IAPAI. SOFTWARE TO PREDICT ACOUSTIC INSULATION IN BUILDINGS IN ACCORDANCE WITH EN 12354/1/2

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ABSTRACT

Software has been developed to predict acoustic insulation in situ in accordance with EN 12354/1/2. Though of general use, the present version is oriented to specifications of the Spanish Building Technical Code. A large variety of enclosures and relative locations in the building can be chosen by means of interactive screens offered iteratively by the program to match every particular case. In parallel, acoustic data of the building, elements and products, can either be chosen among those offered or entered as user's data. The program recognises both situations and indicates this on the summary form, facilitating a way of controlling acoustics provisions at the design level. Return command icons mean that at every point in the running process, data can be changed or amended to data which is more convenient to a smart acoustic building design.

INTRODUCTION AND OBJECTIVES

The aim of this application is to create a tool for helping architects and technicians in the acoustic design of dwellings in accordance with the requirements laid down in the new Spanish Building Technical Code (CTE) [1]. Among the main changes in this code concerning acoustics, are the increase of previous level of acoustic performances, in situ controls and revisions of the architectural project, the latter being the main concern of this paper.

Previous national normative established requirements only concerning the construction elements used. The new normative will state requirements concerning entire buildings. As the predictive method to be used for the project, the method offered by European standards 12354 was proposed. The complexity and the amount of calculations involved, together with the customary acoustic knowledge of potential users, justify the development of an application for its automation.

STATEMENT OF ACOUSTIC REQUIREMENTS

Quantities for stating acoustic performances of buildings and products and building elements, in the Spanish CTE, are established according to Interpretative Document 5 protection against noise, of Directive 106/88 on Construction Products. Global or single number ratings are in accordance with EN ISO 717, yet maintain, as far as possible, the main lines of previous Spanish Acoustic Regulations in Buildings. The type of incident noise is included by means of spectrum adaptation coefficients. However, older names, such as 'insulation in dBA', have been conserved, with appropriate symbols, where they are not confusing. So R_A (= R_w + C) is used for products and partitions, $D_{nT,A}$ (= $R_{nT,w}$ + C) for airborne sound insulation between enclosures and $D_{2m,nT,Atr}$ (= $D_{2m,nT,w}$ + C_{tr}) for façades, as being the most representative. C and C_{tr} always correspond to the frequency interval 100-5000 Hz.

Airborne sound insulation in buildings through façades and roofs, when aircraft noise or railway noise is greater than traffic noise, respectively uses $D_{2m,nT,A}$ (= $D_{2m,nT,w}$ +C) and $D_{2m,nT,Atr}$ (= $D_{2m,nT,w}$ + C_{tr}) . Some supplementary penalties to compensate subjective effects of those two noises with regard to pink or traffic noises have been included on requirement thresholds [2], [3] , [4]. A great number of Spanish towns present large areas where those types of noise prevail over traffic noise [5], [6].

Tentative levels of thresholds for airborne sound insulation ($D_{nT,A}$)are 50 dBA between rooms for residential purposes in different dwellings, and 30 dBA between rooms for residential purposes in the same dwelling. Tentative impact noise level thresholds ($L_{nT,w}$) are 65 dB between adjacent rooms for residential purposes in different dwellings.

Noise levels from appliances and general building equipment are also included in acoustic specifications but they are not included in this software.

FUNDAMENTALS OF THE SOFTWARE

The European set of standards UNE EN ISO 12354 describes a predictive method to estimate the acoustic performance of the whole building from the performance of elements. Acoustic properties of those elements are characterised by laboratory measurements in accordance with standards EN ISO 140: 1,2,3,6 and 8. In buildings these elements do not behave in the same way, because they are joined to each other, creating a complex structure where interactions among elements may cause a considerable amount of indirect sound transmissions, or in other words, a decrease of acoustic insulation.

The predictive method takes into account both direct and second order sound transmissions. The total transmission results form the account of every possible transmission path (through a maximum of two different structures).

Junctions between elements play a capital role in accounting for secondary transmissions as vibration reduction depends directly on them. Empirical equations describing acoustic transmissions through junctions are limited to basic geometric shapes, right angles and symmetric elements in junctions. Only three shapes are allowed: **+**, **L** and **T** junctions.

These standards offer various possibilities to perform calculations, using different insulation indexes, different frequency bands, or simply using global indexes. To our knowledge, Spanish CTE constitutes a pioneering experience adopting this method on a national scale. It is developed in terms of entire building performances, then states fundamental quantities and their respective requirement levels (thresholds). Nowadays this software uses global indexes (single number ratings) throughout the whole computer process.

SOFTWARE ASPECTS

This software is intended to be of use mainly when designing a new building, to prevent having to refer to the acoustic requirements of the Building Technical Code before it is constructed; but it can also be used to solve both airborne or impact sound insulation problems in buildings. Despite the fact that the model used is based on experience with predictions for dwellings, it could be used for other types of buildings, provided the construction system and dimensions of the elements do not differ greatly from those in dwellings.

