ACOUSTIC AND ENERGY CHARACTERIZATION OF BUILDINGS WITH THE USE OF BIM

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ABSTRACT

The acoustic characterization of buildings combined with energy performance represents in some countries of the European Union such as Italy a legal obligation. The Italian state, for public buildings, also obliges to comply with the minimum environmental criteria (CAM). These provide for the new buildings or existing buildings subject to total renovation a minimum performance level corresponding to class two according to UNI 11367 standard. In addition, the transposition of the European directives introduced the obligation to use the BIM for public works on the national territory. This work analyzes digital procedures based on the BIM model to characterize buildings from an acoustic and energy point of view through the use of the BIM model to speed up and make the application of the standards for experimental investigations easier.

Keywords: *BIM, acoustic optimization, energy optimization, Building Information Modeling.*

1. INTRODUCTION

This research aims to analyze and characterize the specific aspects relating to acoustic and energy design in buildings through the help of procedures based on Building Information Modeling (BIM). In recent years, the role has emerged that energy presumes in the various engineering activities [1] with particular reference to architectural, structural and plant engineering design. New buildings or renovated buildings are needed that guarantee comfort conditions not only from an energy point of view[2,3], but also from an acoustic point of view and visual perception. The design challenge that must be addressed today consists in achieving increasing levels of residential comfort with a simultaneous reduction in energy needs. The goal of a research developed during a few years in the construction and software development sectors consists in the study of correlations that exist between different aspects of comfort (i.e. thermo-hygrometric, acoustic and lighting technician) [4]. In the study, the different correlations and interactions that combine the various problems and parameters that can be considered common with each other have been highlighted [5] were studied. With these parameters it is possible to correlate and optimize the building system, everything has been implemented on a BIM platform through the use of the IFC Open Standard data format [5,6]. These methods have been applied to several cases of study in which acoustic measurements [7–9] have also been performed in the various realization phases. The aim of this research was to improve the interoperability of data between the models made for different types of simulations such as energy and acoustic ones. All based on projects carried out with BIM through international interoperable standards internationally such as IFC format [6,10,11]. In the design approach based on Building Information Modeling, we are trying to overcome the problem of information interference by promoting the collaboration between the different objectives through various export options that have a single BIM model as its origin. The objective of the research is to present through the application to cases study the modeling methodologies in BIM in order to make them useful and interoperable to perform different types of analyzes such as energy and acoustic ones. The flow diagram is particularly useful for defining and standardizing the steps to be followed for obtain reliable results, since in most cases the modeling problems and the translation of data in the calculation environment affect the accuracy of the analyzes and results obtained. Finally, the possibility of defining such a standardized procedure represents a significant benefit in the uninterrupted information chain for an analysis and a

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verification of the acoustic and energy performance of the buildings that also involve economic savings.

2. METHODOLOGY

In digital procedures a leading role is played by Model Checking thanks to which projects can be verified and validated not only in the design phase but during all the process steps in order to ensure completeness, transmissibility and consistency of all data and information. In the figure 1 shows the different parameters and the different correlations between the various technical standards provided for the energy and acoustic part in the project phase, and only for the acoustic part in the experimental check phase in situ

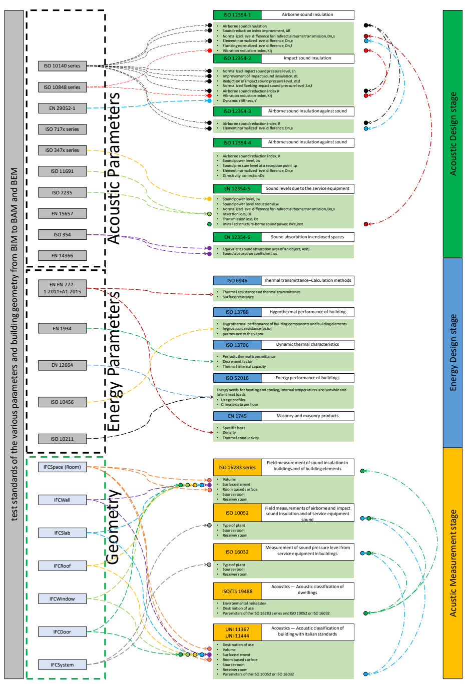

Figure 1. Principal Parameters and quantities to express element/product acoustic and energy performance.

Figure 1 shows all the main parameters that are necessary for the calculation of project phase and the experimental verification phase according to the main reference standards by mending them in relation to the BIM objects as defined in the IFC format. Most of the necessary parameters are not yet managed at the BIM IFC interoperable standard level and must consequently be assigned to the model as additional information. One of the fundamental prerogatives for the BIM model, to be fully usable for acoustic and energy purposes, and assign the necessary parameters, is the coding. If the BIM model has been appropriately codified, by assigning the appropriate unique identifiers to the rooms or simply using the GUID (Globally Unique Identifier) of IFC Space and IFC Elements, it is possible to assign to each measure a unique code that identifies the involved rooms and the elements subject to test. Figure 2 shows example the rooms (in IFC format called "space") coding in the BIM model

Figure 2. Data structure IFC BIM model for energy and acoustic performances correlation.

