

GENERAL AND SPECIFIC CONDITIONINGS TO CONSIDER IN THE PROCESS OF DESIGNING CONSTRUCTIVE SYSTEMS OF INNOVATIVE FAÇADES

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ABSTRACT

The Building Department of the School of Architecture of the University of Navarra is developing for some time a research line related to the development of *constructive systems of innovative façades*.

One of the developed tools in this research line refers to those factors that could determine or influence the final constructive solution. It is also important to take into account the whole life cycle of the new system, its relation to other constructive systems of the building and its influence in the global building process.

A thorough relation of the diverse types of *conditionings*, which should be considered in the design of façades, has been developed as a guide to identify those that explicitly or implicitly will be necessary to take into account in each case study.

Several families of conditionings have been categorized. This complete relation of conditionings allows identifying and defining the main objectives to be considered in each case. These objectives help to define the specific demands (*exigencias*) that should be solved by the façade constructive system.

In this communication we intend to show the importance of these conditionings as a way to study and design these new façades. These conditionings serve as a starting point for the elaboration of a specific programme of necessities related to façade systems. The detailed study of the conditionings allows advancing in the study, analysis, design or assessment of the new constructive systems of façades we expect to develop by means of conceptual and experimental research.

1.- Introduction

The field of research that gives rise to the following communication is the technological innovation in façades. Nevertheless, most of the methodology and concepts treated can be applied to other components of buildings.

During the design process of a particular façade or a new constructive system of façade and during their later assessment, it is fundamental considering every factor that could determine or influence the final constructive solution. It is also important to take into account the whole life cycle of the new system, its relation to other constructive systems of the building and its influence in the global building process.

This way, in the development of every constructive solution we have the certainty that those conditionings which can notably affect or have repercussions on its life cycle have been considered from the beginning of the process.

In this research, a relation of diverse types of conditionings which should be considered in constructive systems of innovative façades is proposed. This relation serves as a guide to identify and define those that explicitly or implicitly will be necessary to take into account in each case study.

This relation of general and specific conditionings has been done with an overall view of the whole building and its life cycle, taking into account its relation to other constructive systems of the building and its influence in the global building process. This relation of conditionings has been developed to be considered in diverse situations that a constructive system of innovative façades could be found, according to the type of building and depending on its location.

This relation of general and specific conditionings, together with the conditionings derived from objectives and resources of the agents involved in the life cycle of buildings, helps making a programme of necessities that should be satisfied with every constructive solution.

2.- Definition of the concept *conditioning*

The concept *conditioning* refers to those aspects of very diverse nature and degree of influence, depending on which the ultimate result of an activity may achieve the intended purpose.

This concept can be applied to different fields: R&D&I activities, projects and processes of building of a whole building or some of its parts (for example the constructive systems of innovative façades) or components, etc.

Conditionings can be of general or specific nature.

In the field of building, the origin of conditionings is in:

- The activities, interests and responsibilities of the agents that are involved in each stage of the life cycle of buildings (developers, architects, builders, civil services and administrations, etc.).
- The intended conditions for the use of buildings.
- The circumstances derived from their location.
- The ultimate characteristics of each built building, and the characteristics of each one of its parts and components.
- The available scientific, technical and technological resources.
- The different compulsory regulations that must be observed.
- The economic resources that are available.

- The researchers' objectives and the organization and management of R&D&I activities that will allow to develop constructive systems of innovative façades.

These conditionings allude to aspects of:

- technical (mainly related to safety and habitability in buildings)
- functional
- aesthetic
- environmental
- social
- and economic nature.

3.- Related concepts

In order to understand why making use of a thorough relation of conditionings of diverse nature related to façades is methodologically important, a series of general concepts and definitions should be considered. These basic concepts are often used in the field of building and may have several meanings or interpretations, depending on the context.

These concepts are not independent. It is advisable to specify and harmonize their meanings in the particular field of the constructive systems of innovative façades, adding precision to their essential aspects and their extent, so that they become unequivocal concepts.

It has been tried to use the denomination of the terms of this research in a similar way to those used in the compulsory regulations, mainly those contained in the Spanish regulations CTE [1].

Some of these concepts can be applied to buildings as a whole or to their separate parts (e.g. the constructive systems of innovative façades) or to particular components.

3.1.- Requirements

The concept *requirements* refers to circumstances or conditions that are necessary to achieve something.

This concept can be applied to different fields: to R&D&I activities, to buildings as a whole or to their separate parts or components, to a quality standard, etc.

Requirements can be of general or specific nature.

These requirements - usually general requirements- that should be considered in the field of the constructive systems of innovative façades, like conditionings, allude to aspects of technical, functional, aesthetic, environmental, social and economic nature.

