CALCULUS AND CONCEPTION OF ARCHITECTURAL INTEGRATED LIGHTING SYSTEMS

Mihai HUSCH
Decolight S.R.L.

The purpose of the thesis is to realize a study concerning technical and qualitative aspects of light and electrical lighting use in interdependence with the architectural space. Given the highly actual interest for the architectural lighting, this paper aims at updating the currently available information with useful methods and techniques, some of them being a first for our country, placed together with those already known and applied, synthesizing them in an original manner, through an effort towards a systemic approach of this interdisciplinary field. Due to the overall complexity of the subject, this paper limited itself to a first general synthetic approach of architectural lighting, previously a missing subject to the lighting specialists, and that opens the perspective of future research, able to take into consideration multiple elements from border areas between most diverse fields, with accent on highlighting the elements through which lighting can provide extra functionality and esthetics for architectural spaces, a more comfortable and agreeable environment.

Chapter 1 makes a short theoretical and practical overview of the current status of the studied field and introduces an original proposal for analysis of architectural lighting by similarity to the principles of architectural analysis, based on general quantitative and qualitative aspects, but, as well, on specific esthetic aspects.

Chapter 2 deals with the quality of lighting systems, determining aspect in the connection lighting– architecture, with aspects concerning luminance distribution, light color and modeling architecture elements through the use of light.

Chapter 3 presents the known computational methods (global and point) for lighting systems and the schemes for logical treatment of automated computation.

Chapter 4 describes a series of particular structures used in the interior architectural lighting: walls and lighted ceilings and integrated systems natural – artificial lighting, each of them with usage examples for different rooms studied by the author.

Chapter 5 presents solutions for architecture integrated interior lighting interior, with specific aspects for every type of space: museums, churches, conference rooms, commercial spaces, restaurants, high spaces (atriums, halls), transition areas (receptions, waiting rooms, halls, corridors). The material, highly illustrated with examples of architectural solutions, presents particular lighting aspects for a series of spaces and destinations, considered the most representative for the applicability field of architectural lighting.

Decorative-architectural lighting of building facades is the subject of chapter 6, where the fundamental aspects of the conception of these lighting systems are described: the relationship light-building, light sources and used light devices, the physical arrangement of light devices based on the building characteristics, computation methods.

The modeling of light systems is described in the chapter 7, together with developing methods: physical modeling or computer graphic simulation.

Chapter 8 presents modern solutions of indirect systems for interior/exterior lighting with projectors and reflector surfaces. The description of these systems, with their advantages and disadvantages, with examples of applications, form a preamble to chapter 9, where the author presents an original computation method for indirect lighting systems with projectors and secondary surfaces formed by reflector panels. The description of the method is done starting from the theoretical aspects and contains the light source modeling, computation of direct illumination of the reflector panel, computation of form factors and computation of the reflected component.

In order to get a pointwise solution, the chosen mathematical model assumes a combination between finite element discretization, the radiosity method and iterative numerical methods for solving systems of equations. The surfaces are divided in finite elements (elementary surfaces), that absorb and reflect the light, thus becoming elementary light sources. Because the physical process is iterative, the iterative numerical methods have not only a mathematical support, but a physical support as well.

The main steps in the numerical approach have been:
- domain discretization;
- computation of the form factors;
- form and solve the produced system of equations;
- graphic visualization of results (as a table of values, as graphic output of illuminance and luminance values, rendered images of the environment).

For the automated calculus of light systems with projectors and reflector surfaces, the author has developed an original computer program entitled **Enlight** that allows obtaining the point lighting values on the representative surfaces of a closed space. Due to the complexity of the considered geometrical and luminotechnical parameters, a manual computation is not possible. In order to validate the produced results, an experiment has been set in a closed space of the Lighting Systems Applications Center of the Faculty of Installations – U.T.C.B. The purpose of the experiment has been to get the point lighting values of a floor of a parallelepiped room, the lighting system being formed by a projector with the lighting flow having concentrated distribution in the direction of a rectangular reflector panel, this one diffusely reflecting the light towards the working plane. The comparison between the experimental data and the computed data leaded tot he conclusion of a high accuracy degree of the computation method. This comparison has proved the correctness of the proposed theoretical model. Moreover, we have compared the illumination values produced, for a room having the same geometrical and lighting characteristics, by the computer program Dialux 3, recognized as a standard in the lighting field. The comparison has validated once more the results of our own program.
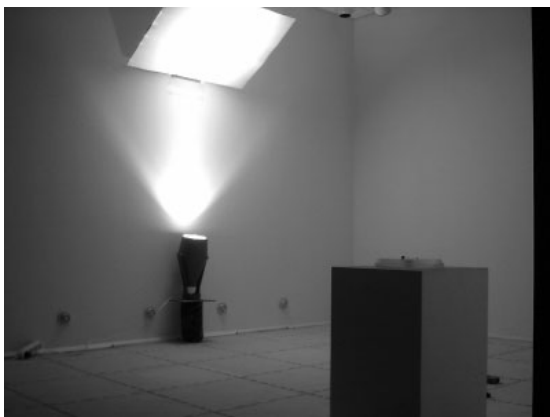
Figura 1 A view of the experimental room and lighting system

