignment of the "range of weight" it is fundamental determining the terms to which attribute respectively, the value superior and inferior that in ISO/DIS 15686-8 is fixed for every Factor in: 0,9-1,1.
In the case of Factor G, it could make reference to a "series of judgments of value" having Factor G a qualitative nature instead of a quantitative one
The variability of the range, really, depends both from availability and reliability of knowledge, and from external conditions tied up to choices referring to maintenance politics.
As previously introduced when the mechanisms of alteration and therefore the ways of breakdown and the causes to which such phenomenon could be brought back, the "weight" assignment to Factor G (0,9/1,1) essentially depends on the measures "taken" (values >1,1) or "not anticipated" (values < 0,9) to prevent such conditions.
It is evident that the most appropriate place to translate such indications, in the case of new construction, is both at the design level, through specifications on technological and material options etc; as well as at maintenance level making explicit a series of actions of control that must be foresee to prevent performance breakdown of considered systems.
As a follow-on from the aforesaid considerations it appeared congruent the hypothesis of structuring a "memory list" based on the individualization of procedural tools (Plan of Maintenance, etc.) inside the national Italian standard, through whose control (presence/absence) it would be possible to deduce a value superior, inferior or intermediary of the range for Factor G.

It would be justifiable assuming a value of 1,1; when knowledge related to mechanisms of breakdown and provisions for their prevention are well known and transferred into each or one of available plan.
Hypothesis is associating to every procedural tool a so more elevated coefficient depending on being directly finalized (Á.), or (B) indirectly, to the control of behaviour during the time of building systems.
Assigning furthermore to every tool a value from 2 to -2depending on the possibility that it would be available, applicable and opportunely compiled. (2: complete; 1: partial; -1: approximate -2: uncompleted)
From which follows for Factor G:

Poor - 0,9: lack of any tool to guarantee correspondence among requirements at the design level and performances over the time.
Assumed - 1: connected with intermediary values to the presence of some of suitable tools well done /or

compiled.

Good - 1,1: presence of one or more tools to guarantee correspondence among requirements at the design level and performances over the time.

3 Experimental Phase: the Study Case

Experimental phase deals with checking hypotheses related to characterization of Factor G, and structuring an "informative system" based on a progressive implementation of information gathered at different scale of analysis.

The existing building and particularly facades of buildings in the historical Centre of Bivongi, Italy, is the application field.

The gathering and the formatting of data introduce two specific steps, each of one based on a sheet system partly structured according to some indications proceeding from ISO/DIS 15686-7. [7]

- An Analytical Phase finalized to a systematic knowledge of urban centre and relative environmental context.
- A Technical Phase or diagnostic phase, whose central operativeness is documentation, interpretation and evaluation of degradation conditions of some technical components of building facades.

The result is an articulated flexible and implementing sheets system that set up a more general Structured Knowledge Program and its progressive refinement (see Table 1).

	SHEETS SYSTEM	
		TITLE
ANALYTICAL PHASE	*Sheet* R-CA -1	Environment, climatic and exposure conditions analysis
	Sheet R-AI -1	Morphological and dimensional data 1
	Sheet R-AI -2	Morphological and dimensional data 2
	Sheet R-AI - 3Tn	Typological Analysis
	Sheet R-AF -1Tn	Consistence and level of use
	Sheet R-AT- 1Tn	Analysis of repairing and replacement interventions
	Sheet R-AT- 2Un	Analysis of typical constructive-technological aspects
	Sheet R-AT -2A	**Abaco of typical** constructive-technological aspects
	Sheet R-AT-3Tn	Analysis of use of materials in buildings
	Sheet R-AT4 S	**Synthesis** of typical constructive-technological aspects and of use of materials in buildings
DIAGNOSTIC P.	*Sheet* RD-1Un	Diagnostic survey, n. 1 Caracterizzation of degradations aspects and performance evaluation
	Sheet RD-2Tn	Diagnostic survey, n. 2 Caracterizzation of degradations aspects and performance evaluation
	*Sheet*RD-3S	Diagnostic survey, n. 3 **Synthesis** Caracterizzation of degradations aspects and performance evaluation
	Sheet VP-1Un	Performance evaluation and associated risk n. **1**
	Sheet VP-2Tn	Performance evaluation and associated risk n. **2**
	Sheet VP-3S	Performance evaluation and associated risk n. 3 **Synthesis**

Table 1: "Sheets System".

As regards Technical Phase some data have been acquired that have allowed defining the Centre according to its own geographical, environmental, urban aspects and, subsequently, characterizing buildings heritage assets placed along an important urban "route": the "Route of the Fair."

The environment conditions analysis, and the climatic and exposure aspects of the Centre and of the analyzed building facades, make reference to some standard document. [8] [9]

The "route" analyzed turned out to be a very useful and representative sample of external fronts characters, individualizing with effectiveness its varying and invariant according to typological, constructive and material aspects.

The survey phase gathered morphological and dimensional data (linear development, surface of façade, building height, inclination and width of the run, index building and road width, and so on) useful to a preliminary knowledge and interpretation of interactions between building facades and conditions in the specific context. (Sheet R-AI - 1 Sheet R-AI - 2)

Contextually, specific investigations finalized to characterization of consistence and level of use (Sheet R-AI 3Tn and Sheet R-AF 1Tn) allowed a detailed functional description of the whole "route", and an evaluation of repairing and replacement interventions of building facades. (Sheet R-AT 1Tn).

