

# 1 BAKER HOUSE DINING: LIGHTING DIAGNOSTIC

## 1.1 Sunlight Penetration

The Baker House Dining room is exposed mostly to southern, southeastern, and southwestern light, and is entirely naturally lit during the day. As a result of the orientation, the spaces receive a lot of direct sunlight throughout the year through windows which are for the most part unshaded and unprotected, as there are no overhangs and no temporary blinds or curtains. Since the sun is lower in the winter months, there is even more sunlight penetration through the south-facing windows at these times, although the frosted skylights let in more light during the summer, when the sun is directly overhead.

The dining room is split into an upper mezzanine level and a lower, partly below-grade main dining level, both of which are heavily glazed on the two south oriented facades. Because the upper level is open to the lower one, light received from the larger upper level windows is permitted to pass down, and light from the skylights also reaches the lower level. This helps considerably in allowing the traditionally poorly-lit basement space to receive ample daylight.

In order to examine the sunlight conditions over the course of the day and year more precisely, a Sketchup model was created of the dining room and interior views at different times were exported, as shown below. The first set of images shows the mezzanine level, and the second set shows the main level. It should be noted that since Sketchup only shows direct light, and not diffused light or daylight, the spaces are actually a bit brighter when naturally lit, but nevertheless, the model is very accurate regarding the main sunlit areas.

### UPPER LEVEL SUNLIGHT



Equinox Morning



Equinox Noon



Equinox Afternoon



Summer Solstice Morning



Summer Solstice Noon



Summer Solstice Afternoon



Winter Solstice Morning



Winter Solstice Noon



Winter Solstice Afternoon

**LOWER LEVEL SUNLIGHT**



Equinox Morning



Equinox Noon



Equinox Afternoon



Summer Solstice Morning



Summer Solstice Noon



Summer Solstice Afternoon



Winter Solstice Morning



Winter Solstice Noon



Winter Solstice Afternoon

The renderings show the specific lighting conditions in the spaces, and as expected, there is more direct sunlight during the winter than in the summer due to the lower solar inclination angle. However, one exception is in the summer in the afternoon, when the skylights bring in an excess of light to the lower level, probably resulting in unwanted heat gains. Because the skylights are actually translucent rather than transparent, the light is more diffused than what is modeled in Sketchup, but the light levels are probably still slightly too high at certain times in the summer months.

## 1.2 Glazing and Shading Systems

The glazing systems differ between the upper and lower levels of the dining room: on the upper level, most of the glazing consists of a six foot tall ribbon window stretching around two entire walls, interrupted occasionally with wood mullions. The glass is thick, single pane glass, and the window is inoperable (although there are ventilation louvers above the southeast part of the ribbon window which are no longer used due to the installation of air conditioning in 1999). There are no ostensible shading devices of any kind, and the lack of solar protection can result in undesired glare on the tables in the mornings, especially around the equinoxes. Although the dining room does not open for dinner until 5 pm, students sometimes work in this space during the day and the glare can be problematic. Because the glass is single pane, the lack of shading can also cause an undesired excess of solar heat gains (and losses at night), as explored in the previous *Thermal Balance* report.

The lower level glazing system utilizes rows of operable double hung windows with double pane, argon-filled glazing. Although there is no shading or solar protection system for this level either, the more efficient windows greatly help with solar gains. However, glare is still issue at some times. The space is lower, and therefore exposed to less sky, than the mezzanine level, so the problem is smaller. Glare does occur in the mornings in the summer and equinox months, and at noon in the summer months due to the skylights, as described above.

## 1.3 Daylighting and Electric Lighting

The space is naturally lit during the day, as described above, and there is no need for electric lighting before dusk. Because two of the four facades are almost entirely glazed, enough light is ensured of entering the space, and its relatively small size and light-colored ceilings and floors help to transmit the light to the parts further from the windows. Therefore, there is no real delineation between naturally lit areas and darker areas requiring artificial light. This is helped greatly by the fact that even the furthest parts of the lower level have access to the sky via the opening to the mezzanine level, as shown in the lower level view above.