In the field of buildings and their parts and components, the requirements are defined by means of a set of main objectives expressed in qualitative and/or quantitative terms, which are translated into a set of specific exigencies that must be fulfilled in order to prove that every requirement has been satisfied.

By means of satisfying all the requirements considered in each case study, it can be verified that a building and its parts (for example the constructive systems of innovative façades) and components are appropriate to the intended use.

These requirements are specified depending on the intended use of the building and the developer's objectives.

Buildings and their constructive elements have to satisfy the intended requirements during their life cycle, particularly when they are in use.

A complete and unequivocal definition of the type and level of requirements (including their main objectives) that have to be considered and satisfied, must be done.

The requirements that a building and its parts and components have to satisfy, can be fixed in a first stage to define a reference standard which will allow establishing the exigencies to fulfil and the features that must be achieved. Such reference standard serves to compare every particular solution with it and to check what rate of nearness we have reached.

The main mandatory requirements that must be considered in buildings and their parts and components are directly derived from the application of CPD 89/106/EEC [2] –essential requirements– and the Spanish LOE [3] –basic requirements–.

Other requirements related to buildings and their parts and components, have a voluntary nature and the aim of improving the minimum level of features that is derived from the mandatory requirements. These voluntary requirements can have several purposes: economic objectives, prestigious, competitiveness, etc.

3.2.- Exigencies

The concept *exigencies* refers to the action or effect of asking for some specific thing which is necessary to fulfil or achieve something that has been previously fixed (conditionings, mandatory or voluntary requirements, etc.).

This concept can be applied to different fields: R&D&I activities, buildings as a whole or in their separate parts (e.g. the constructive systems of innovative façades) or a particular component, etc.

Exigencies can be of general or specific nature.

These exigencies that should be considered in the field of the constructive systems of innovative façades, as well as conditionings or requirements, refer to aspects of technical, functional, aesthetic, environmental, social and economic character nature.

These exigencies are derived from the main objectives of each requirement that should be satisfied in each case study.

Each exigency will be characterized and quantified depending on the minimum level of features that buildings and each one of their constructive elements should achieve, so that every solution has got the capacity of fulfilling the exigencies corresponding to the fit level to satisfy the main objectives which have been defined as necessary in

order to consider that a building and each one of its parts and components are fit for the intended conditions of use.

The main mandatory exigencies that must be considered in buildings and their parts and components are directly derived from the application of the Spanish compulsory regulations CTE [1].

Other voluntary exigencies related to buildings and their parts or components are derived from the improving requirements that have been incorporated in the development of a new constructive product with several aims (e.g. a constructive system of innovate façades) as objectives of developers or researchers.

3.3.- Features

The concept *features* refers to one element (a building, a construction product, a simple component, etc.) ability to bear any action keeping a right performance, which is the element does not undergo damages, deficiencies or improper appearance changes.

Building features and constructive element features are influenced by its design and the way it has been manufactured or assembled in the building, as well as the characteristics and properties of its components. A correct use of the building is also necessary in order to keep a right appearance of the façades for a long time.

Features are mainly of technical or functional nature.

The level of features that should be achieved in each case study and should be kept for building life cycle determines the characteristics and properties that should be got and the conditions that should fulfill a particular constructive solution by means of its technical and formal design.

Most characteristics and properties of diverse nature of façade components (physical, mechanical, chemical, electrochemical or biological nature) and their conformity assessment procedures are defined in national or european standardization documents.

These standardization documents are useful to draw up the technical specifications which define the features of every constructive solution that allows attaining a certain constructive system of innovative façades.

The term *performance* expressed in CPD 89/106/EEC [2], related to the behaviour of a building or its parts or components when solicitations are received by them, coincides with the concept *features* defined above.

4.- Methodology of application

The thorough relation of *conditionings*, taken systematically into consideration, allows identifying and defining the *main objectives* of the *requirements* that explicitly or implicitly have to be considered in each case study.

These requirements serve also as a reference to define the set of specific *exigencies* that is necessary to fulfil in order to prove that mentioned objectives are satisfied.

Each exigency will be characterized and quantified defining a minimum *level of features* that have to be achieved through the performed constructive solutions.

In this way, the relation of conditioning serves as a starting point for drawing up a definite *programme of necessities* related to façades in each case study.

5.- Relation of conditionings

The next families of conditionings have been established during the research about constructive systems of innovative façades.

These families are also applicable to the study of a building as a whole or to its parts and components.

