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# THE METHOD BY FACTORS TO ESTIMATE SERVICE LIFE IN BUILDINGS PROJECTS ACCORDING TO NORM ISO 15686

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**Abstract**
This paper approaches the review and explanation of the method for estimating factors for service life on buildings projects in accordance with ISO 15686. This paper discusses generally the most important factors affecting the durability of buildings and addresses an example of a case study which illustrates this norm. This article describes and differentiates the concepts of reference service life and design service life in the estimation process of buildings service life.
**Keywords*:*** Service life, Durability, Method, Buildings, Factors.

## 1. INTRODUCTION

The planning of durability in buildings must be carried out by means of learning and applying the corresponding norms such as the Canadian technical norm CSA S478-95 (R2001) “Guidelines on Durability in Buildings”, whose copyright belongs to the Canadian Standards Association (CSA); as well as knowledge on the technical norm ISO 15686 “Buildings and constructed assets-service life planning” and the model or methodology called LEED®, in its Canadian version, which includes considerations of architectural design to improve and increase the durability of the building (CaGBC, 2011). It is worth mentioning that the success of the project, as for durability, will depend to a large extent on the interpretation and application of these norms and lineaments in the process of building design and on the criterion and professional experience of the designer or architect and also on the knowledge on design and construction of all the members of the involved team project.

Planning durability is closely linked to the service life planning of the project; as a matter of fact, the Canadian norm CSA S478-95 (R2001) is very similar in many aspects to norm ISO 15686 “Buildings and constructed assets-service life planning”, mainly on the considerations of the factors to estimate the service life of the components, construction materials and parts that the buildings are composed of.

The definition of durability for buildings according to the Canadian norm CSA S478-95 (R2001) refers to the capacity that a building or a building component has to reach the optimal performance of its functions in a determinate environment or place without the need to carry out neither mayor corrective maintenance nor

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reparations or replace spare parts and materials (CSA, 2001). It is worth noticing that durability is not a period of time, but a capability or quality of the building or of one of its components to perform well in what it was designed for, in a determinate environment and for a determinate service life; separately, the concept of service life is defined as the period of time after installation or construction during which a building or the parts comprised in it meet or exceed the performance requirements for which they were designed and built (ISO, 2000). Therefore, in spite of being different concepts, they are closely linked, since both concepts intervene in the process of design and construction of buildings and determine aspects such as maintenance costs, procedures of both preventive and corrective maintenance, performance of components and construction materials, security in the building, effects from the environmental impact caused by the building and even impacts on the comfort of the users along the entire lifecycle of the building.

## 2. DURABILITY AND SERVICE LIFE IN BUILDINGS ACCORDING TO THE TECHNICAL NORM ISO 15686

Nowadays the use of models and methods of sustainable design in construction, for instance the U.S. LEED®, or the British BREEAM® models are experiencing a boom in the sustainable design of buildings; not only does the impact of these methods extend to the process of sustainable architectural design, but also to the planning of service life of the construction elements (Hernández-Moreno, 2010) and the improvement of the building durability. Figure 1 shows the stages of the lifecycle of buildings; this figure helps us understand better in which stage the planning of service life of a building begins. Figure 1 also shows that the service life of a building comprises the stages of use, operation and maintenance of the building, as its service life begins from the ending of its construction (ISO, 2006) and it is in the stage in which the building is utilized that the strategies of design and durability have to be considered from a prior estimation of service life. An adequate or recommended way to estimate the service life in building design is the method by factors, which has to be considered from the pre-design and design stages. In pre-designing service life it is important to define the factors that will affect the durability of the building and which in addition have to be taken into account to plan service life, as for the calculation of or estimation of service life. In the design stage, said service life is taken as a parameter to learn the time each of the components will work or be useful for (Masters and Brandt, 1989) to finally design on the basis of a determinate or foreseen period for the building as a whole (seen as a system) and thus take the pertinent previsions in the design stage and later the adequate actions in the construction stage.

