Innovative Design & Construction Technologies – Building complex shapes and beyond
May, 6-7th 2009

The building materials' and components' database for an evidences-based design approach

Bruno Daniotti, Mario Claudio Dejaco, Sonia Lupica Spagnolo

Politecnico di Milano – Building Environment Science and Technology (BEST) Department

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The design process has always to meet, since the preliminary approaching step, every specific requirement which is foreseen for the building to realize. In a certain way, this operation represents an every time different prototype which varies according to the design demands for the considered room and the carried function, but also according to the used building materials: such an approach is already difficult by itself, but if we consider that at present the availability of technical information about building materials, components and systems is often incomplete or lost among many documents or even absent, it is evident that the designer's activity becomes very uneven. That is the reason why, the definition of a database for building materials in which indicating each informative attribute to be considered becomes fundamental in order to:

- provide a correct, univocal, clear and complete information for every building stakeholder;
- help manufacturers to individualize the real needed information to join to their products, so to allow an easier comparison among products themselves and, as a consequence, to push towards a better quality of the entire building process (improving production, design, but also management).

The paper deals with an analysis of the necessary information for designers and for maintenance planners, providing different levels of deepening according to the intended use. A particular attention will be paid on the so called "evidences-based design" which gives the opportunity to point out and to consider the most meaningful design matters, making an aware choice of building materials, components and systems. The International Service Life Data Base developed by CSTB with Politecnico di Milano will be reported as a tool for service life prediction, and buildings' management.

Introduction

The current cultural framework of the building process should lead to develop a design step based on a careful evaluation and respect of fundamental needs (and following requirements) such as safety, comfort, usability, aesthetics, management, integrability, environment protection, which are all correlated to buildings' durability. This means that the design step has to take into account each possible evolution of building elements (and, in particular, their performance levels) over time.

The necessary information to correctly choose building materials and components comes essentially from two sources:

- data provided by manufacturers, which are usually more commercial than technical;
- experience gained from the observation of building products' behaviour over time which allows stakeholders such as designers, installers and maintainers accumulating a precious know-how they are not always available to share.

Although information papers (technical and nontechnical ones) can provide enough indications to permit a correct evaluation and choice of construction products, such indications are often scattered inside not standardized documents, which can require long and difficult interpretations. That is the reason why the comparison among analogous materials realized by different manufactures can be very complex and many times impossible, so that the less scrupulous operator chooses always the same materials and components from habit and not according to a careful evaluation about their employment. In this optic, the predisposition of standardized technical information should favour a better knowledge of building products and, as a consequence, a higher quality level of building designs.

Moreover, it is also important to take into account a differentiation of performance levels according to the intended use: for instance, private and public buildings can require different performance levels which can vary significantly. That is why the hotel field differs from the common residential field for many performance requirements or why flooring materials, even if they have to satisfy "usual" needs (users' safety, comfort, usability, etc.) generally express different performance evidences: for example, in hospitals flooring materials vary the level of asepticity according to the place in which they are used (at the entrance, in a corridor, in an operating-theatre, etc.) and this provokes different problems of cleanability and durability for covering materials which have to be accurately taken into consideration since the first design steps in order to guarantee a better course for the entire building process.

A database for collecting building materials and components' information

The collection of building materials and components' information appears as a very useful tool to improve the quality level in the construction field: if it is structured in order to provide all the necessary information in a clear and effective way, it can allow a fast and correct choice and use of the building material or component to employ.

The definition of such a database is based on the following considerations:

1) it has to provide a complete, but synthetically, information (an excessive quantity of data can jeopardize the compilation, the updating and an effective use of data themselves); it is difficult to foresee the suitable quantity of data to give, but among these it is necessary to make a selection according to the main users' needs and to the intended use (the evidences-based design approach), with a possible deepening to study materials' characteristics;

2) it has to allow a precise and fast searching (from this point of view, the needs/requirements classification is useful because it gives the possibility to select a specific set of data);
3) manufacturers have to provide technical information in a uniform/standardized way (linking it to predefined fundamental needs or requirements) and share it through the database;
4) the database has not to be used to choose building materials and components without a critical evaluation by designers, thanks to a reasoned and accurate comparison among their performances and characteristics according to the intended use;
5) also external users can add information inside the database (in particular, data coming from the actual use of building products, evaluating them after the installation).

