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DIAL EUROPE: A DECISION SUPPORT TOOL FOR EARLY LIGHTING DESIGN

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ABSTRACT

DIAL-Europe is the final product of a three year European project that ended in March 2003. During this project the "Swiss" tool LesoDIAL, developed during the IEA task 21 in 1999, has been expanded with, among other items, an artificial lighting module. The objective of this module is to support artificial lighting design for architects in the early design stage. The tool gives help to find lighting solutions and provides an estimate of illuminance values on the work plane and walls and provides additional guidance on qualitative aspects and visual comfort as well as on switching control and integration with daylight. The module is based on generic light sources and luminaires.

This paper is divided into two parts: the first part presents an overview of the new functionalities of the final version of DIAL-Europe, and the second part focuses on the artificial lighting module.

INTRODUCTION

DIAL-Europe has been developed during an European project that has been executed from April 2000 until March 2003. During this period the capacities of the "Swiss" tool LesoDIAL have been enhanced and enlarged. LesoDIAL has been developed during the subtask "Daylight Design Tools" of IEA task 21 that was completed in 1999, (Paule et al. 1998; Paule & Scartezzini 2000). The aim was to give architects relevant information regarding the use of daylight, at the very first stage of the design process. Among the features that made this program successful, one can notice its very intuitive interface and speed. Another interesting feature is the possibility to simultaneously access calculation facilities (evaluation module), detailed information on lighting (lexicon) and visualisation of existing or simulated case studies (comparison module). Furthermore, the "diagnosis" facility based on fuzzy logic rules proves to be a very efficient means to guide the user towards an optimal daylight design.

The first year of the DIAL-Europe project has been used to work on making the interface more user-friendly. The resolution of the screen has been improved. The number of daylight openings that can be taken into account is increased from 6 to 10 per room façade. The option to describe vertical fins has been implemented. There is also now greater flexibility for the user with regard to specifying dimensions outside the range normally used within DIAL-Europe. For example, regarding reflectance values, the software warns the user when they are choosing a value outside what is recognised as the 'normal' range but the user is then prompted to confirm this choice. Details such as these, coupled with many other refinements, make the tool user-friendly, and will help enlarge its applicability for both professional and student.

During the second and third year of the DIAL-Europe project LesoDIAL has been expanded with:

1. European standards and climatic data;
2. Overheating [OH] module;
3. Artificial Lighting [AL] module;
4. Case Studies Database Extension.

In the next paragraph the four functionalities will be dealt with shortly, based on (Paule 2002; De Groot & Paule 2002). The algorithms for the AL module will be explained further in the paragraph after that.

NEW FUNCTIONALITIES

European Standards and Climatic Data

Overall objectives

The overall objective of replacing Swiss standards and climatic data by European standards and climatic data is to expand the applicability of the tool. Further, the algorithms used in DIAL have been extended to improve the daylight autonomy prediction, and to also take into account sunny skies, shading devices and advanced daylight systems. Additional objectives include the selection, development and application of visual comfort criteria and the specification of diagnosis criteria.

Climatic data

Meteorological data from Meteonorm (Meteotest 2002) have been used to adapt the daylight autonomy calculation to a large number of locations throughout Europe. The calculation is based on the external horizontal diffuse illuminance. Polynomial functions describing the cumulative probability for outdoor diffuse illuminance to attain a given level are obtained for each location. These new algorithms have been implemented in DIAL-Europe. Data from approximately 150 cities in 16 European countries are available. The countries covered so far include: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the UK.

Thanks to these functions, the annual daylight sufficiency is estimated, based on daylight factor values and with respect to the required indoor illuminance.

Calculation

BRE's simplified algorithms (BRE 2002) have been implemented in the software. These algorithms allow the program to take into account the contribution of ground reflection in both open outdoors and atrium cases.

The calculation grid has been modified from 9x9 in Leso-DIAL to 12x12 in DIAL-Europe. This increases the precision of the calculation and leads to a better knowledge of the maximum and minimum values of the daylight distribution.