The most relevant factors that affect the durability of buildings based on the Canadian norm CSA S478-95 (R2001) "Guidelines on Durability in Buildings", as well as the technical norm ISO 15686 "Buildings and constructed assets-service life planning" are:

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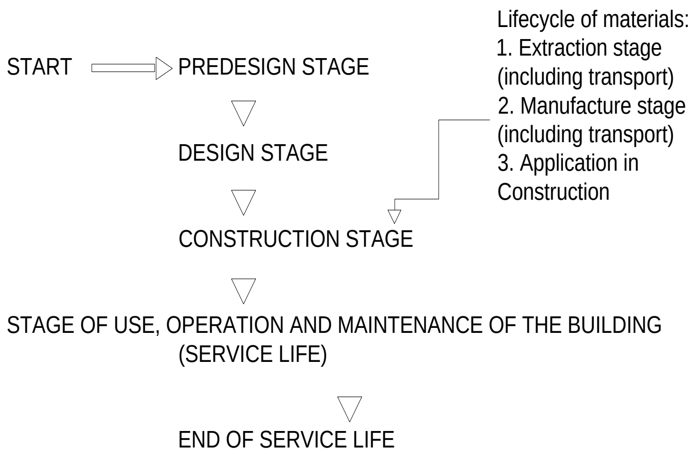


FIGURE 1 - STAGES OF THE LIFECYCLE OF A BUILDING (SOURCE: HERNÁNDEZ-MORENO, 2011)

A. Quality of construction materials and components;

B. The level or degree of architectural and construction design, as well as that of its facilities;

C. The quality and level of the workforce in the execution of the processes of construction and installation, under the corresponding technical norms and construction regulations;

D. The environment inside the building, such as: humidity, temperature and diverse existing chemical and physical agents;

E. The environment surrounding the building, such as climate and urban pollution;

F. The use of the building according to manuals and specifications produced by the designers and builders, which turn into better operability of the building;

G. The degree or level of maintenance according to the specifications in the manual of maintenance produced by the designers and builders and those by the producers or manufacturers of the materials used in the construction.

As a matter of fact, the aforementioned facts are the factors that are evaluated in the method by factors, one of the main methods largely used to estimate the service life of construction materials and components (AIJ, 1993), ISO 15686 prescribes this method based on knowledge referring to materials and technology for construction. The method by factors estimates service life by means of a series of factors that are related to determinate conditions and specifications of utilization of the materials and components of the building. The formula to predict the estimated service life (ESL) by means of this method is:

$$ESL = RSL \times A \times B \times C \times D \times E \times F \times G \quad (1)$$

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Where: RSL is the reference service life of a similar building or of any material or component of the building that can be taken as empirical information by the designer from laboratory tests or information from the product manufacturers (Masters and Brandt, 1989). RSL is only a starting point, as the key to estimate service life is performed by means of thoroughly assessing the aforementioned factors A, B, C, D, E, F and G. Therefore, the assessment of ESL according to the method by factors requires defining a single RSL as well as values for factors A to G. It is worth mentioning that this method by factors is not a predictive degradation model, but one based upon empirical information that can be utilized to plan service life having as reference specific information on the project (Lacasse and Sjöström, 2003). It can be considered that formula (1) contains all of the factors that play a role in the life service of a product; none of the technical norms ISO 15686 nor the Canadian CSA S478-95 (R2001) assign a constant value for each factor, but before applying the formula, the designer must explicitly assign the values of these factors, according to the particular conditions of the project; to do so, the designer must be knowledgeable on the quality of materials, construction systems, deterioration agents and everything related to the project as for design and construction. This method is not structured as a probabilistic method; however it shall be based on probabilistic characteristics of the internal and external characteristics which the construction materials and components are subjected to, thereby the factors may vary according to different statistical distributions and so, the more experienced and knowledgeable the designer is the more successful the project will be (Moser, 1999).

In norm ISO 15686-1 there is an instance of how to apply this method, and it is assumed that the factors must group into three values 0.8, 1.0, or 1.2; it is assumed that each value corresponds to the lowest, mid and highest possible values, and in this part it is where the subjectivity of the qualitative values assigned by the designer appears, this is to say those values assigned by a person decrease a little the reliability of the method if the designer does not have sufficient knowledge and relevant experience for this kind of tasks.

## 3. AN APPLICATION EXAMPLE OF ISO 15686 THROUGH THE METHOD BY FACTORS

Let us suppose the design and construction of a structure for the roof of a mid-sized house in Toluca, State of Mexico, Mexico, which will be built by a qualified enterprise, in this project it has been planned to use a traditional system of plain concrete slab, made with Portland cement with an F´c= 180 kg/cm2 and reinforced steel of Fy= 4200 kg/cm2 built in situ.