The identification of the necessary data for building design and maintenance planning is important for a precise definition of the database. In particular, in order to create easy-to-use tools, different levels of information about performances and Service Life will be individualized, according to the stage of the building process: from few needed data in the preliminary design to numerous input and output data for the executive design.

The Service Life Database

Among such information, data about service life and reliability have to be provided because during the last few years the attention to the concept of durability has progressively grown up becoming more and more important in the design process. The experience, in fact, shows the existence of an unavoidable phenomenon of decay over time for technical elements' performances. When such performances do not reach anymore the foreseen acceptable level required to the technological system, it is necessary to activate adequate maintenance interventions in order to restore their intensity. Thanks to the durability assessment it is possible the acknowledgment of a technical element's attitude to supply, over an established time and with a programmed intensity, the initial technological performances. This, also, for the following reasons:

- **for legislative impositions:** standards such as the Italian law n. 109/94 and the following decree (which has the force of law) n. 163/06 have obliged to draw up "performance specifications documents" and maintenance plans for every public works' design; as the maintenance plan provides the scheduled maintenance activities in order to maintain over time the wanted functionalities, characteristics of quality, efficiency and economic value, the necessity to know Service Life turns out to be evident;
- **for economic reasons:** the value of built works has assumed more and more importance in the conscience of users/owners (both public and private); the life-cycle management process turns out to be of fundamental importance in the economic evaluation of every single partnership, especially now that, in Italy, it becomes more and more diffused the use of alternative tools for finding the necessary funding for public works, such as the project financing or the Public-Private Partnership;
- **for environmental reasons:** the shortage of materials and the progressive impoverishment of fossil energetic resources have pushed the building field to face such a thematic; nevertheless also the problem of buildings' environmental impact has assumed big

importance in the last few years, bringing towards a collective sensitization for esteeming environmental impacts of realized works. [1]

Through the analysis of Service Life management systems from the point of view of the necessary information to allow designers evaluating duration and planning maintenance, CSTB and Politecnico di Milano are structuring an international RSL database, thanks also to the Italian network of search on the durability (Politecnico di Milano and Torino, Universities of Napoli, Palermo and Catania); such database will contain the input data necessary to tools ICT for the management of service life.

In Europe, the only currently available database (with information about materials' standard duration) comes from England: it is called Construction Durability Database and it is constituted of seven groups, each containing a wide number of elements and technical sub-elements. Such a database was commissioned by an insurance society (Housing Association Property Mutual) and realized thanks to the studies carried out by BRE (Building Research Establishment), coming from 15 years of collection and of experimentations from the Building Group Performance and from other analogous organizations.

Also CSTB has already predisposed a Reference Service Life database [Hans et al. 2008], which is available on the web and which becomes a very important tool to:

- exchange and collect data deriving from different providers of data, such as manufacturers of building and construction products, researchers, national assessment bodies and technical approval organizations, database holders;
- elaborate evaluating and driving grids to determine each of the seven factors needed by the Factor method (see table 1).

AGENTS	**REMARKABLE FACTORS**		
Agent related to the inherent quality characteristics	A	Quality of components	Manufacture, storage, transport, materials, protective coatings (factory-applied)
	B	Design level	Incorporation, sheltering by rest of structure
	C	Work execution level	Site management, level of workmanship, climatic conditions during execution of the work
Environment	D	Indoor environment	Aggressiveness of environment, ventilation, condensation
	E	Outdoor environment	Elevation of the building, microenvironment conditions, traffic emissions, weathering factors
Operation conditions	F	In-use conditions	Mechanical impact, category of users, wear and tear
	G	Maintenance level	Quality and frequency of maintenance, accessibility for maintenance

Table 1 - Used factors applying the Factor method.

This RSL platform has been developed, as mentioned above, to contain a series of grids in which data are conserved and indexed. These grids are associated to a set of RSL.

