Daylighting the Built Environment

October 3, 2006 • Kaohsiung, Taiwan

The 2006 Global Forum for the Built Environment Sustainable Technology

Strategies and Applications of Synergic Design Methods for Wood Architecture

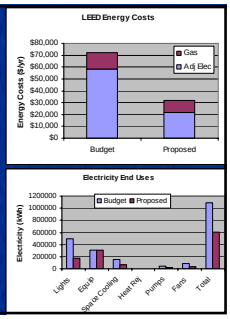
George Brelig, RB+B

Session Overview

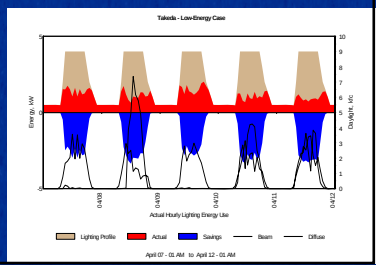
- Positive Impacts of Daylighting
- Daylighting Fundamentals for Different Programatic Uses
- Strategies for Successful Daylit Spaces
- Integration of Electric Light and Lighting Controls
- Case Studies and Lessons Learned

Daylighting Design

Daylighting saves money and energy

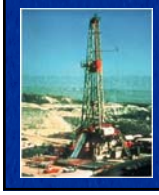


Lighting energy saved



Daylighting provides visually superior spaces

Daylighting – Good for the Environment

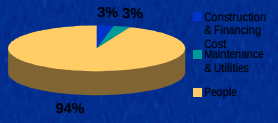


Daylighting and Human Performance

- Increased productivity, performance & satisfaction
- Reduced absenteeism
- Reduced employee turnover
- Increased retail sales

Daylighting

- And Human Performance



20 Year Cost of Ownership: Office Building

Daylight in Schools

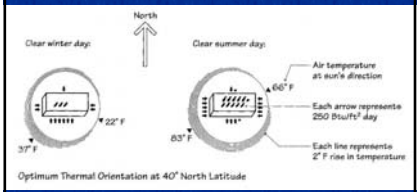
- **Improved Visual Environment**
  - Intensive visual task needs
- **Heshong Mahone Group Studies**
  - Test scores for 21,000 students analyzed
  - Students progressed 20% faster on math tests and 26% on reading in day lit classrooms
  - Operable windows improved progress by 7-8%
  - Views increases satisfaction and attention
  - Observed with 99% statistical certainty

Design for daylight

- Shade to prevent glare and heat gain
- Redirect light to where it is needed
- Control the total amount of light : size , Tvis, exposure
- Light surfaces to manage brightness
- Integrate with electric light and architecture

For comfort , savings, and satisfaction

Optimum Bioclimatic Orientation



Optimum Thermal Orientation at 40° North Latitude

Facility Operation Hours and Sunlight availability

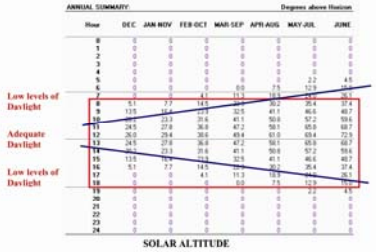
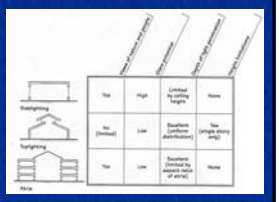


Figure 2: Solar altitude angles, with times and dates of facility operation indicated within red box, and times of marginal sunlight availability indicated by the blue lines.

