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OPEN-PLAN OFFICE LIGHTING

Interactions with other performance variables

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Over the past ten years, those of us in the architectural lighting design field have seen the process of lighting design theory become increasingly complex, with a growing interest in the issues of visual task performance and visual comfort, and an increasing reliance on calculation as the basic method of design verification.

At the same time, the average practitioner of lighting design tends not to work directly with these newer perceptual metrics, but rather relies on the information and product-based results of efforts to increase lighting quality which originate within the manufacturing community.

While the lighting manufacturer becomes increasingly interested in this ongoing scientific research, the designer normally tends to apply the same judgmental test to determine final lighting quality as he has in the past, the test of client satisfaction. While many in the lighting design field have felt defensive as a result of a low level of interest in or knowledge of the "science" of lighting, recent research and practice within this and related fields suggest that the architectural design process is moving toward a new set of technical definitions based on client satisfaction, and to some degree, common sense is again becoming respectable.

Open plan offices

In the late 1960's, the open plan office was first seen in applications in the United States, as the concept migrated from Europe and Canada. With its introduction, the concept of the office and its organization became more clearly defined by function rather than by status, as had previously been the case.

The concept of the open plan office was the first clear attempt to define architectural interior planning as an "efficiency based" or functional performance problem, and the problem of "interior design" and its contribution to office design would never again be the same. What had previously been an intuitive attempt at creation of a pleasant, functional space was now emerging as the problem of "space planning," with its attendant work-flow studies and bubble diagrams. Management consulting had now become part of

interior architecture.

Similarly, as the 1970's progressed, other areas of interior architecture began to exhibit the same application of scientific study. Between the late 70's and mid 80's, views emerged in many areas based on performance definitions, many of which had grown from the open plan office concept. "Lighting level standards" had been partially displaced by "visual performance" and "visual comfort," "speech privacy" had supplanted "noise control," "thermal comfort" had begun to overtake "temperature" and the need for "views" had now been overtaken by the science of "daylighting."

The previous problem of office design had been that of providing a desk and chair in an open, well-lighted, moderately noisy 70 °F office, hopefully with outside views. Now, the process became one of placing the occupant in a "workstation" with "acoustic panels" and "task light."

While the physical change in office design was obvious, a more subtle shift occurred. Where one designer had previously had responsibility for most, if not all, of these decisions, there were now a set of specialists at work on portions of the problem. None of them was involved with the problem in its entirety. The designers, and their responsibility on the typical large project, became: 1) architect—building envelope; 2) electrical engineer—lighting; 3) mechanical engineer—HVAC system; 4) interior planner—space planning/design; 5) acoustic consultant—noise/privacy.

While previously one designer, working on the office interior, had some experiential information regarding the problems of each of these disciplines, the specialist knew more about his own discipline and little or nothing about those disciplines of the other design players. Thus, as the office design process became more complex, the new specialization led to more single-dimensional solutions and less understanding of the interactions between disciplines; each player had to have "faith" in the adequacy of his cohorts in practicing their respective disciplines.

A second major change occurred in the design process itself. From the early history of architecture and design, the designer learned the benefit of an application by trial and error, either by viewing the solution or by prototyping it and experiencing the results. With the advent of specialization and the scientific approach to design, calculational process and design automation began to supplant experience and hands-on evaluation. In the newer design process, these mathematical tools began to overtake conventional design: 1) architect—building envelope calculations; 2) electrical engineer—zonal cavity calculation; 3) mechanical engineer—HVAC calculation; 4) interior planner—work flow study and equipment needs survey; 5) acoustic consultant—privacy calculations.

A final shift that was inherent in this process was the move to symmetric and homogeneous design which was necessary in order that the calculations be simple enough to predict results with a reasonable degree of confidence. Thus, the typical office project now had identical lighting grids across the space, similar thermal levels throughout, similar acoustic treatment throughout, and little daylight throughout.

While offices previously had variations in all of these variables, there was now a symmetric, standardized environment throughout. Since there was little variation, the assumption of design was that the performance levels of these variables must be suitable to resolve any performance needs possible in the office environment. Where office interiors, like eating establishments, used to suggest some architectural regionalism, they now suggested a national continuity of similar approaches.

Performance interactions

While the specialized designers of these newer office types were very pleased with the performance results of much of their work, the occupant of these spaces was a far less willing victim of the new interior specialization. Additionally, while the specialists only considered the new office in terms of the performance within one discipline, the occupant experienced the office performance as a whole.

When the occupant of the open plan office sat down at his workstation, he realized that his total view was that of an acoustical panel, and that the variation, texture and complexity of the office was gone. He also noticed that the windows, which had previously brought him daylight, were now being used either for private offices or to light the corridors of the open plan office.

When he began to listen to his environment, he realized that it was far quieter than it had been previously, although he could still hear and understand conversations of those adjacent to him.

The privacy that had been promised never materialized, for the most part, although the feeling of enclosure suggested that his employer considered him to be more important than previously.

When he tried to work in his workstation, he began to discover that it seemed "dimmer," although the same number of lights were in the ceiling, and he began to depend on localized "task lighting" to resolve this new problem.

