MICROCLIMATIC IMPACT: GLARE AROUND THE WALT DISNEY CONCERT HALL

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ABSTRACT

Buildings have an impact on the environment at a macroscale in terms of the resources that they use. But they also have an impact in the microclimate of their immediate surroundings. One such building is the Walt Disney Concert Hall, designed by Frank Gehry. It is a landmark, scintillating building, in more ways than one. Occupants of surrounding buildings have complained of elevated temperatures and visual glare. Ground temperatures at the sidewalk are uncomfortable and freestanding lightweight objects get hot enough to soften plastic. This paper records a method of measuring the visual glare and some of the thermal impact of the light reflected onto the surrounding environment.

1. INTRODUCTION

The Walt Disney Concert Hall (WDCH) is: partly building, partly concert hall and partly free form sculpture. The above grade portions include an office wing, clad in white limestone, several outdoor gardens and two outdoor amphitheaters, and two buildings clad in stainless steel. In fact, the stainless steel is often a freestanding curtain or skin. Much of the steel skin is curved and composed of convex and concave undulating surfaces. The bulk of the building is brushed stainless steel, but the Founders Room and the marquee for the California Institute of the Arts Roy and Edna Disney California Arts Theater (REDCAT) is made of polished stainless steel. In many ways, it is a state-of-the-art building, pushing the envelope of architecture.

Any building that pushes the envelope discovers new difficulties as well as new beauties. The very sparkle that excites the viewer also presents some difficulties. As Jim Hahn, the mayor of Los Angeles, said during the dedication ceremony, “This building has a UV factor of 100” (L.A. Times, 10/21/2003). He was referring to its brightness on the world stage but also to its physical effects on those in its proximity.

There are portions of the building that are especially reflective. The polished stainless steel of the Founder’s Room and the REDCAT marquee reflect, and in some cases concentrate significant amounts of light. This poses the possibility of glare at a distance and even thermal problems on nearby surfaces. Stationary light weight surfaces in the vicinity of the REDCAT marquee can get very hot. There is the possibility of interference with traffic. The brushed stainless steel panels result in much milder reflections, but are also examined.

The County contracted Sapphos Environmental, who in turn contracted Schiler & Associates to study the impact of the building on the Promenade Towers, a commercial and residential building west of the WDCH. Several
more questions became apparent during the study. There were two questions relating to heat gain. Were there unacceptable thermal gains in surrounding buildings, such as Promenade Towers? Were there any locations adjacent to WDCH which were dangerous? (It has long been known that there is a negative impact with any new construction in an urban environment\(^1\)). There were also two questions relating to visual glare. Was there disability glare in any of the surrounding apartments? Was there any other sort of disability glare which would be dangerous?

2. METHODS AND APPROACH

The thermal issues and the visual issues were addressed separately, in order to be thorough. The former was tested with dataloggers and an infrared thermometer gun, the latter approached through a series of digitized photographs and computer simulations. It was clear that there would be some overlap; much of the quantitative information for both issues was determined by serial simulation and/or measurement over time.

2.1 Thermal Issues

The thermal issues were first addressed by talking with employees of WDCH and surveying the area. Interesting anecdotes were also gathered from persons at the site, as well as the locations already observed to overheat. Employees of the REDCAT ticket office recounted melted plastic traffic cones, spontaneous combustion in waste receptacles and trash bins. An anonymous employee told of a bystander who roasted a hot dog with the heat from the building. None of the stories could be directly verified, but it was clear that there were locations around the building which could get hot.

In walking around the building, there were areas where it was possible to feel the heat in passing. These were largely the result of concave surfaces which focused direct beam sunlight off both the polished and brushed stainless steel surfaces. There was some heat reflected from the brushed surfaces, but not in concentrated areas. Maxim/Dallas iButton dataloggers were embedded in the sidewalk and in the street where the foci (which traversed}

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**Fig. 2 - Photograph of Founders Room**

**Fig. 3 - Simulation of Founders Room**

**Fig. 4 - Color Coded Isoluminance Plot of Founders Room**

slowly throughout the day) would be at their most concentrated. Where there were foci in mid air, a dark colored foamcore board was suspended in the beam and the temperature was measured with a Raytek infrared thermometer.
2.2 Visual Glare Issues

Three options were considered to determine and locate disability glare: physical models, computer simulations and extensive photography which would be digitized and analyzed. Gehry had models which could be photographed or computer models which could be used in lighting simulations. On site photography was prohibitive given the number of possible locations and the need to photograph a year’s worth of data. The physical models were not sufficiently detailed, nor were their scale and size conducive to tilting and positioning the models. It was decided to use computer simulations to check multiple locations at half hour intervals over key dates. This was used to determine the most critical times and then photographs were taken in-situ at those times to verify the simulations.

The computer model of the WDCH was divided into sections. Each segment of the building consisted of just under a million vertices. The files were simplified by combining surfaces (or deleting vectors) to approximately 100,000 vertices each. The files were run on AGI32, Radiance and Lightscape. For exterior reflections, Lightscape proved to be the most similar to the behavior of the building in direct comparisons between simulations and digitized photos of the same date and time. Simulations were then displayed as isoluminance plots and color coded. A uniform scale was applied so that luminance levels from 12,000 candelas/m² to 15,000 candelas/m² were shown respectively orange through red. (Higher values were all shown in red.) This allowed comparison between different dates and times and from different locations, including the middle of surrounding intersections, the viewpoint of apartments across the street and other critical location.

