THE SCIENCE & ART OF "DAYLIGHTING"
BRINGING NATURE'S LIGHT INSIDE

Philippe C. Dordai, AIA, NCARB
Hillier, Princeton, NJ
Philippe Dordai is a Principal with Hillier,
a seven-office, multi-disciplinary architecture and planning firm

Daylighting refers to efforts to harness natural light, primarily to increase a building's energy efficiency, but also to bring light inside. In the past, architects have had a fairly narrow range of traditional choices in solving the problem of daylighting. Relatively high maintenance solutions have been utilized in Europe, resulting in long, thin (and expensive) buildings. Efforts to control daylighting and increase energy efficiency in this country have focused on providing various types of reflective coatings on glass.

Recent developments in daylighting techniques can be classified as either "passive", which rely upon a particular, fixed configuration of building elements or "active", which involve devices which track and react to the position of the sun. In general, passive solutions, even when cost-effective, are less precise. Meanwhile, new technologies such as photo sensitive coatings and micro-laminated coatings on glass promise modified active systems without the costs associated with the moving parts of the present systems. Ultimately, the ideal solution is one which is fully integrated and uses daylighting to supplement artificial light in a dynamic and energy efficient way.

As the advantages of using natural light become more apparent - not only as measured by increased energy efficiency but in terms of improved morale and productivity - daylighting will become a more integral part of building design. At the same time techniques to provide such solutions will become increasingly sophisticated and precise.

Background

Daylighting has become increasingly important in buildings, in part because it is recognized as relating to the improved morale and productivity of a building's occupants. Building codes in some European countries require that all office workers have access to some daylight. While increased productivity is more difficult to measure among white-collar workers, anecdotal evidence among office workers is extremely strong regarding preferences for natural light a feeling of connection to the outdoor environment. Planning specialists are now incorporating surveys into their research to attempt to quantify those productivity gains.

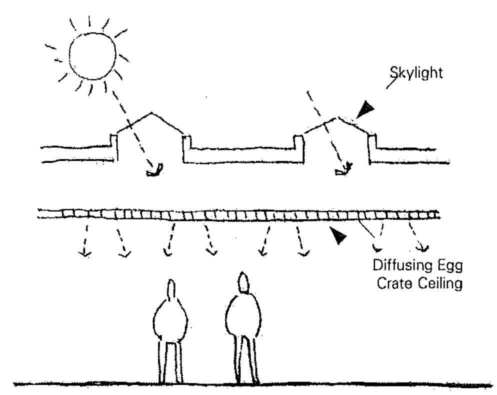

figure 1

The problem of how to bring daylight into buildings is not new. In the past, architects have had a fairly narrow range of traditional choices in solving this problem, relying on light shelves, skylights, louvers and clerestory glass, etc. (FIGURE 1-2) to selectively admit natural light.
The solutions have usually relied upon some manipulation of the depth of the building's exterior wall and have commonly been viewed by owners as high maintenance solutions.

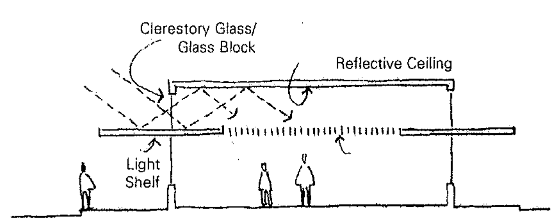

figure 2

In Europe, where energy costs are high, daylight control devices have typically been a part of exterior wall systems and have involved relatively expensive and high maintenance solutions such as manually adjustable or motorized blinds. (FIGURE 3). European architects have also designed longer, thinner buildings to insure that daylight is available to all. However, these buildings are more costly to build because their shape (FIGURE 4A) requires more exterior wall square footage to enclose the same volume of space than in a more conventional rectangular or square building (FIGURE 4B).

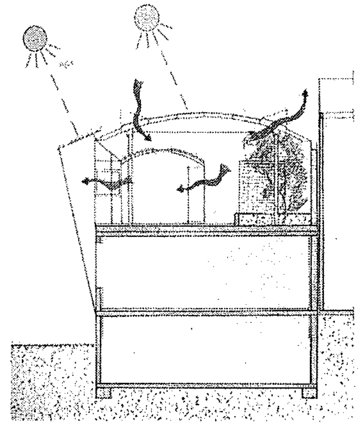

figure 3

In the United States, daylighting and related energy performance solutions have focused on either adding insulation to the existing envelope to reduce thermal transmission or on providing various types of reflective coatings on glass to control different parts of the solar spectrum. Early coating methods were rather crude, allowing less daylight to penetrate; these worked by reflecting most of the light off the mirror glass facade (FIGURE 5). Subsequent combinations of tinted glass and special coatings have resulted in more sophisticated glass which rejects the infrared band of the spectrum (heat) and permits the visible portion to pass through the glass. These types of low-E glass coatings are also designed to admit heat into the building during the winter and reject it in the summer.