The standards UNE EN ISO 12354 entail a tedious, non-trivial method of calculus. Thus, this software works as a calculation tool to render the process less complicated so that all the calculations are invisible to the user. As the users are not supposed to be experts in acoustics, the software is intended to be self-explicative so that they will find it as simple as possible. Passing through the different screens a selection of the appropriate formula automatically occurs.

Though the current version is restricted to use single number indexes throughout the process, in accordance with the calculation model adopted in Spain, slight changes may render the software of general use in most European countries.

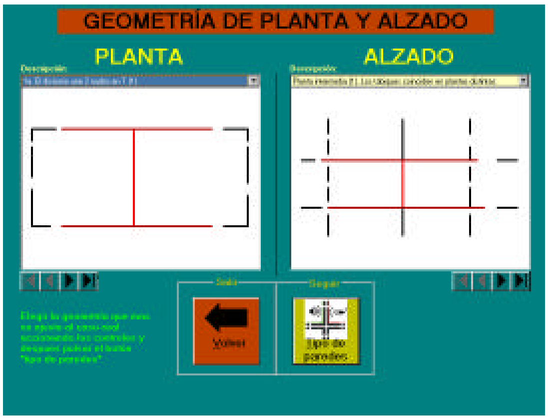
The user will pass through a series of dependant interactive screens which sufficiently describe the situation desired to obtain the necessary precision level. It is designed for pairs of dwellings (except in the case of façades where the emitter is supposedly outside the building). Therefore the entire house should be seen as a set of pairs of rooms. For the calculations the application will need to have part of the geometry and dimensions of each room and the acoustic characteristics of the elements. So as to simplify the process and save time, the software is designed to give the user the simplest offer in every single case.

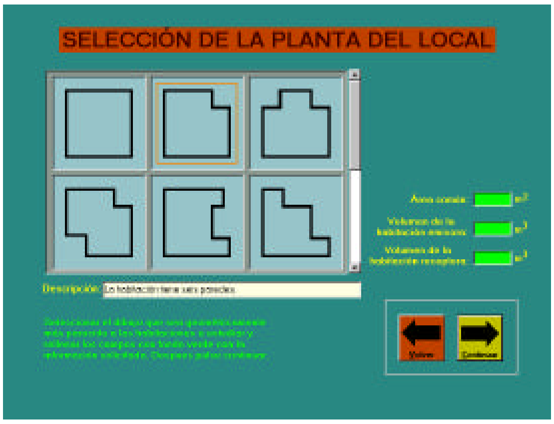
It can solve both airborne and impact sound insulation in a number of different situations. In the case of façades, the three different noise environments included in the normative are taken into account in the program. The user can choose the façade shape, and windows, doors and slits can be simulated in every wall.

For impact noises, three different relative situations can be chosen: rooms at the same level, superposed rooms and rooms joined in diagonal.

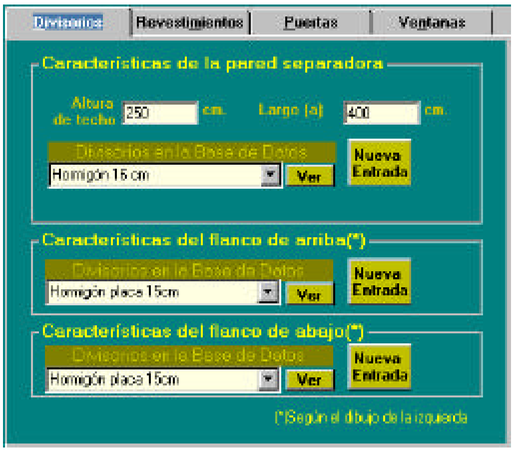
On the first screens, the user is asked about the type of noise and the situation of the dwellings in the building. With this simple information the software makes the first selection of possible relative situations for the dwellings and this is shown on the screen.

Then, the selection of the geometry is done by a system of sketches and descriptions. A huge set of different figures has been developed to cover the majority of possible situations, always under the restrictions of angles and symmetry of the junctions, imposed by the method. These limitations do not seriously hinder the capabilities of the software as most of the real cases are based on simple geometric shapes which are all reflected in that set.