[1] ISO 14040 "Environmental management - Life cycle assessment - Principles and framework",
ISO 14044 "Environmental management - Life cycle assessment - Requirements and guidelines".

During the phase of capitalization of the Service Life documented for every grid, the customer of the platform can integrate the duration data according to the collected information. The information can have many origins:

- experience;
- ageing tests in natural environment;
- accelerated ageing tests;
- numerical simulation;
- bibliographical studies.

Another important peculiarity of this database, not present as an example in the English one, is the possibility of being implemented from anyone, after the validation from the administrator of the database.

After the login, it is, in fact, possible to choose:

- to create or to modify a grid;
- to add new data;
- to consult already existing data.

The insertion of new data or the modification of already uploaded data is driven by a wizard.

The set of RSL consists of:

- the duration in years, with the differentiation of the type of distribution around the mean value;
- the breakdown modality;
- the selection of the several levels of factors in the grid;
- the complementary information such as year, place, sources, data quality, observations.

It is possible to choose among different formats to specify the distribution around the mean value of duration:

- determinist (i.e.: 50 years);
- triangular (i.e.: about 50 years, more or less 2 years);
- uniform (i.e.: from 47 to 52 years)
- trapezoidal interval (i.e.: between the 48 and 51 years, but with the possibility to have also 45 or 53);
- Gaussian distribution.

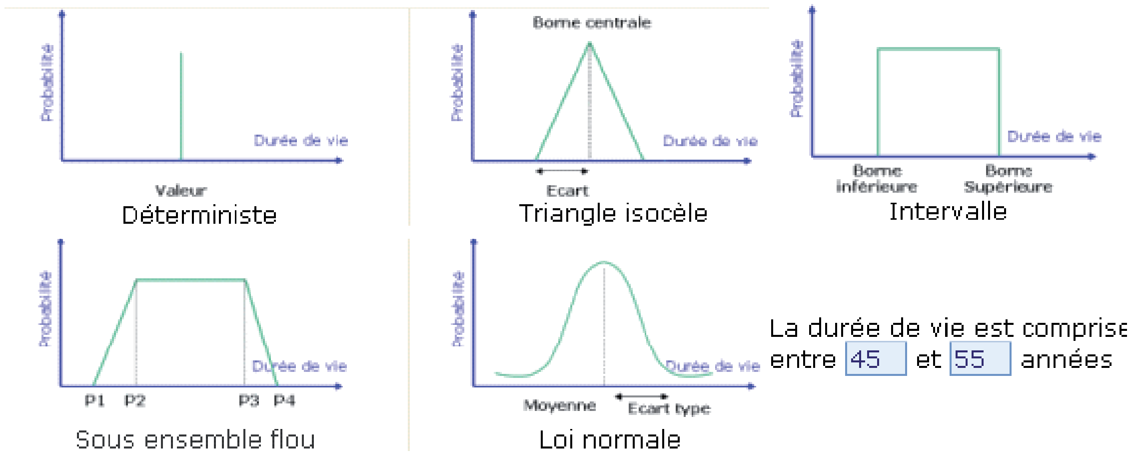

Figure 1 – Distribution formats around RSL mean value

The choice of the format will be realized according, in particular, to the used sources for data attainment.

The grids for Service Life database management

A first example of evaluating grid which has already been inserted in the database has as object external systems for thermal insulation (ETICS), synthesis of the last two years of experimentation for the appraisal of the durability. The designed experimental programme as a whole includes accelerated laboratory ageing, long-term outdoor exposure, comparison and analysis of results: according to it and in order to implement the today existing methods for Service life prediction, the Durability of the Building Components Group at BEST Department of the Politecnico di Milano, in collaboration with the French institute CSTB, has developed, a driving grid valid for the ETICS. In such a grid, every factor of the Factor method is subdivided in more sub-factors, each of which focalizes, through a methodological approach, on different aspects which can accelerate degradation or alter performances of the building component, involving direct consequences on its durability.
Such an approach wants to become a tool, scientifically validated and simple to apply, for determining Service Life of building materials and components.

