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*A roadmap for the improvement
of earthquake resistance
and eco-efficiency of existing
buildings and cities*

Alessio Caverzan, Marco Lamperti Tornaghi
and Paolo Negro
Editors

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SAFESUST Workshop

*A roadmap for the improvement of earthquake resistance
and eco-efficiency of existing buildings and cities*

Joint Research Centre, Ispra
November 26-27, 2015

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A New Model to Evaluate the Performance of the Building Envelope: the Case study of *Energy Park*

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ABSTRACT

The rating system of the building envelope is sustained and is a completion of the BRaVe system (Building Rating Value) offered by the Polytechnic of Milan and is the result of a working group of the laboratory Gesti.Tec.

The rating of the envelope represents an analytic system through which it is possible to examine in depth the elements that contribute to identifying objectively the level of "quality" of a building envelope with the aim of aiding the design of the systems of vertical closure so that it is possible to identify (clearly state) if a specific enhancement can or cannot be functional with regard to the technological aspect.

Keywords

Rating system, building envelope, performance of building envelope, enhancement of buildings, curtain wall, intelligence systems.

INTRODUCTION

A building's envelope, in modern architecture and in the construction market, is now not thought of as a simple division from the outside, but has acquired multiple functions due to the evolution of both buildings and materials (Puglisi, 2014).

"It is more and more significant the fact that the building envelope is defined not as an isolated object that is self-related, but as a "skin" or "membrane", something that breathes and controls the mechanisms of exchange with the outside environment, in the sense of a building, as a living entity, guaranteeing the upkeep of optimal living conditions inside it, thanks to a metabolic exchange of mass and energy with the surroundings" (Altomonte, 2005).

The enhancement of buildings now represents an innovative approach that pays particular attention to the potential for transformation of the property, placing it in relation to the urban context and the needs of the market, increasing its profitability (Tronconi and Baiardi, 2010).

THE BUILDING ENVELOPE IN THE ITALIAN MARKET

According to the Uncsaal report, the sector related to the production of façade components, despite a physical decrease in production due to the ongoing economic crisis, is following a path towards a constant evolution and innovation of products, which aims to produce innovative and energy-efficient components (Uncsaal n.ro 2, 2013).

Today the sector of the building envelope is characterised by a high fragmentation of supply and by the predominance of small companies, often generic ones. Data supplied by the *Agenzia delle Entrate* (Inland Revenue) in 2011 indicate that there are 12,068 companies in clusters related to the production of metal doors and windows. In the majority of cases, these were individual firms (6,687 companies) or small artisan companies (3,525 companies). Only 1,857 companies (15% of the population) are corporations, of which

most are small. The companies that operate in the sector of metallic doors and windows are of two types: non-specialised producers of doors and windows (generic companies that produce doors and windows) and companies focused on the continuous façade (curtain wall companies). The average size of the curtain wall companies are considerably larger than those of companies producing doors and windows, with an average production turnover over 11 million euros with approximately 50 employees, versus 3.7 million euro production and around 25 employees for generic door and window producers (Uncsaal n.ro 1, 2013).

ACTIVITY	NUMBER OF COMPANIES
Manufacturers of metal frames and curtain walls:	12.086
✓ Company capital	1.857
36. Partnership	3.525
✓ Sole traders	6.687

Table 1. Breakdown of companies in cluster linked to the production of windows.

	AVERAGE VALUE OF PRODUCTION	AVERAGE NUMBER OF EMPLOYEES
Manufacturers of windows and facades	5,6	30
- Manufacturers of windows	3,7	25
✓ Manufacturers of facades	11,4	47

Table 2. The size and the number of employees in companies operating in the field of frames.

RATING SYSTEMS IN USE TODAY

Today the valuation methods that are used are very varied and not well known; very often, especially in small companies, there is no knowledge of such methods. The reason for this is probably that the market itself does not contain systems that are recognised on an international level: in fact, some of these methods are strongly based on the national context where they have been developed.

"The majority of systems deal only with some of the variables considered fundamental for an overall valuation of the performance of a building: particularly spread are the aspects related to the containment of energy consuming and the compatibility with the environment" (Ciaramella and Tronconi, 2011).

None of the analysed systems has the aim of evaluating the performance according to "transversal" criteria, regarding different thematic or scientific areas of the building envelope.

Fueling the uncertainty of companies who undergo the selection of a valuation method is the presence on the market of two types of methods:

Figure 15. the "standards" : are systems that evaluate the presence of building services, types of services, infrastructure, etc. and are derived from 'best practices' in the selection of building adopted by the major companies in the property market.

Figure 16. the "labels": are tags recognised by the market but, very often, evaluate only the environmental aspects of the building and can be applied to all buildings.