<u>Overheating Module</u>

Overall objectives

The overall objective of the H&C module is to indicate the thermal implications (overheating) of the proposed window design with a level of input and output detail compatible with the daylight tool.

Achievements

Following a detailed analysis of the Admittance Method and the Free-floating Internal Temperature Method, it was decided to programme and implement a simple 3-node Resistance Network Method (RNM) into the tool, in order to calculate the overheating risk. The model takes into account the solar gain, lighting gain, climate data and ventilation rates within the room, as well as its thermal mass and occupancy pattern. Users of the software will then be warned of the overheating risk of their design.

Users will be able to specify the room type by selecting from a set of images within the software. This makes the choice between heavy, medium and lightweight building types much easier for non-experts.

Expert rules, based on fuzzy logic statements are implemented to prompt the user to optimise the design.

Many other parameters as orientation, glazing ratio, shading device and ventilation strategy, etc. will be used in this optimisation process to reduce the overheating risk.

Sunny skies, shading devices

Modelling work has been carried out using Radiance in order to provide information on shading devices and advanced daylight systems. A standard room has been modelled incorporating four different types of shading device: overhangs, light-coloured louvers, non-specular light shelves and diffusive blinds. This work has produced utilisation factors for input into the daylight software element of the tool.

<u>Artificial Lighting Module</u>

Overall objectives

The overall objective of the AL module is to develop an artificial lighting design module that would be compatible with the level of input and output detail in the daylight tool. Guidance will be provided on qualitative aspects and visual comfort, switching controls and integrate them with daylight.

Achievements

Work has been undertaken on the development of a set of generic lamps and luminaires for offices, hospital wards, and schools. The user will be able to specify the preferred light source, the light distribution required within their room, and the type and location of the luminaires. After the user has selected the source and luminaire of his or her preference, s/he can determine how many luminaires must be positioned of this type and also the distance between floor and luminaire. In the future it will be possible to select additional luminaires of another type, after which the design loop will be repeated.

In addition to this, diagnostic 'expert rules' have been developed that will help the user to select artificial lighting components. The rules are built as IF-THEN statements and either generate lines in the 'diagnosis' field of DIAL-Europe, or select the most suitable generic lamp or luminaire. One example is that depending on the preferred colour temperature, colour rendering and shape of the source (line or point) the user is addressed if the preferred combination is not possible.

Case Studies Database Extension

Overall objectives

The overall objective of this functionality is to increase the scope of the examples of real buildings and to develop and refine the criteria for their selection and the quality of their description and analysis. Also covered within this functionality is the generation of a range of simulated case studies, both to fill in 'gaps' in the real database and to illustrate parametric series for key variables.

Achievements

The selection of parameters and experiments have been completed as scheduled and work on the 2-year long period of simulations has commenced. The initial simulations, using Adeline and Radiance, have focussed on atria, with 162 cases being modelled. The atrium being simulated has been chosen from a real building from the Daylight Europe project. This was done in order get realistic proportions, materials and colours. Parameters are varied within each case and the results obtained show renderings, geometrical and photometric data for the room, daylight factors and daylight autonomy as well as graphical information about the room.

The data being prepared in this functionality will enable the user to compare the proposed design with the similar example(s) from the database. The test for similarity will be carried out by fuzzy-logic rules, as it was in LesoDIAL.

ARTIFICIAL LIGHTING DESIGN

After the user of DIAL-Europe has completed and evaluated his or her daylight design s/he is offered the possibility to also execute the AL module. Only if the amount of daylight is insufficient for the tasks to be executed in the specific room the user will be encouraged to develop an artificial lighting design.

The user interface of the AL module has been developed by Bernard Paule, who also developed the daylighting interface, (Paule 2000), and who is part of the DIAL-Europe project team. He has taken care that this part of the program is consistent with the rest of the tool.

In the daylight design some of the parameters needed for the artificial lighting calculation have already been specified by the user.. These parameters are copied to the AL module and are show to the user on the first screen of the module, figure 1.