The only strong deterrent in light transmission throughout the space is main wall material, which is a rough brick, as shown at left. This material is dark-colored and therefore absorbs much of the light that hits it, rather than reflecting it back further in the room. Because all of the other materials are white, however, this does not seem to negatively affect the daylighting quality too significantly. The ceilings are white plaster with light wood slats on the top level, the railing wall is white plaster as well, and

the floors and steps are light gray tile. The columns are also painted white.



## 1.4 Lighting Evaluation

In summary, Baker Dining receives a Very Good rating regarding its daylighting. There is ample sunlight and skylight penetration throughout the year due to its orientation and window opening arrangement, with more direct sun in the winter months when solar gains are desired and less in the summer when they are not. The space is sized and proportioned so that light can reach the furthest corners, and light-colored materials are used, with the exception of the walls, to help transmit light to these areas. The main complaint with the space is the glare that occurs on the tables during the mornings, which can be distracting and cause eye strain, and

the high solar gains in the equinox months, which might be improved upon by the addition of a solar protection system. However, as the space is programmed primarily for dining and not reading or writing, a higher contrast can be tolerated. The architect, Alvar Aalto, uses the contrast for stunning visual effect to create a special and particular experience in the space, as shown in the photograph above.

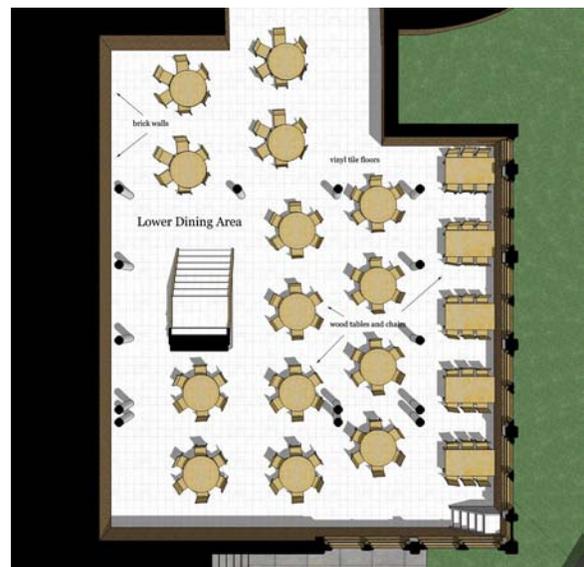
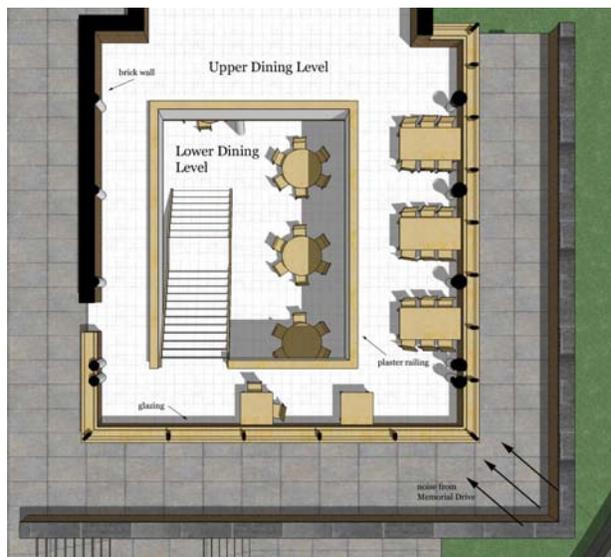
## 2 BAKER HOUSE DINING: ACOUSTICS DIAGNOSTIC

### 2.1 Space Uses and Acoustic Requirements

Baker Dining is split into four major spaces: the upper dining area, lower main dining area, the serving and food preparation area, and the kitchen. As with the lighting analysis, the acoustics portion of the project will focus on the lower and upper level dining spaces together, because the two spaces are open to each other through a double height space. The dining area will be evaluated acoustically for two conditions: when the dining hall empty during most of the day and when it is full during dinner time.