	Location	Architecture	Technological flexibility	Furniture interior design	Structure	Building comfort	Care facility staff	Energy performance	Security	Safety	Rental value	Facility & building management	Year	Classification methods	Total number of parameters	Web based system	Benchmarking of buildings
BOSTI													1980	Different from building to building			
BQA													1985	Numerical scale	137		
BQI													2004	A, B, C, U			
BOMA														A, B, C			
DQI													2002	Graphics	100		
International classification office														A, B, C			
Logometrix													2006	Report indicating score			
Office class Bulgaria													2006	A, B, C	26		
Office classification ABCD													2006	A, B, C, D	50		
REN													1990	Comparison with examples	150		
Star office rating														Stars from 3 to 5			
Politecnico di milano													2008	AAA, AA, A, BBB, BB, B, CCC, CC, C, D			

Figure 6. The standards systems.

	Location	Architecture	Technological flexibility	Furniture interior design	Structure	Building comfort	Care facility staff	Energy performance	Security	Safety	Rental value	Facility & building management	Year	Classification methods	Total number of parameters	Web based system	Benchmarking of buildings
3 rd system													2006	Stars from 1 to 3			
BREEAM													1990	Sufficient, good, very good, excellent			
DGNB													2008	Gold, silver, bronze			
EU Energy Pass													2002	A+, A, B, C, D, E, F, G			
Green building challenge													2000	Score scale			
HK BEAM													2003	Platinum, gold, silver, bronze			
LEED													2000	Platinum, gold, silver, certified			
NABERS													2009	Stars from 1 to 5			
Protocollo ITACA													2002	Scale scores and examples of buildings			

Figure 7. The labels systems.

RATING SYSTEM OF THE BUILDING ENVELOPE

The rating system of the building envelope is sustained and is a completion of the BRaVe system (Building Rating Value) offered by the Polytechnic of Milan and is the result of a working group of the laboratory Gesti.Tec.

The rating of the envelope represents an analytic system through which it is possible to examine in depth the elements that contribute to identifying objectively the level of "quality" of a building envelope with the aim of aiding the design of the systems of vertical closure so that it is possible to identify (clearly state) if a specific enhancement can or cannot be functional with regard to the technological aspect.

The system identifies different areas of analysis, each of them distinguished by variables that contribute to determining the "performance" level of the envelope (Puglisi, 2012).

Areas of applications

The system can be applied on tertiary building envelopes and, particularly on:

- a. Envelope enhancements in order to evaluate achieved improvements or reduction in performance;
- b. Pre-existing buildings to evaluate the performance characteristics of the envelope;
- c. Buildings in design phase with the purpose of simulating various scenarios and implement the most suitable type of envelope.

The survey questionnaire

The system requires the completion of a questionnaire that, for each item, offers a choice of responses or the simple indication of "yes/no". The survey questionnaire is filled in directly by the designer or by the person who has at his/her disposal the data of the original project and of the enhancement project. It is composed of two parts:

Figure 17. A descriptive sheet that contains the general data of the property to be analysed.

Figure 18. A series of sheets regarding the technological/descriptive aspects of the envelope, its performance, intelligent characteristics, the security and maintenance regarding the property before and after the enhancement.

The system of point attribution

The rating system that is proposed considers 5 families (envelope, technological performance, intelligence, security and maintenance), each of which is divided into different groups (factors) and subgroups (parameters), for a total of 45 entries examined.

Specific scores are allocated for each family, factor and parameter, each of them weighted by its level of importance. The criteria that led to the definition of the scores was that of pairwise comparison, that has allowed the classification of families, factors and parameters in relation to the importance attributed to them in contributing to the determination of the quality of the building envelope of a tertiary building, in terms of performance. Specifically, the envelope has received a score of 30 points, with 35 points for technological performance, 14.50 points for intelligence, 10.50 points for security and 10.00 points for maintenance. The sum of these points is equal to 100.

Rating system output

Upon receipt of the completed questionnaire, the data is entered into a database from which an output is generated that allows you to represent numerically and graphically, the result of the evaluation. In the tables generated by the system for each factor and parameter the following are represented:

- The maximum achievable score.
- The score the building has achieved before the valorisation (enhancement) operation.
- The score the building has obtained after the requalification operation.

The total mark generated by the rating system, expressed as a percentage, classifies the "quality" level of the building envelope.

On the basis of the score obtained it is possible to associate the analysed building to a marking scheme that defines the value of the rating (AAA, AA, A, BBB, BB, B, CCC, CC, C, D).

This score is then described by a radar chart that represents the result obtained for each family in percentages.