- 1.- Sociocultural conditionings.
- 2.- Aesthetic conditionings.
- 3.- Legal conditionings.
- 4.- Conditionings related to technological standardization and to the certification of products and systems.
- 5.- Technical conditionings.
- 6.- Conditionings related to sustainability and environmental impact.
- 7.- Conditionings related to the maintenance of façades.
- 8.- Conditionings related to control and assurance of the technical reliability of the constructive solutions performed with innovative façade systems.
- 9.- Conditionings related to the measurement and optimization of the economic valuation of innovative façade systems.
- 10.- Conditionings related to the interests and responsibilities of the agents that are involved in the life cycle of innovative façade systems.
- 11.- Conditionings related to buildings morphology and scale.
- 12.- Conditionings related to the development of the technical documentation of innovative façade systems.

Some of the aspects included in each one of these families are concisely explained below.

5.1.- Sociocultural conditionings

Those aspects which should be taken into account in design and development of constructive systems of innovative façades, related to a set of social and cultural circumstances are considered in this family of conditionings. Such aspects have got an increasing impact in the development and evolution of the complex building sector, especially in the building process and building technologies that are used to design and erect every building, particularly the constructive systems of innovative façades.

Some factors should be considered:

1. New technical possibilities and their evolution. Such possibilities are based on scientific, technical and technological advances in the building sector and in other sectors. Also, a technical training for researchers is necessary.
2. National, European and international regulations.

3. The necessities of society, market and the building sector, which are diverse and variable. Also, a consequent diversification of types of buildings with very different uses, according to users' necessities.

4. Economic possibilities in different scopes (private sector, business sector, financial world, public resources) and diverse countries.

5.2.- Aesthetic conditionings

These conditionings are related to expressive possibilities of every constructive system of innovative façades (formal chances, spatial development, appearance, image of values that designer, developers or owners wish be transmitted, etc.) Some aspects should be considered to define such conditionings in each case study:

1. Possibility of using construction products with a different nature, a different appearance and assorted size (format).

2. Freedom for adapting components to the volumetric and formal composition of building.

3. Freedom of constructive systems of innovative façades for making suitable for designing (position, size and shape) of windows spaces.

4. Maintenance of a right appearance in façades in spite of the passage of time.

5.3.- Legal conditionings

Those aspects which should be taken into account in design and development of constructives systems of innovative façades are considered in this family of conditionings when are related to the increasing inciden of numerous regulations that control the building sector in all the countries. These aspects have a notable influence on the characteristics that constructive systems of innovative façades should have got.

We must consider some different aspects to define these conditionings in each case study:

1. Spanish compulsory regulations: fundamentally the Spanish regulation CTE [1] that develops the Spanish LOE [3].

2. Regulations of European Union: particularly differents European directives: CPD 89/106/EEC [2] and its interpretative documents [4], Directive on the energy performance of buildings 2002/91/EC [5], Directive relating to the assessment and management of environmental noise 2002/49/EC [6], etc.

3. Other compulsory regulations according on buildings use, twon-planning rules and by-laws, regulations arise from environmental questions, safety, etc. And those regulations about the R&D&I activities that we are carrying out.

5.4.- Conditionings related to technological standardization and to the certification of products and systems

Those aspects related to the huge influence of standardization and certification on the constructive systems of innovative façades should also be considered.

It is necessary to consider what level of industrialization is getting by the constructive products being a part of a building, in order to define these conditionings in each case study. The more industrialized constructive products, more level of standardization, and more regulations of quality assurance.

The field of standardization is broader and broader. ISO standards are transposed into EN standards and these are in UNE standards. This procedure helps to open up new wider markets.

Standardization is grounding of later certification, that helps to prove the characteristics and features of every constructive system of innovative façades, contributing to developers, users and insurance companies confidence; and doing tests and inspections of constructive products carried out easier and lower.

5.5.- Technical conditionings

We must consider a set of numerous technical aspects that should be defined, studied and resolved in every constructive system of innovative façades forming a part of a diverse type of buildings with different use conditions and a particular location.

It is necessary a separate analysis of each one of the technical aspects, but a estimate of their global repercussion depending on their simultaneousness and their features must be done too, in order to define these conditionings in each case study.

This important family of conditioning is explained in depth by means of the communication presented by prof. Germán Ramos Ruiz.

5.6.- Conditionings related to sustainability and environmental impact

Aspects related to construction (building) and use of buildings and to each one of their parts (mainly constructive systems of innovative façades) during their whole life cycle (from manufacture of construction products to get rid of waste products generated by building demolition) and their influence on the environment for this long time should be considered.

The aspects of constructive systems of innovative façades related to sustainability should be specially considered in two stages of building life cycle: the efficient utilization of resources for building it; and the efficient building use.

The aspects of constructive systems of innovative façades related to environmental impact should take into account the different hole of alternative construction products; reducing waste products during the process of building; reducing energy consumption during building use and maintenance tasks; and favouring segregation and classification of residues during building demolition.