Finally, he began to notice problems of temperature control and air flow. It became very apparent that if he smoked the smoke didn't easily leave the environment any longer, but rather began to stagnate.

Thus, while the specialists were designing this office to the highest levels of the technical definitions currently in place, the occupant of the space, with no technical knowledge, could easily see that the overall solution brought about many specific problems, and the reports of success by the design team did not provide the occupant with any additional comfort.

The problem of specialization and models

While the occupants of these offices know the extent of their performance failures by experience, the specialized designers generally did not understand the basis for these problems for two reasons. They only understood one discipline and caused failures in other disciplines via their work, and their calculational models were oversimplified and often directly failed in their predictions.

Most decisions in architecture have more than one result.

Often, when the most important result is not even considered in the process of making the decision, the following interactions tend to occur: 1) Since acoustical control suggests division and barrier use, acoustical decisions often reduce lighting, daylighting and airflow performance. 2) Since lighting is often selected by spacing-to-mounting height ratios, the distance between lights tends to make barriers more efficient in obstructing them. 3) Since lighting is often chosen with wide vertical distribution, barriers assure that less light will reach the task. 4) Air diffusers and returns are designed based on theories of air flow in unobstructed rooms, and obstructions tend to "short circuit" the path from supply to return. 5) While daylighting requires openness, open plan workstations are the paradigm of closure.

The mathematics of the various disciplines add to this problem in a very predictable way. An excellent example is the use of the zonal cavity calculation in the open plan office.

The zonal cavity calculation, as published in the *IES Handbook*, is based on the theory of the averaging of the total lighting available by the area that is being lit, and the calculation is reasonably valid in empty rooms. There are a number of assumptions inherent in this method, including: 1) The lighting system is symmetric throughout, 2) Reflectances are constant on each of the relevant architectural surfaces, 3) The space in question has no barriers.

When applied to the open office, this method provides predictable failure, and it has been the basis for a number of cases of client litigation. Specifically, when this calculation is applied to the average open plan office, the results overstate the lighting level by about four times at the occupied workstation. (*i.e.* 50 fc becomes about 12.5) This has been confirmed by hundreds of specific measurement cases.

In acoustics, the model chosen for application to the open plan office is often based in ASTM standards related to sound absorption and transmission. Generally, it is assumed that the selection of appropriate products results in the satisfactory acoustic performance of a space. The failure of these metrics results in the fact that there is very little adjacent acoustical privacy in the open plan office setting, because the distance between persons is not great enough. The acoustical community has recently demonstrated that neither of these ratings has a very direct bearing on speech privacy, and that other variables, such as distance between occupants, are generally more important.

The models which are most commonly in use in the application of daylighting to buildings are the "daylight factor" method and the calculations of fenestration efficiency developed by Lawrence Berkeley Laboratories. The models suggest that the issue of daylighting is the issue of the efficiency of the building shell.

Many daylighting practioners know that the use and design of the interior is far more important than the design of the building cross-section; the standard approach to open plan office design and layout will often mitigate all daylighting use within a very short distance of the building shell.

Finally, the HVAC community and the members of ASHRAE have long been proponents of calculations to determine the application of heating and cooling systems that are, generically, not too dissimilar from the zonal cavity calculation of the lighting field. These calculations assume the room in question to be open and obstructed, and they have predictive value in these cases.

In the open plan office, they do not take account of the restriction on air flow provided by the open plan dividers. They also do not consider the "short circuiting" effect of these panels on the air supply and returns. It is interesting to note that measurements of airflow inside of workstations are often one quarter of their value in the open areas of the same office, and the value of these measurements often suggests a stagnant air condition.

Recommendations

Many of these issues are subjects of recent or current research, and much information will be available over the near term; others have not yet achieved as much recognition. With regard to the perspective of our lighting practice, these are some views that we tend to apply to this type of office.

Remember that in all of these areas of performance, the most important variables are: 1) distance to objective or task, 2) orientation of source, and 3) intensity of source in task direction. Solutions should be defined via these and other variables before products are considered.

In the open plan office, the CU (coefficient of utilization) is far less important than the efficiency of the application; how much light is available vs how much reaches a task. We call this the CA (coefficient of application). In open plan offices, many high CU products have very poor CA ratings.

Non-symmetric lighting systems that move with the furnishings are often the most "CA" efficient possibilities. Visual comfort includes the absolute need to have light reflectance surfaces surrounding the occupant.

Task lighting is hardly ever the same quality as general or "ambient" lighting systems, due to its position in front of the viewer. Try to insure that half of the task lighting comes from the general lighting system.

Discussion and control of other issues is important in this type of office: graphics, visual tasks, and VDT monitor selection.

It is important that acoustic panels not be used where they provide no privacy benefit. Suggest to your client the use of an acoustic consultant who is sympathetic to the use of exact rather than blanket solutions, and who will not "panelize" all occupants. (It is interesting to note that corporate facilities departments usually suggest confidential privacy needs for 5–10 percent of their employees, and yet open plan offices usually surround everyone with panels.)

Most problems of performance in the open plan are complex; the only way to assure an understanding of that performance is through the use of prototypes, and clients are generally in favor of this approach.

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