First and foremost, Baker is a dining hall, occasionally hosting parties and concerts several times a year as well as monthly house meetings. The space also serves as a makeshift music room for pianists. Thus, the acoustical requirements for the space are not as stringent as for places such as a concert hall or library. Even so, the space should accommodate conversations between people seated at each table without carrying and the general noise level should be minimized. After speaking with several residents of Baker, the general consensus found is that the dining hall is generally not too loud. When the dining hall is fully occupied, the noise level on the lower floor can get a little bit high, but not loud enough to render conversations inaudible. The upper level is a good space for eating and having a quiet conversation. Though sound travels up from the lower level to the upper level, the residents describe the background noise as comforting and conducive to studying. For indoor speaking levels, there are no echoes, flutter echoes, or standing waves, but there is some flutter echo when the space is subjected to loud sound. For our purposes, we will evaluate Baker Dining as a dining hall, the purpose it was designed and is used for on an every day basis.

### 2.2 Description of Spaces



The plans above show the overall layout of the upper and lower levels, as well as the arrangement of the dining tables. Most of the surfaces are hard and quite reflective, as there is a lot of brick, glass and plaster. These reflecting surfaces will tend to increase the reverberation time in the space, which might be undesirable depending on the degree. Also, the large parallel walls may cause flutter echoes due to their geometries. The section below shows the connection between the upper and lower levels to illustrate how sound might carry between these spaces.



### 2.3 Calculating the Reverberation Time

$$RT = 0.163V / Abs$$

$$V = 51,255 \text{ ft}^3 = 1,451 \text{ m}^3, \text{ see } Thermal \text{ Balance Report for calculation}$$

$$Abs = \Sigma(\alpha_i S_i)$$

The surface areas are calculated for each material in the dining hall through examining floor plans and measurement:

$$\Sigma S_{wall,brick} = 368.09 \text{ m}^2$$

$$\Sigma S_{glass} = \Sigma S_{wall,glass} + \Sigma S_{skylights} = 74.65 \text{ m}^2 + 15.75 \text{ m}^2 = 90.4 \text{ m}^2$$

$$\Sigma S_{ceiling,wood} = 115.74 \text{ m}^2$$

$$\Sigma S_{ceiling,plaster} = 311.19 \text{ m}^2$$

$$\Sigma S_{floor,tile} = 287.26 \text{ m}^2$$

**Table 1** Absorption Coefficients from Data Sheet D.3.5

	<b>125Hz</b>	<b>500Hz</b>	<b>2000Hz</b>
$\alpha_{brick}$	0.05	0.02	0.05
$\alpha_{glass}$	0.3	0.1	0.05
$\alpha_{wood \text{ slats}}^1$	0.3	0.15	0.1
$\alpha_{plaster}$	0.2	0.1	0.04

<sup>1</sup> The values for the wood slats that make up the ceiling of Baker Dining are approximated by the value for absorbent and porous plywood. The wooden slats in the ceiling are placed in intervals so that pockets of air are created between the wooden slats. Thus, though the wooden slats are hard and non-absorbent, the ceiling structure as a whole can be modeled as absorbent. As sound waves travel to the ceiling entering the air pockets, the sound is absorbed through reverberations between the wood slats.

$$\alpha_{tile} \quad 0.03 \quad 0.03 \quad 0.05$$

An estimated 10% of the floor space is shaded by seats. Thus, the floor absorbency is decreased by 20, 40, and 60 percent for 125Hz, 500Hz, and 1,000Hz for the percentage covered by chairs and tables. The final calculation for floor absorbency is given by the equation:

$$Abs_{floor,tile} = 0.90(\alpha_{floor,tile} \cdot \Sigma S_{floor,tile}) + 0.10(\alpha_{floor,tile,shaded} \cdot \Sigma S_{floor,tile})$$

Taking into account the shading of the floor by chairs, the values for the absorption of all the surfaces are:

$$Abs_{surfaces,125Hz} = 150.46m^2$$

$$Abs_{surfaces,500Hz} = 73.00m^2$$

$$Abs_{surfaces,2000Hz} = 60.78m^2$$

However, total absorbance of the room must include the absorbance of seats or seated people must be included where the maximum capacity and number of seats in the room of the room is 140 people. The values of absorbance are given by Table 2.