The representation of the results of the rating system is derived from histogram charts where are highlighted as an absolute value: the maximum score that can be obtained (left column), the markings that are actually obtained by every factor and parameter that have been analysed before (central column) and after (right column) the valorisation operation.

This allows a clearer view of the improvements/worsening that have occurred as a result of the enhancement operation for the five analysed families.

THE ENERGY PARK

One application of the building envelope rating system are proposed below: the Energy Park - Segro in Vimercate, a recently built building where the method is applied to evaluate the characteristics of the performance of the envelope.



Figure 8. The property of Segro in Vimercate (MI). Source: Garretti Associati srl.

Location	Vimercate (MB)
Functions	Tertiary, laboratories, IT rooms, training rooms, auditoriums, testing rooms
Building time	November 2008 - November 2009
Customer	SEGRO
Designer	Garretti Associati srl
Stakeholders	
Construction management	Garretti Associati srl
Security manager	Garretti Associati srl
Structural engineers	B.M.S. Progetti
Plant engineer	Lombardini 22 srl
Construction company	CESI
Facades and windows	Teleya
Project landscape	Garretti Associati srl
Design Features	
Surface	11.500 mq
Number jobs	About 900
Energetic class	A+
parking lots	559
Amount	15 million euro

Table 3. Some data of Energy Park.

Energy Park is located in the heart of the well known Polo Tecnologico della Brianza (the Science Hub of Brianza) approximately 20 km from down town Milan. It is strategically located for easy access to the traffic arteries of Northern Italy, and it is connected to Milan via the Ring Road East, with a dedicated junction at only a 200 metres distance. Excellent accessibility as well to the A4 (Turin-Milan-Venice) Motorway Junction of Agrate. Besides Building 03 and the new Alcatel-Lucent Campus on the west side, the development of Energy Park includes the completion of 4 additional buildings. Buildings P1, P2 and P3, looking onto the ring road, will be subjected to radical renovations. Moreover, once completed, ENERGY PARK will have over 100,000 sq m. of working spaces and research labs.

Energy Park was developed with a special commitment to deliver against the most ambitious sustainability goals. Each of the new buildings is planned with a 22 metres core depth, with a façade system in precast concrete panels and a shell system which provides for a reversed insulation and a steel ventilated front. The size of the windows is such as to guarantee a good natural lighting factor, even though maintaining a high protection from direct irradiation. Façades have in fact a balanced opaque and transparent bodies ratio with elements fully in glass, concentrated in a highly visible part of the buildings: the entrance halls and the bioclimatic glasshouses, strengthening further their architectural character. It is this way possible to achieve a balance between the winter and summer's energy savings and the optimization of natural lighting contribution.

The rating system of the building envelope applied to Energy Park reaches peaks of excellence in the most households with particular reference to the building envelope, the technological performance, the security and the maintenance, achieving a very good score in the rating system ("AAA").

				MAX	AS BUILT	
		Type 1	Type 2	Max Score	%	Score
1	ENVELOPE	1.1	Relationship with Form	3	100%	3
		1.2	Type of envelope	7,5	100%	7,5
		1.3	Openings	9,5	95%	9
		1.4	Facade Shading	9	94%	9
		1.5	Roof Shading	1	100%	1
2	TECHNOLOGICAL PERFORMANCE	2.1	Energy Class of the Building	4	100%	4
		2.2	Thermal Conductivity	20,5	100%	20,5
		2.3	Light Transmission	3	100%	3
		2.4	Sound Insulation	5,5	100%	5,5
		2.5	Meccanical ventilation	2	100%	2
3	INTELLIGENCE	3.1	Intelligent Systems	6	100%	6
		3.2	Photovoltaic system and presence of renewable energies	7	50%	3,5
		3.3	Comunication	1,5	67%	1
4	SECURITY	4.1	Security glass	8,5	100%	8,5
		4.2	Control systems	2	100%	2
5	MAINTENANCE	5.1	Ordinary maintenance	5	90%	4,5
		5.2	Maintenance Systems and tools	5	80%	5
TOTALE				100	94%	95

Table 4. The results of the rating system applied to Energy Park.