Using the method by factors that allows calculating the Estimated Service Life (ESL) by means of the correction of the Reference Service Life (RSL) by diving or multiplying the values in a range of .08, 1.0 and 1.2 and using formula (1):

ESL= RSL x A x B x C x D x E x F x G

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1st. The value of RSL is determined, in this case by means of a document from the National Institute of Building Science (WBDG, 2011), which contains a design guide called Federal Green Construction Guide for Specifiers, in the section referring to Service Life Requirements in Edifications, section 1.6, subsection 01120; a RSL of hundred years is selected, it corresponds to a structural element that responds to conditions of heavy maintenance and difficulty to replace the element itself.

2nd. The value for each factor is determined:

| Factors | Assigned values |
|---|---|
| A. Quality of the materials and components of the construction. | 0.8 |
| B. The level or degree of architectural, construction and installation design. | 1.2 |
| C. The quality and level of the workforce executing the construction and installation processes under the corresponding technical norms and construction regulations. | 1.2 |
| D. The internal environment of the building: humidity, temperature and other existing chemical and physical agents. | 1.0 |
| E. The external environment of the building: climate, and urban pollution. | 1.0 |
| F. The use of the building on the basis of manuals and specifications by the designers and builders, which implies the better operability of the building. | 0.8 |
| G. Degree or level of maintenance according to the specifications set in the operation manual produced by the designers and builders and by the producers of the materials used in construction. | 0.8 |

(Source: author's own elaboration)

3rd. The values are substituted in formula (1):

ESL= 100 x 0.8 x 1.2 x 1.2 x 1.0 x 1.0 x 0.8 x 0.8

ESL= 73.72 years

4th. The estimated value of Service Life for this case corresponds to 73.72 years, which means that the Design Service Life decreased because the durability conditions of the project were neither the best nor the most optimal, mainly as for the quality of the materials and workforce in the in situ construction of the concrete slabs, as in Mexico in general, norms and regulations, operation and maintenance are not followed, which noticeably decreases the service life of the building.

This example is a mere hypothetical case in which RSL is determining, as it is not only about the design service life but a starting point to estimated service life, which will indeed be used as the service life of a determinate project. It is important to mention that the estimation of service life in components or construction materials is relatively easier that the estimation of the whole building system, in which formula (1) would not only be applied to single component but to a large number of construction components comprised in the complete system, i.e., the building; likewise, the success in applying the method by factors will depend on the

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experience and knowledge of the designer, and the more experience and more knowledge on design and construction the more reliable the estimation of service life.

## 4. CONCLUSIONS

The preset work outlines the meaning and concept of the method by factors applied to the estimation of design service life for buildings; yet, at the same time we manage to describe and differentiate the concepts of reference service life and design service life, which are closely related in the process of assessing service life. Below, we present the most important conclusions that refer to the method by factors used to assess service life according to norm ISO 15686:

- In the first place, it is worth mentioning that the method by factors is not a probabilistic predictive model to determine the service life of a construction component or of the entire building, but a method to approximate service life under specific design circumstances determined by the subjective criterion of an experienced designer, in which the reliability of the method directly depends on the knowledge and experience of the very designer.
- It is concluded that the durability factors of the Canadian norm CSA S478-95 (R2001), which completely agrees with the factors of estimated service life from technical norm ISO 15686, assesses service life by means of applying a series of factors that are related to determinate conditions and specifications of use of materials and components of the building.
- Reference Service Life (RSL) is only a starting point, as the key to estimate service life is by means of the appropriate assessment of the aforementioned factors, but at the same time this parameter is very important to obtain a better approximation to design service life.
- It is also concluded that two of the factors that most affect the durability and service life of buildings in Mexico are, firstly, the quality of materials, as there is no good quality control for most of the materials used in construction in Mexico; and secondly, maintenance in Mexico is low, for many times there is no user manual for a determinate building under certain requirements of use and maintenance.
- The method by factors is only recommended if the experience and knowledge of the designer are very good, likewise it is recommended for a very fast and efficacious estimation, mainly in systems such as an entire building. If a very accurate service life is sought, and the designer does not have sufficient experience and knowledge to perform such an approximation, other alternatives will be necessary to calculate service life, namely predictive, statistical and mathematical methods and

even deterioration simulation in laboratories directly on test specimens of the materials and components of construction.

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