Experiences with Radiance in Daylighting Design, Part IV

8th Annual Radiance Conference
Harvard Graduate School of Design
October 22nd, 2009
Zack Rogers
Integrated Design Associates, Inc.
Presentation Outline

• Project sampling

• Projects Revisited

• Early design optimization engine (PIDO)

• Radiance comparison
Project Sampling

- Orchard School District - Library Expansion, San Jose, CA
- Sequoia Gymnasium, Redwood City, CA
- Arapahoe Elementary School, Arapahoe, WY
- Casey Middle School, Boulder, CO
- Las Cruces Recreation Center, Las Cruces, NM
- Downtown Education Center, Oakland, CA
- CalTech Linde Robinson Lab, Pasadena, CA
Orchard School Library Expansion

- New open daylit expansion to an existing non-daylit library
- Balance of daylight between old and new and from bright entry
- Washing surfaces to reduce contrasts
Orchard School Library Expansion

Daylight Illuminance

- SPOT_day_calcs.py, “field files”, genfieldpts.py, and new excel tool to process and display illuminance data

- Solatubes to brighten darker bookshelf areas
Sequoia High School Gymnasium

- Large central pop-up monitor provides majority of daylight in glare free, veiling free manner.

- Monitor geometry provides direct solar control

- PV’s maximized on roof area
Sequoia High School Gymnasium

- Contrast and glare concerns for large north and south clerestory windows

- Large “lightshelf” integrated into basketball hoop structure
Arapahoe Elementary School
East Classrooms

Current Design Performance

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<thead>
<tr>
<th>Design Condition</th>
<th>Zone 1</th>
<th>Zone 2</th>
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<td>Avg</td>
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Workplane Daylight Autonomy, 40fc Target

Daylight Autonomy Performance Chart, 40fc Target

Design Alternative Performance

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Workplane Daylight Autonomy, 40fc Target

Daylight Autonomy Performance Chart, 40fc Target
Arapahoe Elementary School
Media Center

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<table>
<thead>
<tr>
<th>Design Condition</th>
<th>Zone 1 Avg</th>
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**Annual Average:**
- Zone 1: 55 fc
- Zone 2: 247 fc
- **Annual Maximum:** 2776 fc

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**Annual Average:** 143 fc
- **Annual Maximum:** 1005 fc

### Workplane Daylight Autonomy, 30fc Target

- Winter: 80% 
- Spring: 90% 
- Summer: 70% 
- Autumn: 80%

### Daylight Autonomy Performance Chart, 30fc Target

- **Stacked Daylight Autonomy Percentage**
  - DA: 80%
  - MWDA: 90%
- Daylight Autonomy Evaluation: Reevaluate Design
Casey Middle School
Commons / Cafeteria

- Work done at Architectural Energy Corporation
- Balance daylight from dominant east window wall
- Lightshelf used to help distribute east daylight
- Solatubes sized and spaced to provide balanced daylight throughout
- Egg shape intentional symbol, centered within school with a green roof! One of the first for Colorado
Casey Middle School
Glare Issues

• Two historic facades kept, rest of existing school demolished
• Majority of west facing façade opens up into a large media center space
• No exterior shading or too darkly tinted glass allowed
• Automated diffuse louvers at a fixed angle used to provide glare control and daylight redirection
• Core learning spaces 91% daylit!
Las Cruces Recreation Center
Pool Balance and Veiling Reflections

- Work done at Architectural Energy Corporation
- Water definition from an existing pool project – coursey calibrated using an IQ cam
- Horizontal illuminance vs. vertical
- Image subtraction helps illustrate impact of design options
Las Cruces Recreation Center
Central core and workout areas

- Ceiling slopes studies to improve contrasts
- Bris soleil provided and optimized to minimize hot Las Cruces sun
Downtown Education Center
Classroom Wing

- Corridors and common space left unconditioned but sheltered

- No glass requirements provides high level of daylight to be “borrowed” by adjacent classrooms

- Overhead cut-away view rendered with -i, false color displays illuminance distribution
Downtown Education Center
Classroom studies

- Solatubes considered for dimmest 1st floor south classrooms

- When coordinated with trusses, solatube lens can be centered with a 3’6” plenum depth

- 6’ lightwells in commons walkway provide borrowed daylight in lieu of solatubes

- 30% translucent glazing for south daylight windows, louvered overhang shades lower windows
Downtown Education Center
Classroom ceiling finish comparison