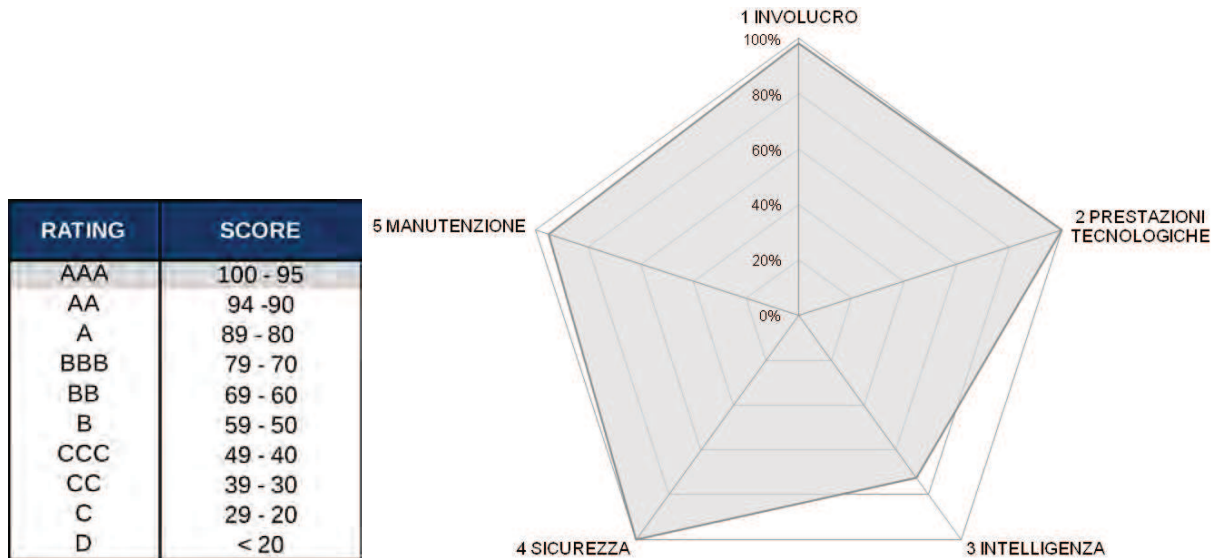


Figure 9. The results of the rating system applied to Energy Park.

The quality level of the envelope up to 98% and it is characterized by:

- Type of envelope: it is characterized by various types of façade (structural, ventilated and continuous).
- Openings: the windows are equipped with thermal break and low-emissivity glasses are installed.
- façade shading: are characterized by a combination of shading in the horizontal and vertical shields. In particular the shields are hyper performance, in fact the tents have low emitting characteristics.

The building thanks to the characteristics described above, achieves the maximum scores in all parameters analyzed.

The quality level of technological performance of the building envelope the maximum score possible. The building, in fact, lies in A+ energy class, is designed to provide a lot of number of air changes per hour, is characterized by very low transmittance and by a good level of acoustic-sided glossy. Façade sound insulation has also met legal requirements (DPCM 5/12/1997 “Determination of passive acoustic requirements of buildings”). The number of air changes per hour to meet the current legal requirements (Building Research Establishment Environmental Assessment Method, RICS).

The quality level of intelligence of the envelope reaches 72%. The building achieve excellent scores in the following areas:

- the clever features: the building has solar trackers, artificial lighting reactive systems for heat recovery systems, different for every area (foyer, interior and perimeter areas, CED) directly connected to the internal network through wiring;
- control systems: for cooling, ventilation, heating, humidity and solar shading;
- use systems that use geothermal energy.

Instead constitute points of weakness the following areas the absence of the photovoltaic system and the absence of systems that contribute to the communication capacity of the building with the external environment.

The quality level achieved by the family of security around the envelope is equal to 100%. The building, in fact, is characterized by the using of security glass like anti-injury, anti-fall and anti-burglar-vandalism-crime and the CE branding of the glass.

The quality level of the family regarding maintenance up to 85% and it is characterized by:

- The constant implementation of a maintenance program during the years considered.
- The possibility of lowering mobile scaffolding from the roof and allowing a ladder within 5m of the building so that some external maintenance can be easily done.
- A high availability on the market of replacement components for the envelope.

Instead constitute point of weakness the absence of self-cleaning glass integrated into the facade.

CONCLUSION

In the enhancement process, the renovation of the building envelope has a decisive role. A product that is correctly enhanced is subject to a simple insertion in the market and it adds value to the investor and to the context where it is set. High quality buildings are usually qualified by the real estate market with the term "Class A". This definition, taken from models of financial rating, doesn't correspond to a precise, objective and scientific identification of the elements that determine it: elements as the "flexibility of the surfaces", "high standard plants", the presence of "raised floors" or other features that characterize the building's equipment, are generically listed. The envelope rating system's aim is to spot elements that can objectively identify the level of "quality" of a building envelope. In particular, this system wants to clarify if indeed a redevelopment, only limited to the building's envelope, may or may not be functional in terms of technology and function.

Contributes to the Roadmap

The rating system of the building envelope should be applied to any enhancement of the building in order to improve its performance.

Open Issues

The rating system of the building envelope should be applied not only to the tertiary buildings, but to all types of building.

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