3. RESULTS

3.1 Dataloggers

The dataloggers indicated a noticeable increase in the ground surface temperature in the vicinity of the REDCAT marquee. The first interesting data was observed in the equinox readings.

The typical maximum temperature peaked at about 125 degrees Fahrenheit (°F) (52 C). The maximum temperature at one of the curb edge locations and in the roadbed focal point peaked at about 138°F (58 C). Although elevated, such temperatures are not dangerous to people unless there is prolonged exposure. There was a typical pattern to the data. Sunrise was clearly visible as the sidewalk began to heat up. There was a dip shortly after the peak, followed by a steady fade as the sidewalk cooled. Further inspection showed that there was a high rise building which shaded the marquee at the indicated time, as well as the sidewalk, resulting in the temporary dip. It was predicted that June sun angles would be steeper and there would be no such dip.

The patterns were similar to the spring temperatures, except that the days became progressively longer, before cooling off and there was, indeed, no shadow from 333 South Grand Street.

The typical maximum temperature peaked at about 140°F (58 C). This is surprisingly close to the spring values, indicating that the radiant heat is the dominant factor and the air temperature is a secondary consideration, especially on ground surfaces. Again, such temperatures are not dangerous to people unless there is prolonged exposure. Stationary exposure to a direct focus (>10 minutes), however, would result in the equivalent of a bad
3.2 Digital Simulations

The computer simulations taken at half hour intervals from all the different viewpoints surrounding the building yielded several difficulties relating to two areas of the building. The Founders Room caused difficulties for the Promenade Towers as well as the possibility of interaction with traffic at the Hope St and First St. intersection. Figures 7 and 8 show winter and summer series of one view of the Founders Room.

Notice that the December values never achieve the luminances of the June values. The dangerous values are color coded in red.

The REDCAT marquee (which was causing the thermal difficulties) also projected into traffic at the intersection of Hope St. and Second St. Figures 9 and 10 show spring and summer series of the view from the intersection.

Zooming in on the respective offending dates and times led to two further steps; those moments and views could be photographed and the photographs could be digitally processed to determine whether there really was glare with the actual building materials. Further study of those simulations and photographs determined exactly which of the panels were the source of glare and as a result, need to be changed.
For example, the isoluminance plots for June show multiple views of the Founders Room which indicate very high luminances on highly specular surfaces. See figures 11 and 12.

The isoluminance plots of the REDCAT marquee indicate that essentially the entire marquee is problematic at one time or another. See figures 13 and 14.

3.3 Luminance Histograms

It is generally accepted that there are three types of glare: disability glare, discomfort glare and veiling reflections. For the purposes of this study, there was a slight re-categorization. Disability and discomfort glare were viewed as one continuum, with disability the most extreme and discomfort fading to innocuous forms of contrast. Instead, the source of the glare was considered and classified into two categories. A source of extreme brightness, such as the sun, which is beyond the capacity of the eye to adapt, was designated as “absolute value” glare. Some sources of glare might be below that threshold, but could still be a source of glare because of the fact that the eye has adapted to a lower background level. Such glare was designated “adaptation glare.”

A method has been developed by Schiler\(^2\), Japee\(^3\), Culp, et al which uses histograms of images to determine whether there is a likelihood of glare. From the histogram, it is possible to pick out the background level. It is also possible to pick out any glare source well in excess of the background. It has been found that when the ratio of the glare source to the median of the background exceeds 3:1, most observers find the environment to be an instance of glare.
The simulations determined the key dates, times and locations. Photographs were taken of the key dates and times and were subsequently digitized. See figure 15. Histograms of the photographs were processed to see whether they represented contrast glare. See figure 16.

4. SOLUTION

The primary cause of the thermal glare was the fact that the polished stainless steel surfaces were highly specular. Similarly, the specularity increased the luminance in the direction of the reflection, exacerbating the visual glare immensely. So the most effective and least obtrusive solution appeared to be to reduce the specularity of the most critical surfaces.

Several solutions were tested. Four different films were tested, two of which would have been acceptable in terms of diffusion, but questionable in terms of durability. One coated fabric was tested, which was acceptable in terms of diffusion, but clearly not a durable solution. One version of sandblasting the surfaces was considered. Six different combinations of manually applying an orbital or vibrational sander were considered. The best solution was a combination of vibrational sanding, for coverage, followed by orbital sanding, for aesthetic reasons.

The fabric solution was applied to the worst offending surfaces of the Founders Room and proved to be effective on all of the surfaces covered. Designs were sandblasted onto the REDCAT marquee and were found to be useful, but insufficient without covering the entire offending surface.

The fabric was chosen as the temporary solution and has been installed on the Founders Room. A combined vibrational sanding followed by an orbital sanding has been selected as the final solution for all of the surfaces.

5. CONCLUSION

Buildings clearly have an impact on the surrounding environment; they can shift the microclimate substantially. As there are more and more reflective surfaces, this becomes increasingly dangerous. This is especially true of buildings which have concave surfaces. Such buildings must be simulated or tested in advance to avoid significant overheating in surrounding buildings and even in outdoor public spaces, where dangerous thermal situations can result.

Similarly, all reflective surfaces should be considered with regards to glare interfering with traffic safety and causing undue visual discomfort in surrounding buildings. The County was proactive in responding to complaints and Gehry and Associates was willing to be involved in solving the problem. That allowed a solution which was aesthetically pleasing (or at least minimally disruptive) and yet effective. In the future, such problems should be avoided by considering the issues of glare in the design or design development phase of any architectural project.

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7. REFERENCES


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