**Table 2** Absorption from Data Sheet D.3.5

	<b>125Hz</b>	<b>500Hz</b>	<b>2000Hz</b>
$Abs_{emptyseat / person}$	0.121	0.279	0.316
$Abs_{peopleseated / person}$	0.158	0.400	0.436

$$Abs_{peopleseated} = Abs_{peopleseated / person} \cdot 140people$$

$$Abs_{emptyseats} = Abs_{emptyseat} \cdot 140seats$$

Total absorbance of the room is given by the two equations below for an empty room and a room filled to maximum capacity:

$$Abs_{tot} = Abs_{surfaces} + Abs_{peopleseated}$$

$$Abs_{tot} = Abs_{surfaces} + Abs_{emptyseat}$$

Calculation of RT for an empty room:

$$Abs_{tot,125Hz} = 161.04m^2$$

$$Abs_{tot,125Hz} = 93.86m^2$$

$$Abs_{tot,125Hz} = 85.74m^2$$

$$RT_{min} = 0.163V / Abs_{min,Hz_i}$$

$$RT_{min,125Hz} = 1.47s$$

$$RT_{min,500Hz} = 2.52s$$

$$RT_{min,2000Hz} = 2.76s$$

Calculation of RT under maximum capacity:

$$Abs_{tot,125Hz} = 172.58m^2$$

$$Abs_{tot,125Hz} = 129.00m^2$$

$$Abs_{tot,125Hz} = 122.24m^2$$

$$RT_{\max} = 0.163V / Abs_{\min, Hz}$$

$$RT_{\max, 125 Hz} = 1.37s$$

$$RT_{\max, 500 Hz} = 1.83s$$

$$RT_{\max, 2000 Hz} = 1.93s$$

At 500Hz at a volume of approximately 1,500 cubic feet, the value for reverberation time is 1.83 seconds at maximum capacity. In comparison to the values for optimum reverberation time for speech and music for a room with a similar volume, the values for reverberation time are 0.9 and 1.5, respectively. The reverberation time is slightly higher than the optimum values for both music and speech. This value makes sense because of all the hard surfaces in the volume: hard floor tiles, a large surface area of glass, brick, and large ceiling surface area. With so much surface area for sound to bounce off of, the space naturally has a higher reverberation time. The high reverberation time accommodates the occasional rock concerts held inside the space, while making the dining area seem lively and full of people during dinner time.

## **2.4 Background and Outside Noise Sources**

Overall, the background noise level of Baker Dining is low except during peak dining hours. During peak hours, the noise level is still low enough to conduct a conversation while eating. When the dining hall is empty, the greatest amount of ambient noise is generated by the air conditioning and electrical systems in the space. Sounds of traffic also permeate the space from the nearby Memorial Drive, but the noise level from the street is almost undetectable.

## **2.5 Acoustical Evaluation**

Overall, the space effectively accomplishes its acoustical purpose. The walls muffle enough of the noise so that there is no echoing or flutter echo under normal speaking levels, and the space is never too loud so that conversation is obstructed. The hearing conditions are ideal for a dining space. Sound does not travel too far from a speaker except when directly below the double story space, but even then, the voices contribute to the comfortable ambient noise of the upper story. If it were desired to decrease the reverberation time slightly in order to reach optimum values, more absorbing materials should be installed in the space, such as seat cushions (as pioneered by Sabine) or acoustical ceiling panels.