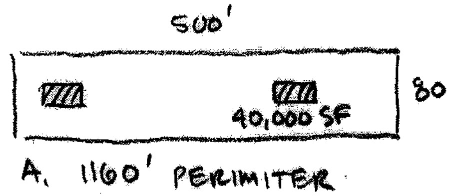

figure 4A

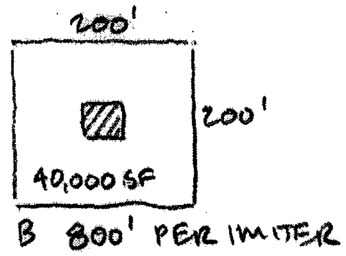

figure 4B

Recent Developments in Daylighting Techniques

In general, the recent daylighting solutions we are discussing can be categorized into two groups; "passive" solutions, which rely upon a particular, fixed configuration of building elements to redirect the sun, and "active" solutions, which consist of moving parts which react dynamically to the position of the sun to optimize the daylighting in the building.

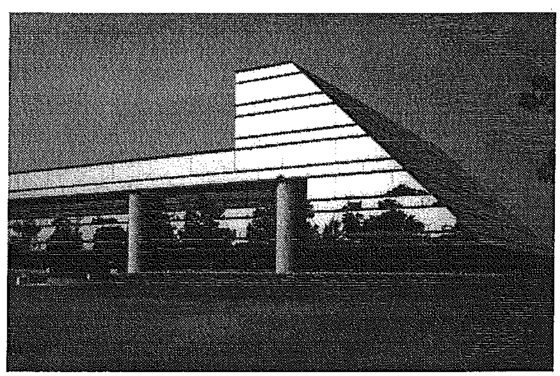

figure 5

Our initial design concept had proposed two basic approaches to daylighting. The first utilized exterior and interior light shelves (FIGURE 14) to redirect sunlight onto the ceiling; the second utilized large two-story "work studios" (FIGURE 15) which because of their tall glass openings would admit daylight deep into the center of the building (FIGURE 16). These interior spaces were conceived of as functioning like a traditional lightwell - which would normally be enclosed by exterior wall construction. This concept demonstrated the advantages of utilizing interior construction for the boundary wall of the lightwell, a relatively economical alternative to the original exterior lightwell. The ultimate design evolved into a multi-component system in which each part plays a significant role in the overall scheme.

The components of the system are as follows:

- A 9'-6" interior ceiling height within a 13'-0" floor-to-floor height to permit the design of an indirect lighting system and maximize the depth of the daylight penetration.
- A ceiling surface and adjacent wall finishes designed to optimize brightness and reduce glare and contrast.
- A series of twelve, two-story high work studios designed as team work rooms and as overall sources of daylight for the adjacent office areas. These rooms are equipped with interior light reflectors and computer-controlled roller shades to again redirect sunlight and skydome light onto the ceiling of these two-story spaces.
- A largely open interior plan with no perimeter offices to maximize the penetration of daylight into the building.
- A well-designed artificial uplighting system which can be dimmed and can handle input from a daylight sensor.
- An exterior wall system which takes advantage of setbacks and projections to shade the vision glass wherever possible (FIGURE 17).

