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Daylight Analysis: Analayzing Daylight Autonomy in the Early Phases of Design on an Adaptive Reuse Project

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DAYLIGHT ANALYSIS

ANALYZING DAYLIGHT AUTONOMY IN THE EARLY PHASES OF DESIGN ON AN ADAPTIVE REUSE PROJECT

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ABOUT

This research investigates methods for increasing the area of daylight autonomy in an adaptive reuse project with deep floorplates. The research employs DIVA simulation tool to assess daylight performance the early phases of design, quantified as Daylight Autonomy (DA), Spatial Daylight Autonomy (sDA) and Annual Sunlight Exposure (ASE). Findings from DIVA analysis reveal that light shelves decrease daylight autonomy but help to reduce glare.

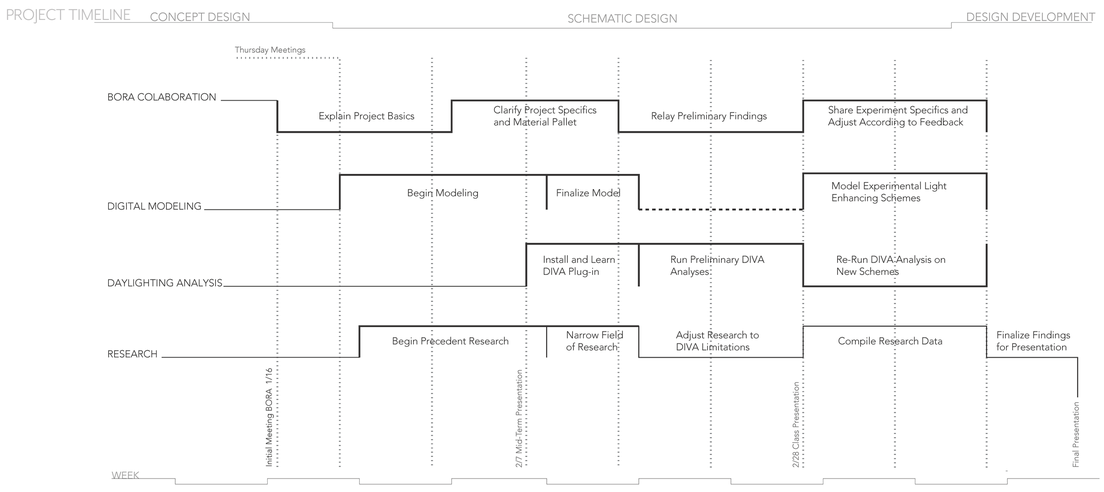
Effective daylight design is critical in adapting a historic building with deep floorplates for office use. Activity-appropriate levels of daylight transmission can offset electrical lighting loads, provide comfortable conditions for occupants, and connect building occupants with the outdoors. This study defines effective daylight as compliant with LEED v4's metrics of "Spatial Daylight Autonomy and Annual Sunlight Exposure." This research identifies the implications of key daylighting design parameters on daylight autonomy levels. Within this study, floorplate depth, the presence of light shelves, future use, and external obstructions are factors influencing daylight level performance.

Sources gathered were organized into three categories: Daylight Design Metrics, Modeling and Analyzing Daylighting Data, and Daylighting Design Strategies. These categories transitioned to become methodology framework of this research. Online tutorials, forums and peer consultation were also referenced for the DIVA analysis tool's effectiveness.

This study seeks to provide a framework for identifying areas of daylight autonomy in the early stages of design. This research was conducted in parallel with the concept design and schematic design phases of the interior renovation of a historic building in the urban core of Portland, Oregon, USA. The adaptive reuse project is focused on providing appropriate levels of daylighting to the proposed offices in a building that had been previously utilized for retail. Existing restrooms, storage rooms, electrical rooms, elevators, stairs and mechanical shafts located about the perimeter of building leave central spaces severely underlit. To preserve the historic integrity of the building, the design team's scope is limited to interior reorganization. This study aims to show that by identifying areas of daylight sufficiency in the early phases of design, proactive programming of a building may help mitigate the need for additional daylight design strategies to provide visually comfortable workspaces.