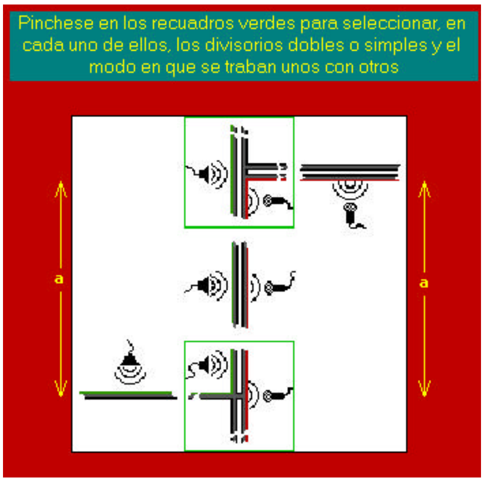




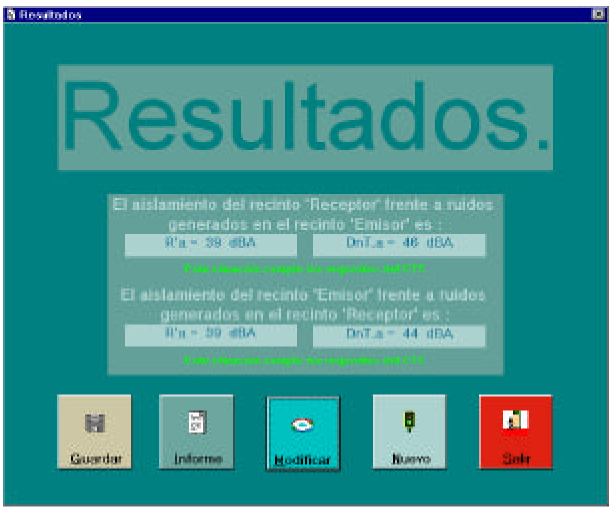
Once the geometry of the situation has been selected, the user browses through the windows where the structure dimensions and characteristics are requested. Depending on the type of noise or whether the separator element is vertical or not, the appearance of some screens changes, as well as the sequence of windows shown. The lists of elements also change depending on those conditions. In the example, sometimes walls will be offered as separator elements and sometimes floors. Shape and colour changes will indicate these differences:



Users will fill in the different tabs on a few screens offering information about the walls, floor, roof, doors, windows, balconies, etc. until the entire situation is described. Clicking the interactive sketches the user will choose between single or double separator walls and the way the flanking walls are attached to them.



Calculations are made assuming both situations, emitting from one side or the other, and both results are presented on the resultant form, thus facilitating the control of acoustics provisions at design level.

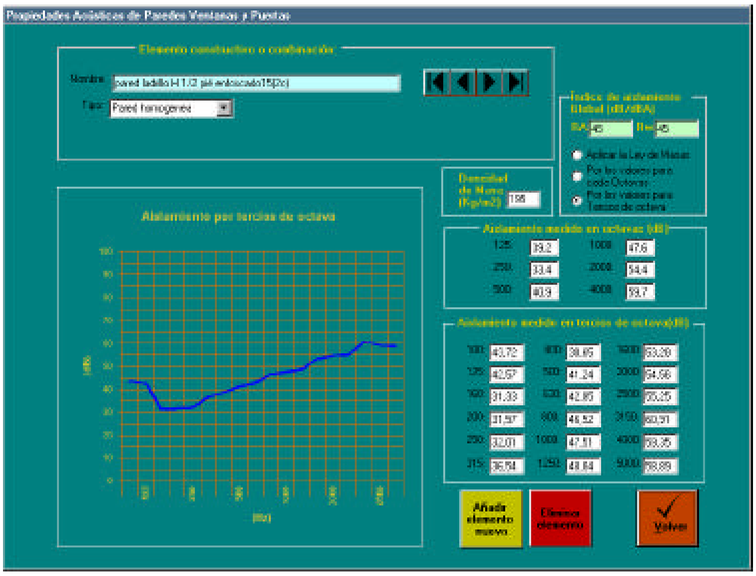


The software allows the user to go to and fro through the different windows modifying previous data and selections to help find the best option for every situation.

As the selections for the case continue, the associated set of equations are progressively adjusted by the program. Once finished, computing automatically carries out the appropriate presentation of the results.

When finished, each case can be saved to be reprocessed in the future together with the results form. The form can be saved in a number of formats and even printed.

A database, properly representing characteristics of Spanish building technologies and elements, is included with its acoustic characteristics measured in laboratory. When choosing the elements from the lists we have the option to consult this database and see the isolation curves. The database has an original set of elements measured in prestigious national laboratories. These original data cannot be modified, but the user can add his own data and modify these at will.



CONCLUSIONS

Software, in accordance with EN 12354/1/2/3 has been developed to help architects and builders fulfil the acoustic requirements of the latest Spanish building normative (CTE). Features concerning the selection of horizontal and vertical room sections, the flexibility of the database, the possibilities of running the program to and fro at any point, the saving and retrieving of case-stories, offer a correct, efficient and smart design tool for acoustic performances in building projects.

Although this application uses the calculation method adopted in Spain, slight changes in the source code would make it suitable for the normative and calculation methods of most European countries.

Results are presented in a form that summarises the main construction and acoustic characteristic of the rooms considered, indicating the conformity, or otherwise, with requirements.

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