The coding system, if correctly used, allows the automatic and/or semi-automatic association of experimental data with the building information model. After the association of the experimental data, it is possible to perform field measurements and acoustic and energy classification according to the different reference standards. In this regard in Figure 3 the analysis and correlation process performed on the elements of the BIM model is graphically described. It is possible using the BIM model for different types of analysis in the building: energy, acoustic, lighting, fire safety and many other typologies.

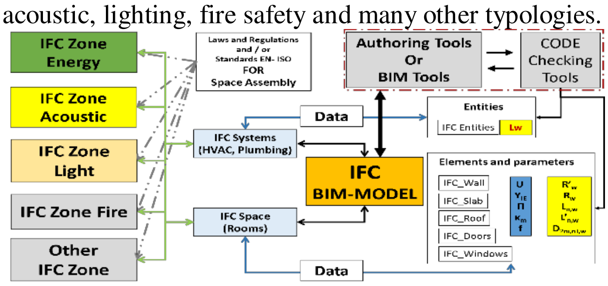

Figure 3. Data structure IFC BIM model for energy and acoustic performances correlation.

In this case the multi -objective analysis was carried out with the GEAR [12] calculation model. The GEAR Tool allows you to keep both the energy aspects and the acoustic aspects of the BIM model at the same time.

3. FROM BIM TO BEM AND BAM

In digital procedures for acoustic and energy characterization of buildings [2,3,6,13,14] a leading role is played by Model Checking thanks to which projects can be verified and validated not only in the design phase but during all the process steps in order to ensure completeness, transmissibility and consistency of all data and information [14] Acoustic Insulation And Building. The control has to start from an initial precheck, called BIM Validation, to ensure reliable results. Such precheck has to verify the information content of the BIM model and then proceed with further analyses as Clash detection and the Code checking. This means that the BIM model has to be the result of a thorough modeling process in order to make possible the validation of the graphic and non graphic content with the aim of ensuring reliable data for the following steps of the process. The check process of a model will be helpful to customers to verify that the model includes all the attributes requested in the EIR (Employer Information Requirements) and developed in the OPM (Operational Plan for Management). In the same way BIM is a basic tool for the individual developer and for the whole working group. Indeed, thanks to the use of IFC format it is possible to bring together in a single model the various projects coming from different branches (architectural, engineering, installations) to detect possible clashes or mutual inconsistencies and correct them virtually for the purpose of bringing forward the set of problems that otherwise would occur in the construction yard where everything is more difficult and expensive. In the EIR and in the OPM the “rule set” must be specified, it is about the set of control rules that are applied to the model, which are subdivided into three check steps: “the rules for the management of information interferences” (clash detection), “ the rules for standard verification” (BIM Validation), and “the rules for the management of information inconsistencies” (code checking). In the transition from the BIM model to the energy model (BEM) or to the acoustic model (BAM) it is also necessary to integrate all the missing information, necessary for the forecast calculation [15–20]and for the instrumental checks in situ. The information to be integrated is that provided for by the different technical standards shown in Figure 1

4. CONCLUSIONS

The BIM methodology applied to the design and verification of the acoustic and energy requirements of buildings has been analyzed. The developed calculation code refers to different regulatory standards, it is implemented as a Windows Application to allow the assessment of the high potential, both in the calculation for energy and acoustic and verification phase only acoustic, resulting from the huge amount of geometric and informative data available with a BIM model. The most important aspects that have emerged in the experimental testing consist of highlighting the fundamental role that the coding system and the IFC standard has to guarantee the interoperability among different software working tools. In conclusion, the code checking performed on the cases study has shown how instrumental investigations succeed in highlighting the acoustic characteristics of the building during all phases of construction and testing, improving the final result in terms of quality. Research has been addressed to the analysis of benefits that the use of BIM methodology provides for the purposes of the procedures for predictive calculations and instrumental verification of buildings; computational results achieved both the design stage and in carrying out final test have been neglected to some extent as already developed elsewhere for the same test. The results obtained in terms of time to run a simulation, and of time to gather the data needed to instrumental verifications, lead to the conclusion that, without any doubt, the use of BIM procedures for acoustic purposes speed up and improve the design and verification process and its quality. Furthermore if the model is properly encoded and all the actors of the production process share the encoding, several processes can be further accelerated and automated, reducing errors and times just for their execution. For the next future we think about extending the model approach to other subjects, which include both predictive calculations and instrumental verifications, namely those concerning fire safety and thermal comfort in the case of a multi-objective model.

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