This research also seeks to provide design professionals a quantitative understanding of the impact that interior design decisions have on daylight autonomy levels. Spatial organization, paint reflectivity, and interior light shelves are examined as methods for increasing daylight autonomy, and the impact of each is quantified.

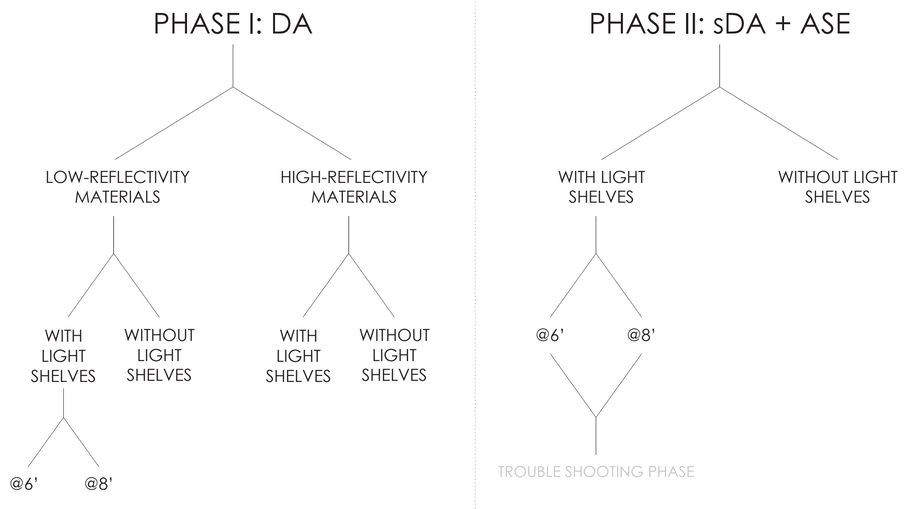
RESEARCH TIMELINE



The research timeline closely aligned with the the SD and DD phases of the project. This study has the potential to benefit design decision making by projecting actionable daylight strategies.

METHODOLOGY

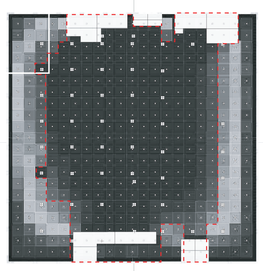
To begin the study, daylight performance metrics were established. Early studies were analyzed as Daylight Autonomy. These studies provided a basis for daylight sufficiency, but did not address glare. The addition of the Annual Sun Exposure metric provided an indicator of potential problems with occupant discomfort. Annual Sun Exposure describes how much of space receives too much direct sunlight, which can cause visual discomfort, or glare. Although the adaptive reuse project does seek not a certification, metrics sDA and ASE from LEED are used as guidelines for measuring daylight sufficiency.



PHASE I: DAYLIGHT AUTONOMY (DA)

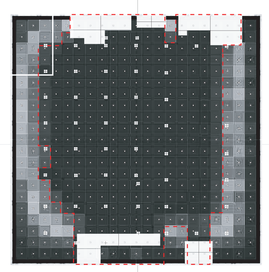
LIGHT SCHEME

LEVEL 2

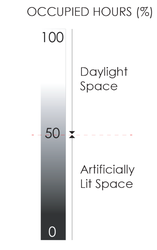


Mean daylight autonomy= 20.47% of time occupied

LEVEL 5

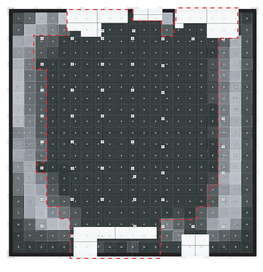


Mean daylight autonomy= 20.77% of time occupied



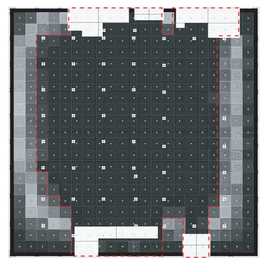
DARK SCHEME

LEVEL 2



Mean daylight autonomy= 18.7% of time occupied

LEVEL 5



Mean daylight autonomy= 19.93% of time occupied

Parameters:

DA Sky: Climate-base (Portland weather fle)