The next step is that the user inputs his or her preferred light source and lamp power (figure 2), light direction (figure 3), lamp shielding (figure 4), and luminaire position (figure 5). When these selections have been made, the user can indicate the amount of luminaires of this type and, if relevant, the rotation angle, figure 6.

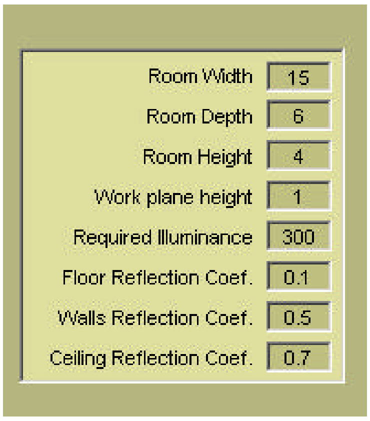

Figure 1: Part of the first screen AL module in which earlier relevant input is shown to the user.

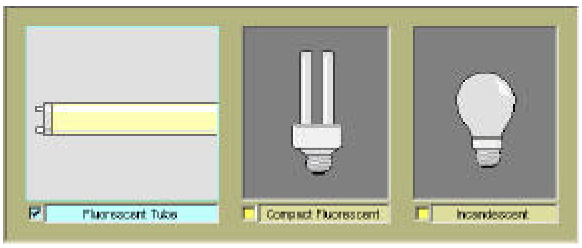

Figure 2: Part of the second screen of the AL module in which the user can select the light source and lamp power.

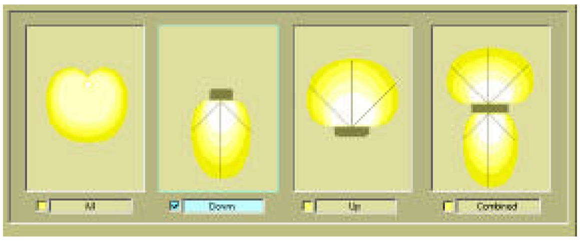

Figure 3: Part of the third screen of the AL module in which the user can select the light direction.

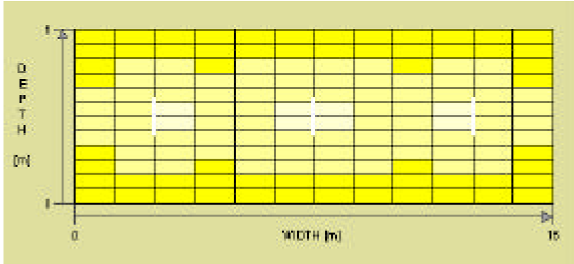

Figure 7: Part of the evaluation screen of the AL module in which the user can evaluate the light distribution on work plane level.

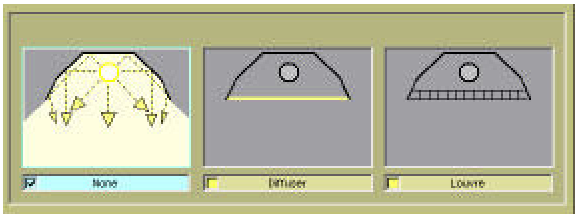

Figure 4: Part of the fourth screen of the AL module in which the user can select the lamp shielding.

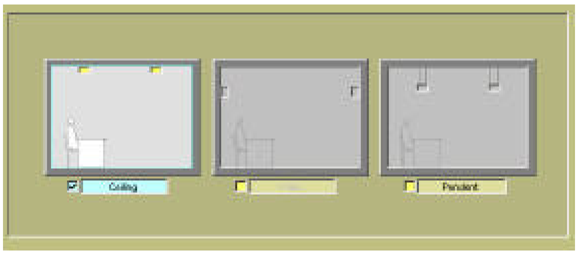

Figure 5: Part of the fifth screen of the AL module in which the user can select the lamp position.