	Facteurs	Niveaux des critères respectif					
A	Solution with ETA	Yes	No				
A	Type of support	New	Existing				
A	Type of support	Rammed concrete	Hollow bricks	Bricks	Structural framework	Wood panels	Distributed insulation
A	Type of insultator	Moulded expansed polystyren	Extruded polystyren	Mineral wool	Wood fibers		
A	Fixing system	Purely bonded system	Bonded system with supplementary mechanical fixings	Purely mechanical fixed system	Mechanical fixed system with supplementary adesives		
A	PVC of render coating's resin	Resin added 95%<=PVC<=98%	Resin added PVC > 98%	Only cement mortar			
A	Finishing colour	Bright	Medium	Dark			
A	Finishing roughness	Coarse grain	Average grain				
B	N° of fixing elements/sqm	N<8	8<=N<=12	N>12			
B	Mechanical fixings	Dimensioned considering wind load	Not dimensioned				
B	Presence of expansion joints	Yes, max every 200 sqm	No				
B	Presence of protecting elements on surfaces potentially exposed to mechanical bumps	Yes	No				
B	Exposure to rain	Totally	Partially	Not exposed			
B	Type of coating's treatment	Rough finish	Sanded finish	Streaked finish	Smooth finish		
C	Insulator storage time in construction site	Limited	Long				
C	Laying according to construction plan	Yes	No				
C	Distance between panels	D > 2mm	D < 2mm with coating inside joints	D < 2mm without coating inside joints	D < 2mm with tips of insulator inside joints		
C	T [C°] during laying	T < 5 C°	5°C < T < 30°C	T>30C°			
C	RH of substrate	RH <= 80%	RH>80%				
C	Substrate planarity	Yes (delta<=7mm)	No (delta > 7mm)				
C	Quantity of adhesive mortar	Q<3kg/sqm	3kg/sqm<=Q<=5kg/sqm	Q>5kq/sqm			
C	Mechanical fixing scheme	Type A	Type B				
C	Laying team	Specialized	Not specialized				
D	Indoor RH	RH <= 65%	RH > 65%				
E	Climatic zone	A	B	C	Special conditions		
E	Precipitation level	High (>1200 mm/year)	Middle (between 500 and 1200 mm/year)	Low (<500mm/year)			
E	Wind load zone	Zone 2	Zone 3	Zone 4			
E	Micro environment	Urban	Suburban	Rural			
E	Exposure of the façade	North	West	South	East		
F	Foreseen impacts	Yes	No				
F	Type of use	Residential	Tertiary	Industrial	Pubblic equipment		
F	Category of use	Category I	Categoty II	Category III			
G	Accessible for maintenances	Yes	No				
G	Maintenance frequency	f <= 10 years	10 years < f < 20 years	f >= 20 years			

Figure 2 – Factor grid for ETICS

Concluding remarks

The correct creation of a database as the one above described can have two important positive aspects:

- on one side it can guarantee an easy and widespread availability of the necessary information about building materials (including innovative ones), allowing a better evaluation and choice of building materials themselves;
- on the other side it can push/force manufacturers to standardize the way to present building products, providing comparable data: in a virtuous framework of product's qualification, this prospective should bring to improve the entire construction market: this is then more important if we consider that building products are now to comply with harmonized standards, in the framework of CDP and in future they will have to comply to 7th Essential Requirement on Sustainability and then also to Durability.

Future developments are envisaged through the INNOVANCE project, funded by the Italian Ministry for the Economic Development within the INDUSTRIA 2015 call, which aims at the development of the first Italian interoperable data base for the building sector.

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prof. Bruno Daniotti
Politecnico di Milano, Dipartimento BEST
bruno.daniotti@polimi.it
0039 (0)2 23996002

prof. Mario Claudio Dejaco
Politecnico di Milano, Dipartimento BEST
mario.dejaco@polimi.it
0039 (0)2 23995174

ing. Sonia Lupica Spagnolo
Politecnico di Milano, Dipartimento BEST
sonia.lupica@polimi.it