Light scheme: 85% reflectance walls, 60% reflectance floors, 90% reflectance ceiling
Dark scheme: 39% reflectance walls, 8% reflectance floors, 80% reflectance ceiling

Context reflectance: 20%
Ground plane reflectance: 20%

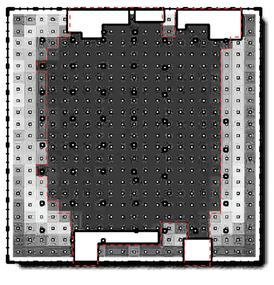
Glass light tranmittance: 70%

Grid height: 2.5'
Grid size: 10'x10'

PHASE II: SPATIAL DAYLIGHT AUTONOMY (sDA) AND ANNUAL SUNLIGHT EXPOSURE (ASE)

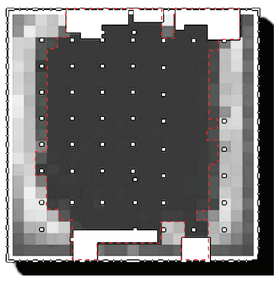
BASE CONDITONS

LEVEL 2

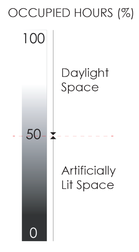


sDA 300lux [50%]: 17.5%
ASE: 10.2%

LEVEL 5

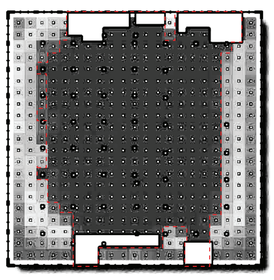


sDA 300lux [50%]: 20.9%
ASE: 8.4%



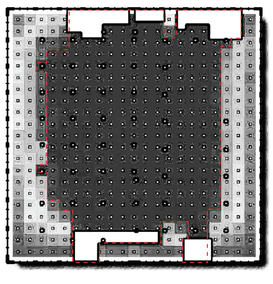
WITH LIGHTSHELVES

LEVEL 2



sDA 300lux [50%]: 17%
ASE: 5.9%

LEVEL 5



sDA 300lux [50%]: 20.9%
ASE: 7.3%

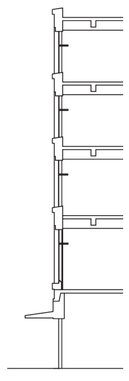
Parameters:

DA Sky: Climate-base (Portland weather fle)

Wall reflectance: 50%
Floor reflectance: 20%
Ceiling reflectance: 80%
Context reflectance: 20%
Ground plane reflectance: 20%
Glass light tranmittance: 90%, 70%

Grid height: 2.5'
Grid size: 10'x10'

Light shelves: 2' deep and 8' in elevation



CONCLUSIONS

Findings from DIVA Daylight Autonomy analysis reveal that increasing the reflectance of internal surfaces increases the daylight autonomy in a building with deep floorplates. Findings from the DIVA sDA and ASE analysis reveal the use of light shelves decrease daylight autonomy in this project, possibly due to their shading effect. Light shelves do, however, aid in controlling direct sun and discomfort glare to help maintain occupant comfort. It can be expected that daylight will penetrate to a depth of about the first column line, with or without light shelves.

This research seeks to provide guidance to the design professionals for this adaptive reuse project. The results demonstrate that employing daylight analysis techniques early in the design process helps identify existing zones with consistent levels of daylight autonomy. Programming the space based on these findings is the most cost-effective method to ensure future users have access to sufficient levels of daylight in an adaptive reuse project. Based on this study's findings, the design team should reconsider allocating budget to light shelves on this project, due the nominal decrease in glare they provide.

This project does meet LEED v4 standards with any design options explored, however having clear early-stage metrics is critical for designers to be able to balance these criteria, and make informed tradeoffs among them.

LESSONS LEARNED

There are a number of limitations of this research. The model was rebuilt three separate times as we better understood the simplicity DIVA needed to produce consistent results. Some early results may be skewed do to the model changes.

- Learning curve of the softwareis not to be underestimated
- Model simplification is crucial
- Metrics should be defined early on, unless the intention of the study is to compare metrics