



A Lighting and Acoustics Report

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The Carpenter Center for Visual Arts

Architect: Le Corbusier, 1960-1963

24 Quincy Street

Cambridge, MA 02138

I. Lighting

Daylighting and Sunlight Penetration

The South studio space on the second story of the Carpenter center is illuminated from the south through the brise-soleil and to a limited extent from the north where the ramp and open air corridor penetrate the building. The curve of the brise-soleil can be approximated as two straight edges, each with a characteristic range of angles for which direct sunlight can reach the interior. As each sheet of glazing runs from east to west, and each concrete baffle from north to south, the baffles should admit all sunlight that comes directly from the south.



The south façade of the Carpenter Center

Along the western edge, half the glazing has direct exposure when the sun is 30 degrees east of south, or 50 degrees west of south. Full shade is reached at 50 degrees east of south or 65 degrees west of south.

Along the eastern edge, the straight approximation is not as strong, but gives half shade at 45 degrees east or 20 degrees west, full shade at 65 degrees east or 35 degrees west. As a first approximation, the concrete floor above is assumed to block light entering at more than 45 degrees from the vertical.

This effectively translates into full shade on days near the summer solstice. About the winter solstice, there is full shade before 8am, after 3pm in the eastern part of the room, and not until sundown in the west. On the equinox, the lit period is between 2pm and 3:30pm, only in the western region. In the summer half of the year, the northern exposure should admit some direct light before 6am and after 5pm, assuming about 10 degrees from east or west.

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The studio in plan

Window Openings

Each of the 30 openings on the south façade of the building (and most of the other facades as well) is set back into a layer of concrete, and is composed of a large glass pane and an opaquely colored vertical *aerateur*. The windows are slanted to face east, and will

receive little to no late afternoon sunlight. On the opposite wall of the room are 6 large glass panes that run along the side of the ramp.



The opaque *aerateurs* and the protruding layer of concrete that juts out between each window make the shading system for the south façade. The north façade does not have a specific shading system but is shaded by the other floors above it and the building on the other side of the ramp.

While heat gains and losses were covered in a previous assignment, the *aerateurs* provide for a means of

ventilation during hours of direct sunlight.

Day Lighting and Reflection Inside the Studio

The room, at about 223 square meters, is relatively large, and since the sun never falls below 20 degrees of altitude during the lit period, and rarely below 30 degrees, direct sunlight will penetrate only a fraction of the way into the space, certainly less than 3 meters. This suggests that most of the room will be dependant on supplementary artificial lighting at all times, as even the best lit areas will be outside the relatively narrow lit periods.

The floor and ceiling are made entirely of concrete, as are the east and west walls. The north wall is mostly glass and the south wall contains small panes of glass with concrete in between. Thus, since light will mainly be entering through the eastward slanted windows on the south façade, the light will first hit the west concrete wall and then scatter to the other surfaces, which are all concrete except for the north façade of windows. Though not quantitatively known, the light colored concrete will probably diffuse a fair amount of light around the room in the morning to mid-afternoon, but probably not enough to illuminate the entire volume, since the windows where light enters are fairly small. However, as was mentioned above, it will certainly illuminate the individual spaces adjacent to the window.

Glare

There is not a large problem with saturation glare since there is little time where the south façade receives direct sunlight to an order of magnitude larger than a luminance of 24000 cd/m².¹ There could be a small amount of indirect glare off the light colored concrete on the west wall and also on the windows on the north façade, but it will probably not be significant since the window openings are small. Obviously, there could be discomfort glare if a student is using a computer whose screen is in front of the window, but this can be easily avoided.

¹ Steven V. Szokolay. Introduction to Architectural Science: The Basis of Sustainable Design. Amsterdam: Architectural Press, 2004.

II. Acoustics

The area of the building that we chose is the large entryway on the ground level. We chose this space because it is a large, high-traffic area that is used as a public gallery as well as an entrance and lobby. This means that there is a lot of ambient noise from people coming in and out of various parts of the building.

This space, and the majority of the building, is constructed entirely of reinforced concrete and glass, with such a small amount of other materials that it can be considered negligible. Upon first glance, it is fairly obvious that this space was not designed with acoustics in mind. There is not any visible soundproofing or sound-absorbing elements in the room, nor are there any non-right angles that would direct the sound in a specific way. The space is essentially a large cube made of reflective material.

Because of the nature of this space, it is often filled with people. Whether they are passing through or meandering around the gallery space, there is an almost constant flow of traffic. As a result of all this foot traffic, there is a lot of conversational noise that echoes throughout the room. In fact, it is one of the only sounds noticeable in the space during the day.

We have calculated the volume of the first floor space to be approximately 700 cubic meters. The walls are almost entirely glass, and the floor and ceiling are concrete. The floor area is approximately 190 square meters, as is the ceiling. The surface area of the glass walls surrounding the room is approximately 260 square meters. The absorption coefficients for concrete and glass are .02 and .04, respectively.² Total absorption would be:

$$\begin{aligned} \text{Abs} &= (s * a) \\ &= 2 * (190 * .02) + (260 * .04) \\ &= 14.2 \end{aligned}$$

Reverberation time for this space would be:

$$\begin{aligned} \text{RT} &= .16 * V / \text{Abs} \\ &= .16 * (700) / (14.2) \\ &= 7.89 \text{ seconds} \end{aligned}$$

From the above calculation, it is clear that the room has a very high reverberation time and, as a result, a lot of echo. The calculation for a “full” room would be approximately the same, since there is not any sort of furniture or anything that would absorb sound waves.

Interestingly enough, considering the noise volume of the room when it is full of people, it is incredibly quiet when it’s empty. This space is set below the plane of the street and is surrounded on three sides by earth. It is also set back enough from the urban commotion of Harvard Square that it is in a fairly quiet part of the campus. All of these factors combined means that there is a very small amount of noise from outside the

² Szokolay.

building. Almost all of the sound in the room at any given time comes from sources within the room.

During working hours, the ground floor lobby of the Carpenter Center can be a bustling place. Because of the high level of echo, the background noise can be overwhelming and make it difficult to hear and carry out simple activities such as having a conversation. On one of our visits, a group was working on an installation in the gallery that involved hundreds of paint cans. The group was putting the lids back onto the cans with rubber mallets. The noise created by this activity filled the room to the point where it was hard to hear the person next to you.

Since this is a lobby, it is not designed to be acoustically perfect. In fact, given the primary use of the space, the level of echo and background noise is not entirely a bad quality. One obvious improvement would be to provide some sort of absorbing material in the room, perhaps on the ceiling, to prevent such a resounding echo. But overall, the noise does not cause any discomfort or annoyance, as the space is intended to be a busy and social area of the building.

Works Cited

The Carpenter Center for the Visual Arts, on the Web at <http://www.archlab.tuwien.ac.at/~carpent/carpenter/carpenter.html> as of March 2006.

Szokolay, Steven V. *Introduction to Architectural Science: The Basis of Sustainable Design*. Amsterdam: Architectural Press, 2004.

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Studio plan: <http://www.archlab.tuwien.ac.at/~carpent/carpenter/texte/gr-lev3.html>

All other photos taken on site by group members.