Linking Radiance & EnergyPlus in an Automated Design Workflow

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August 26, 2011
Skylight Optimization

Grocery Store in Austin, Texas
Goals

- **Client:**
  - Minimize energy (50% reduction)
  - Maximize daylight amenity (metric: daylight autonomy)
  - Achieve uniform daylight across vertical shelves

- **Arup:**
  - Try something new
  - Implement ‘automated design’ workflow
Automated Design Components

- **Rhinoceros** (3D modeling)
  - **Grasshopper** (Parametric geometry creation)
  - **Salamander** (EnergyPlus components)

- **EnergyPlus** (Energy analysis)

- **Radiance** (Daylight analysis)

- **MATLAB** (Execution control, geometry input parameters, data storage, optimization engine.)
Automated Design Process

- Generate sky & sun matrix using Austin climate data
- Generate daylight coefficient matrix using rtcontrib
Automated Design Process

1. Matlab Initialization
   - Grasshopper
     - OBJ
       - Radiance
         - Annual Illuminance Profile
           - Uniformity
           - DA
     - Salamander
       - IDF
         - EnergyPlus
           - Energy Results
   - Matlab Postprocess
     - Final Solution

2. True Optimization
   - Automated Parametric Study
     - Manual Postprocessing
     - Final Solution

ARUP
Automated Design
Scope of Study
Scope of Study

36’ x 48’ structural grid
Scope of Study

36’ x 48’ structural grid

Modeling extents for energy

Modeling extents for daylight
(array of instances)
Lighting Design Criteria
Skylight Options Studied

Skylights run continuously across length of structural bay
Skylight Options Studied

Pop-Up Skylight

- South glazing is diffuse, north is clear
- Overhang dimension is fixed
Skylight Options Studied

North Facing Sawtooth
Skylight Options Studied

Hybrid
Calculation Points

Horizontal

Vertical - Parallel

Vertical - Perpendicular
Daylight Performance

Horizontal

Better performance/value

% Hours above 50C horizontal

Total Glazing Height (ft)

Sawtooth  Pop-up  Hybrid

Max  Min

ARUP
Daylight Performance

Vertical

- Max
- Min

Chart: % Hours above 1000 vertical vs Total Glazing Height (ft)

- Pop-up (E-W Shelves)
- Sawtooth (E-W Shelves)
- Hybrid (E-W)
Overall Performance

Daylight vs. Energy

Better performance
Overall Performance

Daylight vs. Energy
Overall Performance

Daylight vs. Energy

- Hybrid
- Pop-up
- Sawtooth

Energy Savings (kwh/year)

-6000 -4000 -2000 0 2000 4000 6000

48'-0"

3' - 6"

18'-0"

36'-0"
Automated Design Summary

Was it worth it?
Automated Design Summary

- Permitted a much larger set of parametrics
- Optimization could have reduced number of parametrics required (important for longer simulations)
- Facilitated the linkup of Radiance & EnergyPlus using same model