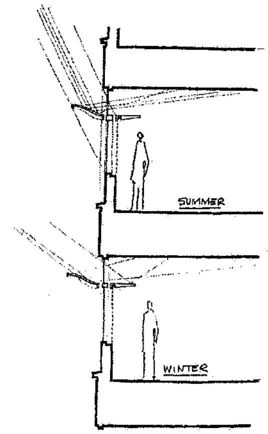

figure 14

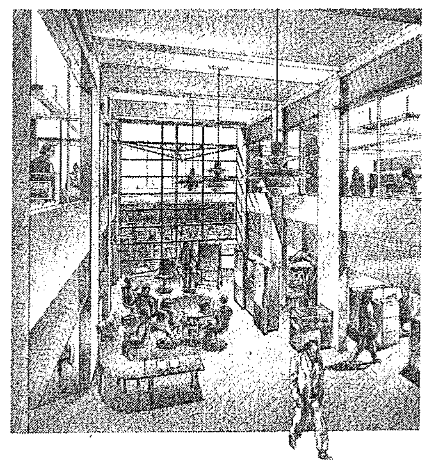

figure 15

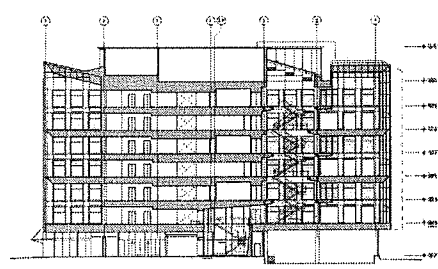

figure 16

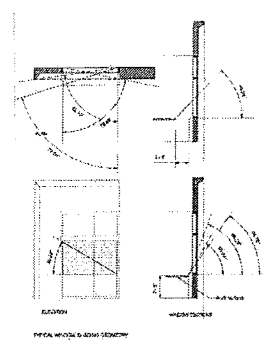

figure 17

o A light reflector/sunshade which acts to redirect more daylight into the transom glass and hence up onto the ceiling (FIGURE 18).

o A sophisticated transom glass which uses acrylic prisms precisely angled to redirect sunlight and skydome light up onto the ceiling of the space (FIGURE 19).

As each component was developed and fine-tuned, computer analysis played an essential role in providing the engineering back-up to what were originally schematic concepts (FIGURE 20). These tools were also used to keep the client informed about the daylighting solutions and gave the design ideas a quantifiable foundation upon which they could be evaluated.

None of the components alone could have done the job. Together they provide an integrated system in which each piece provides a part of the daylighting design, one which permits the occupants to turn off their lights, save energy, and enjoy higher quality lighting.

And so a fully integrated solution developed out of our analysis of the problem at Hoffman LaRoche (FIGURE 21). It involves a complete system which uses daylighting to supplement artificial light in a dynamic and energy efficient way.

The design, predicated on a compromise between a static solution and a dynamic source (the sun), has an analogy in another, more conventional architectural problem, namely that of rain drainage. Think of how well most pitched roof and gutter systems work to drain roofs. Add a rain barrel at the end of the downspout and you have a relatively good model in terms of a passive system which handles an active and variable source acting upon it (rain). To work properly, all the components must be designed together and be in balance. The pitch of the roofs must be steep enough to get good drainage but not too steep as to cause the rain to pick up such speed that it overspills the gutter at the eaves. The gutters must be sized to handle a downpour but not so big that they pick up debris and constantly need cleaning out. At the end, the collector must be sized to provide the right size reservoir.

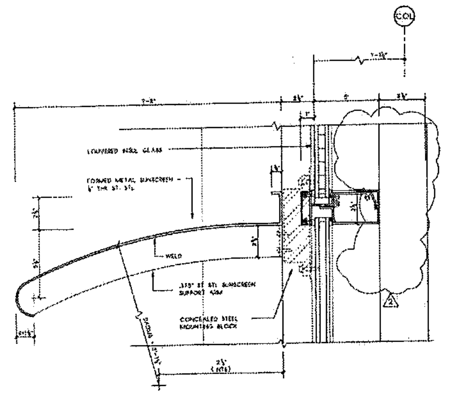

figure 18

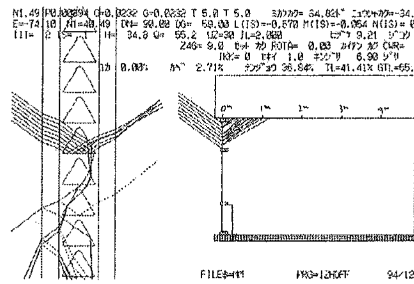

figure 19

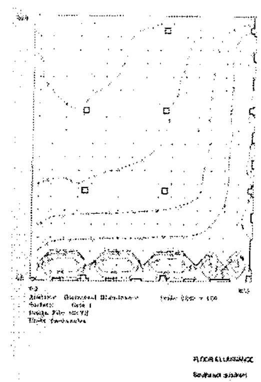

figure 20

figure 21

Like the rain collection system, the sun collection system must be conceived of as a closed loop, from its source to its end point.

Daylighting is becoming recognized as an integral part of building design. As its effect on both cost savings and employee morale begins to be quantitatively measured and demand for daylighting increases, we can expect the techniques which provide such solutions to become increasingly sophisticated and precise.

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