Furthermore investigations allowed verifying typical constructive-technical aspects and use of materials with some applied sheets and abaci advisably built (Sheet R-AT 2Un).

The Technical Phase in this experimentation takes care of one Technological Unity, particularly: the masonries.

Data have been acquired through the diagnostic survey sheet (Sheet RD) and performance evaluation survey sheet (Sheet VP), according to inspections, photographic survey, instrumental tests, etc.

Starting from a open list of some possible pathologies of masonries, requisite and relative performance specifications, a series of relative parameters are introduced in order to allow a preliminary qualitative and quantitative characterization of the observed phenomenon, together with the definition of the entity of degradation aspect and the possible causes.

Contextually, it has been structured a "tendentious" classification of the possible "critical junction" of the building with specific reference to technological unity analyzed.

All this in order to understand both the synergies rising between external agents and the alteration and degradation aspect of materials as well the way how which such degradations interest technological system I n the specific context.

This Phase allowed a first evaluation of "technical quality" of masonries expressing a general judgment: on their functionality and their residual performances according to the categories proposed by ISO/DIS 15686-7, actually related to the type of symptoms, the consequences in comparison with poor performance levels and the associated risk.

As regard to the assignment of the "range" of weight to factor G in the specific context. We have that analysis of alteration mechanisms and therefore ways and causes of breakdown allowed defining a possible range" of weight to the Factor G (0,9 - Poor; 1 - Assumed; 1,1 - Good) according to the measures "taken" (values >1) or "not anticipated" (values < 0,9) to prevent the aforesaid degradation phenomenon.

On the base of hypothesis of structuring a "memory list" of procedural tools (Plan of Maintenance, etc.) it appeared congruent that when the aforesaid Tools result activated it would be justifiable to assume for the Factor G in the analyzed context a value of 1,1.

4 Results

The reached results allow to attribute, for the study case, a value to the Factor G as reported in Table 2

ASSIGNMENT OF RANGE TO FACTOR G ELATING MASONRIES						
MASONRIES					RANGE	DESCRIPTION
2A1	2B1	2C1	2A1 INT	INT.		
70%	80%	30%	40%	50%	Poor 0,9	lack of an any system of protection towards the atmospheric agents, of a suitable system for meteoric waters, of shutters and technological details for protection of façade from water (rain)
30%	20%	60%	50%	50%	Assumed 1	intermediary values connected with the availability of some of the considered systems
		10%	10%		Good 1,1	presence of all the aforesaid systems that prevent pathological degradation process and the control of technical element's behavior during the time according to the relative performances provided

TYPOLOGY OF MASONRIES	
2A1	M. of stone
2B1	M. stone and brick
2C1	M. of brick with lime plaster
2A1	M. of stone with lime plaster
PLASTER	plaster made with cement

Such values expressed in percentage allow to have since now a picture of useful reference to orient possible future operative actions .
A knowledge that is necessary to consider it is the total absence of any operation of maintenance that explains partly some of the results.

Table 2: "Factor G value for specific context".

Contextually further results are:

- Definition of an experimental approach that allows coordinating essential knowledge both for characterization of Factor G and for evaluation of residual functionality of the constructive elements;
- Structuring of a " System of Sheets " looked as a "tool and support to the decisions" in refurbishment or in maintenance routine;
- Acquisition of punctual knowledge about behaviour of building systems during the time in a specific environmental and in-use context, useful to a structuring of a data-base related to the observed ways of breakdown.

Particularly, the "System of sheets" represents an open and flexible tool. In a future hypothesis of extension of research to all buildings elements, it would be functional to evaluate the percentage distribution of the events of breakdown in comparison to the different Technical Elements of one or more Technological Unity. It also would be functional in detecting, a possible "risk" elements classification useful to operate forecasts of breakdowns and to suggest control and intervention during the life cycle.

5 Conclusions

The research aim has been to operate inside normative efforts related to ISOs 15686 that, with reference to Factor Method, highlight progressive refinements and precise statements based on practical application and verification. The early results appear, at now, for some aspects, not conclusive tout court, opening to further close examinations and to new developments. It's clearly fundamental verify the applicability of Factor Method to existing building as well as its implementation through the refinement of Factor G together with the others six factors.

The formulated hypothesis and the relative application opens, contemporarily, toward a specific operativeness connected to intervention on existing building and turns out some future opportunities of research through active collaborations with the administration of Bivongi.

In fact, the most appropriate place to translate the knowledge proceeding from research and the relative attribution of the range of weight to the Factor G, is in structuring Guidelines, as it has been already requested by the Local Administration.

This tool would allow in suggesting the most opportune actions, guaranteeing for the analyzed cases a value of Factor G of, at least, 1 or 1,1. Moreover, the same indications could be translate in useful information at the design stage in order to suggesting opportune technical choices as well as at maintenance level detecting a series of actions for controlling and preventing performance breakdown of technical elements.

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POP CEE Regione Calabria 1998-2000, "*Tools for guide and technical control of design and construction stage in interventions in Calabrian historical centres"*

COFIN 2001, Criteria and tools for evaluating reliability of buildings and buildings component

POR Calabria 2000-2006 Measure 3.16 Action 2 - "*Formation, information and advice in the management of the processes of designing of existing pre-modern building. Employment of Laboratory Material for the architecture, La.M.A./S.T.O.A. Section small historical Centres of Calabria*"

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