• 10 – 20% light loss under daylight conditions
• 30% light loss under electric lighting (60%U/40%D)
• Big Ass fans only cooling, provide necessary air flow while keeping acceptable velocities with the least energy use
Downtown Education Center
Gymnasium studies

- Skylight array compared to a butterfly roof with clerestories
- North clerestory provides sufficient daylight, washes ceiling better and provides a nice southern slope for PV
- Slope became a common architectural theme throughout – aids in our Zero Energy Building goals
CalTech Linde Robinson Lab

Electric lighting for library

- Cove lighting to uplight historic ceiling
- Historic inefficient fixtures retrofitted with CFLs and then MH – no IES data, modeled roughly with 3 spherical lamp sources
- LED linear wall graze fixture used to light solar tower
- Old Solar telescope converted to a daylight collector
- Daylight beams redirected into optical lab on basement floor and subbasement
CalTech Linde Robinson Lab
Task/Ambient Lighting study

• Ambient / task approach to minimize LPDs but provide necessary illuminance
• Conflict between IES and ASHRAE?
• Numerous direct/indirect fixtures studied for optimal efficiency
• Under cabinet LED fixtures boosts illuminance on benches to 70–90fc
• Lutron ecosystem controls for future churn, sophisticated zoning, and dimming
Projects revisited – lessons learned

• Kinard Junior High School, Fort Collins, CO

• Douglas County Elementary School Prototype, Castle Rock, CO

• Fossil Ridge High School, Fort Collins, CO

• Indianapolis Airport, Indianapolis, IN
Kinard Middle School
North Classrooms

- Pyramidal ceiling structure helps spread daylight and reduce contrast
- Secondary lens provided at top of tubular skylight to further soften contrast
- Projector equipment still got washed out with too much daylight, new equipment this year much better
- User take blackout into their own hands! Cheap blackout system - velcro, hooks, and foam core
Kinard Middle School
Corridors

• Corridors and locker areas daylit with Solatubes and large south clerestories
• Additional benefit of daylit building – easier construction, no temporary electric lighting or generator needed!
Douglas County Prototype Elementary
Classroom daylighting

- Translucent polygal overhang provides diffused sunlight to daylight windows
- Sized to block majority of winter sun
- School walls are not 60% reflective
- Educate the occupants! Teachers not aware of lighting or daylight control functions
Douglas County Prototype Elementary Media Center

- Undulating ceiling reduces contrast around solatube lens
- School floor plan required centrally located media center
- Slightly low but sufficient daylight under overcast sky – reconfirmed that contrast and adaptation is as important as overall illuminance
Fossil Ridge Glare Studies
South Classrooms

• Daylighting: The devil’s in the details
• Winter time glare and projection visibility complaints
• Stretched translucent fabric with metal frame chosen retrofit option
• Proper overhang sizing and detailing critical! North clerestory glare off of corrugated metal! Painted a light grey diffuse material to mitigate
Indianapolis Airport Midfield Terminal

Glare Issues

• Variety of control measures studies for peak occupancy glare concerns
• Glare control measures VE’d in lieu of fritted glass, architects best friend?
• Passengers complaining about signage visibility to baggage
• Ticket counters workers complain about glare
• Expensive roller fabric shades to be added – likely with manual seasonal control due to budget
• Great intent botched due to poor follow through and VE process!
Process Integration and Design Optimization Tool (PIDO)

• Built off optimization engine used for structural design in the aerospace industry
• Digital Project CAD modeler exports to IFC file format (Industry Foundation Classes)
• Scripts create Energy Plus files, Radiance files, and structural information from IFC files
• DAYSIM daylight coefficient method used to perform a climate based annual simulation
• Daylight metrics for optimization can be chosen by user
• System runs numerous (100 – 1000) simulations depending on variables selected
• Optimization algorithms limit that amount of parameters ran as peaks are found
San Diego Airport
Radiance vs. mental ray

• Do we need to be worried?

• Further optimization of Radiance?

• Scriptability, flexibility and robustness of Radiance a huge plus!

• Any further validation or comparison studies?
San Diego Airport
Glare

- DGP calculated for Summer 5PM condition
- DGP 100% with no shade or glare control
- Reduced to 51% with 3% openness shade
- Louvered options recommended to control high angle solar gain while preserving views
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Questions?

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