We underline the following contributions of the author of this PhD thesis:
- a synthesis of the existing information for the very actual field of architectural lighting, with specific problems, the current status and practical applications, the first development in this direction being the extended bibliographic study for this topic;
- proposal of a scheme of approaching the study of lighting systems in relation to the model of architectural analysis;
- a synthetic presentation of considerations concerning new solutions for interior/exterior lighting with projectors and reflector surfaces;
- development of an original computational method for indirect lighting systems with projectors and secondary sources made by reflector panels;
- the lighting calculus, with the modeling of the projector-reflector panel set and the development of the computational relationships for indirect lighting on the panel based on the specific geometrical parameters (projector-panel distance, inclination angle of the source axis with the vertical line, inclination angle of the reflector surface with the horizontal line) as well as lighting parameters (distribution curve of luminous intensity);
- development of our one computer program for lighting systems, entitled Enlight, written in C++, and using object oriented programming techniques (OOP) and dynamic memory allocation;
- development of the 1:1 scale model of an indirect lighting system using a projector and a reflector panel and the collecting of experimental data that validate our computer program based on the suggested original method;
- an analysis of the influence of a geometric parameters of an indirect lighting system with projector and reflector panel, with the obtaining of graphical distributions and nomograms, useful in the engineering practice.

Mihai HUSCH
S.C. Decolight S.R.L.
Bucharest, Şos. Mihai Bravu Nr. 444, Bl. V10, ap. 47
Phone/Fax: +40.(0)21. 2121415
E-mail: mihai@hd.kappa.ro

CALCULUL ŞI CONCEPŢIA SISTEMELOR DE ILUMINAT INTEGRATE CU ARHITECTURA

Teza de doctorat a dezvoltat un studiu privind aspectele tehnice şi de calitate ale folosirii luminii şi iluminatului electric în interdependenţă cu spaţiul arhitectural. Dat fiind interesul de mare actualitate faţă de iluminatul arhitectural, lucrarea vine în completarea informaţiilor existente la ora actuală cu metode şi tehnici utile, unele în premieră în ţara noastră, pe care le alătură celor cunoscute şi aplicate deja, sintetizându-le într-o manieră originală, printr-o abordare sistemică a acestui domeniu interdisciplinar….

În capitolul 9 este prezentată o metodă de calcul originală a sistemelor de iluminat indirect cu proiectoare şi suprafeţe secundare constituite din panouri reflectante. Descrierea metodei se face pornind de la aspectele teoretice şi cuprinde modelarea sursei de lumină, calculul iluminării directe pe panoul reflectant, calculul factorilor de formă şi calculul componentei reflectate. Pentru calculul automat al sistemelor de iluminat cu proiectoare şi suprafeţe reflectante, autorul a realizat un program original de calcul automat intitulat *Enlight*, care permite obţinerea valorilor iluminărilor punctuale pe suprafeţele reprezentative ale unei incinte. Dat fiind complexitatea parametrilor geometrici şi luminotehnici luaţi în consideraţie, un calcul manual nu ar fi fost posibil. Pentru validarea rezultatelor programului propriu, a fost pus la punct un experiment realizat într-o incintă a Centrului de Aplicaţii pentru Sisteme de Iluminat al Facultăţii de Instalaţii – U.T.C.B….

Se remarcă următoarele contribuţii care aparţin autorului tezei de doctorat:
- realizarea unei sinteze a informaţiilor existente pentru domeniul de mare actualitate al iluminatului arhitectural, cu problemele specifice, stadiul actual şi aplicaţiile practice, prima realizare în această direcţie constituind-o studiul bibliografic extins asupra temei;
- propunerea unei scheme de abordare a studiului sistemelor de iluminat în conexiune cu modelul analizei arhitecturale;
- efectuarea unei prezentări sintetice a considerentelor privind soluţiile noi pentru iluminatul interior/exterior cu proiectoare şi suprafeţe reflectante;
- punerea la punct a unei metode de calcul originale pentru sistemele de iluminat indirect cu proiectoare şi surse secundare constituite din panouri reflectante;
- calculul luminotehnic, cu modelarea ansamblului proiector-panou reflectant şi obţinerea relaţiilor de calcul pentru iluminarea directă pe panou în funcţie de parametrii geometrici (distanţa proiector-panou, unghiul de înclinare a axului sursei faţă de verticală, unghiul de înclinare a suprafeţei reflectante faţă de orizontală) şi luminotehnici (curba de distribuţie a intensităţii luminoase) specifici;
- concepţia unui program propriu de calcul automat al sistemelor de iluminat, intitulat Enlight, realizat în C++, ce foloseşte tehnici orientate obiect (OOP) şi alocarea dinamică a memoriei;
- realizarea modelului la scara 1:1 a unui sistem de iluminat indirect folosind un proiector şi un panou reflectant şi obţinerea unor date experimentale care validează programul de calcul automat bazat pe metoda originală propusă;
- realizarea unei analize a influenţei parametrilor geometrici ai unui sistem de iluminat indirect cu proiector şi panou reflectant, cu obţinerea unor distribuţii grafice şi a unor nomograme, care se pot dovedi utile în practica inginerească.