5.7.- Conditionings related to the maintenance of façades

Some aspects considered in this family of conditioning include the periodical tasks that are necessary to maintenance of façades (cleaning, fitting of movable components, sealeds, etc.) and the repairs of deficiencies and damages (ordinary and extraordinary repairs, replacement of damaged components, etc.), all with the object of preserving a good appearance in the passage of time, paying a particular attention to critical points which should be cause of significant maintenance costs.

5.8.- Conditionings related to control and assurance of the technical reliability of the constructive solutions performed with innovative façade systems

Several aspects should be considered in each case study:

1. A clear definition of a reference standard that should be easily evaluable (assessable) during the process of building and when the building is finished and in use.
2. To define the level of features should be achieved by the constructive system of innovative façades in each case study, according to demands that will be due to location, to the type of building and to the available technical and economic resources.
3. To define the management and assessment of the warranties, and the technical fiability assurance according to regulations demands and fitness to use.

5.9.- Conditionings related to the measurement and optimization of the economic valuation of innovative façade systems

First, a realistic estimate must be able to. Direct costs of every component of a constructive system of innovative façades and their assembly costs should be considered.

Secondly, it is necessary to reduce indirect costs in design and building: measuring the constructive solutions of innovative façaded more easy and clearly than traditional solutions, and analyzing its repercussion in the global building process (from development to demolition).

If the repercussion of technical fiability can be demostred, energy certifications and other validations are easier. Also, the assessment of posible damages covered by a policy is more accurate, and it can put forward as a business advantage.

Time, availability, safety, auxiliary equipments, output, deadline, etc. All of these are intangible costs that can become significant, depending on their connections in each building process.

5.10.- Conditionings related to the interests and responsibilities of the agents that are involved in the life cycle of innovative façade systems

In this family of conditioning, we should consider how the use of the constructive systems of innovative façades could have repercussions on acts, interests and

responsibilities of the different agents that are individually and altogether involved in the life cycle of buildings.

Amongst agents must be taken into account:

- Developers.
- Designers.
- Construction companies.
- Architects in charge, project directors, project managers, technical advisers, engineering and consultancies.
- Entities and labs for quality assurance in design and building process.
- Insurance companies.
- Manufacturers and fitters of constructive systems of innovative façades, and suppliers of other products.
- Buildings owners and users.

In Spain, the main agents that are involved in the building process are established in LOE [3]. Their responsibilities and warranties are also defined.

5.11.- Conditionings related to buildings morphology and scale

In this family of conditioning, we should consider the physical phenomena that must be taken into account in buildings, and therefore in constructive systems of innovative façades that form a part of them, when such phenomena can have effects that could be cause for an inadequate performance and damages could even happen, according to scale (size) and morphology.

5.12.- Conditionings related to the development of the technical documentation of innovative façade systems

This family of conditionings shows the necessity of making a technical documentation about every constructive system of innovative façades that allows knowing its components, its possibilities of putting them together to get constructive solutions with fit features in each case study; the different design criteria and calculation methods, etc. Such documentation should be specific for every stage of design, building and checking process, and later for a right use of building.

6.- Conclusions

A thorough development of all the different aspects related to each family of conditionings allows having a valuable document in order to study any façade.

It can be used as a way to study and design these façades and allows considering every factor that could determine or influence the final constructive solutions.

Its systematic application to the study, analysis, design or assessment of a façade guarantees that any factor that can have a great effect in the final constructive solutions of each case study is not overlooking. In this way, it allows seeing the connections between conditionings, analyzing their repercussions, and studying gradually these conditionings in depth.

A detailed research of the conditioning allows advancing in the study, analysis, design or assessment of the new constructive systems of façade we expect to develop by means of conceptual and experimental research.

General and specific conditioning to consider in constructive systems of innovative façades could be taken into account as a part of the program and documented, systematized and complete process to guide university research activities in the field of scientific, technical and technological innovation in façades.

The diverse types of conditionings will change qualitative and quantitatively, as time goes by. Because of this, a periodical update of the propounded relation of conditionings will be necessary.

REFERENCES

[3] Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products (PCD 89/106/EEC) (OJ L 40, 11.2.1989, p.12).

[5] Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings (2002/91/EC) (OJ L 1, 4.1.2003, p.65).

[6] Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise (2002/49/EC) (OJ L 189, 18.7.2002, p.12).

[4] Interpretative Documents relates to Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products. The European Commission Communition (OJ C 62, 28.2.1994, p.1).

[2] Ley 38/1999, de 5 de noviembre, de ordenación de la edificación. Boletín Oficial del Estado, of 6 November 1999, no. 266.

[1] Real Decreto 314/2006, de 17 de marzo, por el que se aprueba el Código Técnico de la Edificación. Boletín Oficial del Estado, of 28 March 2006, no. 74, p. 11816 – 11831 and annexe.