Supporting tools for evaluating acoustic building performances at early design stages

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Supporting Tools for Evaluating Acoustic Building Performances at Early Design Stages

Outils d'évaluation des performances acoustiques de bâtiments lors de la conception

Beurteilungshilfen der akustischen Eigenschaften von Gebäuden im Frühstadium

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SUMMARY
The paper emphasises on the necessity to use a knowledge-based system for supporting acoustic design tools which allow designers the capability to evaluate acoustic performances of residential buildings at early stages of design, i.e., massing and sketching development.

RÉSUMÉ
La communication met en évidence la nécessité d'utiliser un système à base de connaissances pour implémenter des outils permettant aux concepteurs d'évaluer les performances acoustiques de bâtiments d'habitation dans les phases les plus précoces de la conception, soit lors de l'établissement du plan masse et de l'esquisse architecturale.

ZUSAMMENFASSUNG
Der Beitrag zeigt die Notwendigkeit für ein wissensbasiertes System auf, um Beurteilungshilfen zu erzeugen, die dem Architekten die akustischen Aspekte beim Bau von Wohnhäusern zu berücksichtigen erlauben. Besonders in den entscheidenden Entwicklungsphasen wie Konzeption, Statik und Rohbau sind solche Hilfsmittel sehr nützlich.

1. INTRODUCTION

Building performances in general and acoustic performances in particular result from the combination two types of performance : architectural and technical performances. The global performance of building depends closely on the decisions made at the early design stages [1].

In residential building, the acoustic design objective can be reduced, in first approximation, to the acoustic insulation [2 , 3]. This one aims at carrying out the appropriate elements (geometrical and technical) so that the sound level received in one room is located within a range depending on the nature and the origin of sound, room purpose,.. when an exterior noise source is emitted [4].

Acoustic design process can be considered as a sequence of decisions made at different levels of abstraction with several design stages were identified [2 , 3]. Each stage is more detailed and more specific than the former in terms of objective and description. Regardless of the design stage the main objective (insulation against noise) is the same but the way to achieve this objective is different

The evaluation of acoustic building performances can be made by using some tools like Qualitel's [5] and CSTB's [6] Methods. These ones are generally used for evaluating acoustic building performances at later design stages and can not be used at early design stages for a lack of information (neither the site and nor the building are completely described). Hence, the only plausible way to predict the acoustic performances of a building at these stages is the application of context-sensitive past experience in the form of rules of thumb (heuristics).

From the relevant points of view, we contend that significant benefits can be realised by developing a Computer Aided Design system for assisting the designer to determine the acoustic performances of a building particularly at early design stages, where the impact of decisions made at these stages are more significant than choices made at later design stages in terms of cost-effective issues. K.B.S has to be chosen due to the context of building acoustic design.

2. ACOUSTIC BUILDING STUDIES

Acoustic building insulation can be carried out in several ways [4 ; 7]. By relying upon sophisticated and expensive technical solutions, the designers can ensure the protection of building against exterior as well as interior noise sources. But this protection can be also achieved through a good choice of building placement and orientation, a good distribution of apartments and rooms and to some technical means which are more economic compared with the previous case [7]. In fact, with a judicious implementation of building (for example parallel to a surrounding road), it is possible to reduce the noise level, to which one façade of the building is subjected, of 15 dB (A) [4]. We would like to turn attention to the fact that, in order to increase a sound reduction index SRI of a single wall of 3 dB (A), the wall's unit surface weight has to be doubled.

The sophistication of technical solutions to propose and consequently the cost, in order to fulfil depends closely on the quality of architectural solutions. Hence designers must try, as much as possible, to exploit the characteristics of site where the building is to be constructed and to find out the optimal architectural configuration of rooms and apartments [8]. They must, for example, place the bedrooms and living away from the sources of noise such as service duct, elevator, energy central production, noisily roads,... However, trade-offs must be made to achieve a good overall balance. In fact, the acoustic aspect is not the only aspect to be assured by a building, and the designer must consider the overlapping of the different functions of building like thermal, structural ones. In any way, acoustic building aspects must consider from the formative design stages and solutions have to propose if the designers do not like to rely upon sophisticated and expensive technical solutions for the achievement of the acoustic objectives.

3. ACOUSTIC DESIGN PROCESS

Acoustic design studies are inherently complex because of the high degree of interdependencies between various design parameters like building orientation, rooms organisation, components characteristics and so on. In fact, the choice of one parameters limits the range of assignable values to the others parameters. For instance, the implementation of bedroom beside an elevator implies the use of a very heavy wall which the unit surface weight of the wall must be 550 kg/m^2 al least. If the reinforced concrete is used as constructive materiel, thus the thickness of the wall must be superior to 22 cm.

Acoustic design process can be viewed as a sequence of decisions made at different levels of abstraction with four design phases were identified [9]: (i) - "Massing Stage (M.S.)" : the objective is to study the relationship between the building and its environment. In fact, the acoustical engineer can assure the protection of the integrity of the building with a judicious location and disposition of the building in relation to the surrounding noise sources . (ii)- "Sketches Stage (S.S)" : the acoustical engineer attempts to ensure a complementary integrity protection against outside noise by using features as balconies, flat set backs, ... and to study the spatial distribution of rooms and apartments,... in order to ensure the protection of rooms against inside noise sources. (iii) - "Preliminary Design Stage (P.D.S.)" : if the desired acoustical protection is not achieved, the acoustical engineer relies upon physical elements such as walls and windows. This is the objective of the third design stage. The assessment related to this level is based on global values expressed in dB(A). (iv)- "Detailed Design Stage (D.D.S.)" : sometimes this assessment can give misleading results, which is why acoustical engineers are trained to make spectral analyses and this is the objective of the fourth design stage.

4. TOOLS FOR EVALUATING THE ACOUSTIC PERFORMANCE OF BUILDING

Some existing methods can be used to evaluate the acoustic performances of a building like CSTB's [5] and Qualitel's methods [6]. They give a rough estimation of acoustic performances of design alternatives at later design phases (P.D.S. and D.D.S.), but they require a detailed description of site as well as building components. Therefore, the methods can not be employed to evaluate the acoustic performance at the earlier phases where the most of building parameters have not yet been assigned specific values and where it is difficult to guide the decisions by these methods because of a lack of information. Evaluation is generally based on rules accumulated during experience, . Hence, the tools to used for the evaluation of acoustic properties of design alternatives, are to be founded on heuristic, rules of thumbs.

The development of such tools is described in [10]. They consist of some prototypes expressed as production rules, forming a small expert system. These rules translate the recommendations of some experts into prototypes related, on one hand, to the implementation of residential buildings beside airport and roads,... and, on the other hand, to the organisation of rooms and apartments.

Knowledge Based systems have to be chosen for supporting compute design tools allowing the prediction of acoustic building performances at the early design stages for their multiple advantages [11 ; 12]. In fact, these systems are very appropriate for implementing tools based on heuristic like the tools to be used for evaluating the acoustic performances of building at formative stages. In addition, the K.B.S allows an easier up-dating of knowledge, and powerful Man-Machine interface [11 ; 13].

5. CONCLUDING REMARKS

Our objective is to specify the computer environment for implementing a set of computer design tools which allow to evaluate the acoustic performances of design alternatives corresponding the early design stages. For this purpose, the acoustic building design process was analysed and different levels of abstraction are identified with. Then, the appropriate tools to be employed, for each design stage, is specified. Knowledge based systems are not only suitable but indispensable for supporting tools allowing to evaluate the acoustic building performances at early design stages because of the context which characterise acoustic building design at these stages (context are grossly described).

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