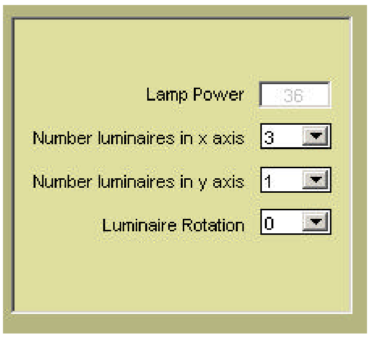

Figure 6: Part of the first screen of the AL module in which the user can enter the number of luminaires and, if applicable, the rotation angle.

Now all parameters are known the evaluation of the artificial lighting can be executed. The illuminance level is calculated for 144 points on work plane level (figure 7), floor level, all four walls, and the ceiling using the point source method, (explained in the next paragraph). From these values the maximum value, the minimum value, the mean value and the centre value are deduced and presented to the user.

The exact values can also be presented on screen in a table of values that can be exported to an excell-file.

ARTIFICIAL LIGHTING ALGORITHMS

The ‘point source method' is being used to estimate the illuminance level of artificial lighting. For line sources (fluorescent lamps) it is assumed that the lamp consists of several points, see figure 8.

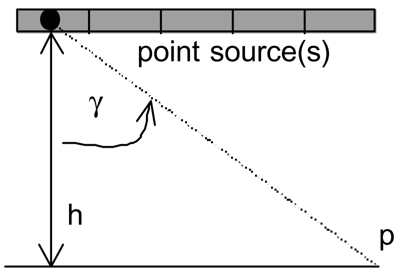

Figure 8: The parameters of the point source method.

Depending of the lamp power and thus lamp size, more point sources that each radiate an equivalent part of the total luminous intensity, are combined to form one line source.

The direct illuminance in point p:

$$E_p = \sum_{lamps} \sum_{j=1}^{n} \frac{\frac{I}{n} \cdot \cos^3 \gamma_j}{h^2}$$

with

j = 1/n^th of the lamp that radiates 1/ n^th of the total lamp flux;
n = number of point sources in which a line source has been divided, n=1 if the source is a point source itself;
I = total luminous intensity in [cd];
H = shortest distance between the lamp and the work plane;
γ = angle between h and the shortest distance between the lamp and point p.

The indirect component is considered to be uniform over all the room surfaces:

$$E_{ind} = \frac{\phi_T}{A_T} \cdot \frac{\rho_{av}}{1-\rho_{av}}$$

with

ϕT= total flux of all lamps [lm];
AT= total area of all room surfaces [m2];
ρav= average reflectance of room surfaces.

Calculation routines have been implemented to evaluate illuminance levels on each of the room surfaces (including work plane). Radiance videos have been embedded in the glossary in order to allow the user to see the influence of the colour temperature, the number and the distribution of a selection of luminaires.

CONCLUSIONS

More and more architects demand simple tools to optimise the use of daylight inside buildings, as early as possible in the design process. There is a real tendency to check daylight availability in buildings during their conception. Due to its philosophy for simplicity, rapidity and intuitiveness DIAL-Europe is in a very good position to fulfill this demand.

Further, DIAL Europe has the potential to educate the users to design more energy efficient. De Groot and Paule (2002) have been demonstrating earlier that after one year of availability on the internet 1,000 copies of DIAL Europe can be distributed, supposedly influencing only 10% of these designers to improve the use of daylight in new medium-sized (2000 m^2) buildings from 'typical' to 'good'. Assumed was that here 'typical' means almost no use of daylight and 'good' assumes a conservative 50% reduction in lighting energy. This estimate, together with the known typical yearly lighting energy consumption of this type of offices of 54 kWh/m^2 delivered electricity (BRESCU 2002), would sum up to an energy saving of 5.4 GWh/year.

Furthermore, visual comfort would be improved if users of DIAL Europe follow the instructions in the diagnosis area of the tool. Especially now also artificial lighting issues are considered as well, the user should be capable of designing an integrated lighting design (including daylight and artificial lighting) that causes minimum visual discomfort.

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- ESTIA SA

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