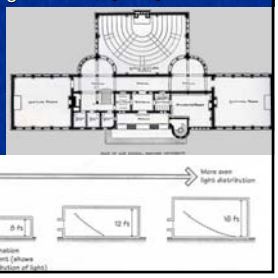
Daylight Design Considerations

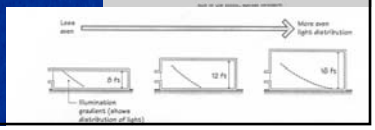
- Sources
  - Windows
  - Overhead
- Form Givers
  - Daylight Control
  - Geometry/Form
  - Glazing
  - Surfaces
- Electric Light

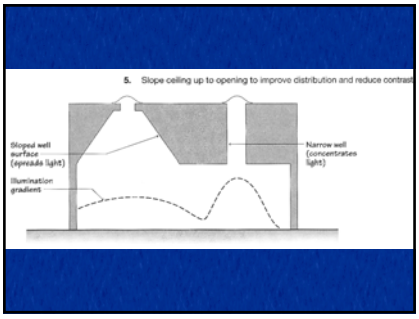


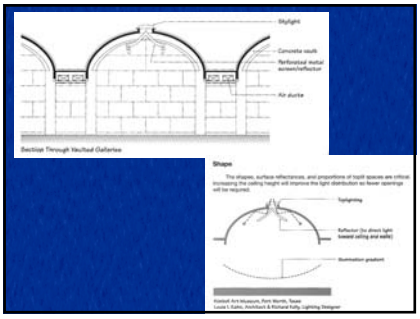
Lighting design strategy is part of the building form

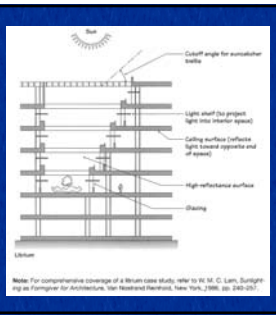
Side lighting: Narrow Plans, High Ceilings

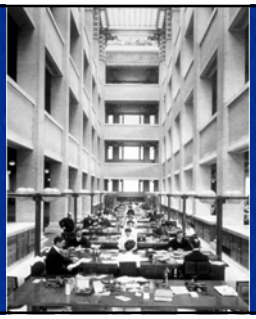












Larkin Building
Frank Lloyd Wright

NUK's Library

The 4 Keys to High Quality "Cool Daylighting" Design

- Daylighting Aperture Placement
- Daylighting Source Brightness Control Strategies
- Glazing Transmittance
- Lower Contrast and Enhance Uniform Distribution

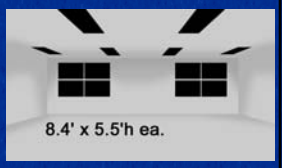
Vermeer, 1670

Conventional Glass Placement: Classroom

Glass Area = 92 s.f.

Exterior Window/Wall Ratio = 0.22

Ceiling: 9'0"



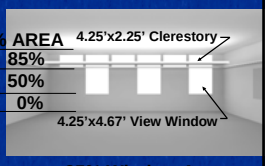
Aperture Placement / Size

Recommended Glass Placement: Classroom

Glass Area = 116 s.f.

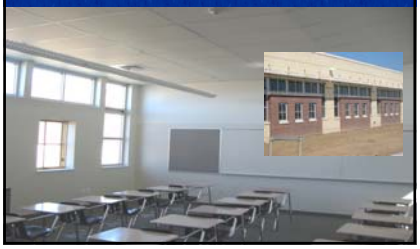
Exterior Window/Wall Ratio = 0.28

Ceiling Height = 10'-0" to 10'-6"



+25% Window Area

Glazing tuned for aperture



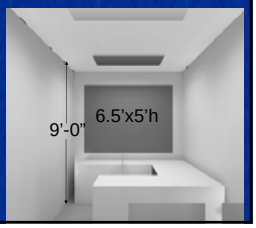
Aperture Placement

Conventional Glass Placement: Office

Glass Area = 32.5 s.f.

Exterior Window/Wall Ratio = 0.32

Ceiling Height = 9'-0"



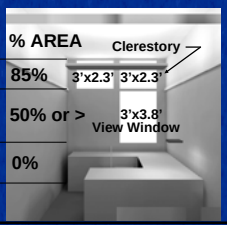
Aperture Placement

Recommended Glass Placement: Office

Glass Area = 25.2 s.f.

Exterior Window/Wall Ratio = 0.24

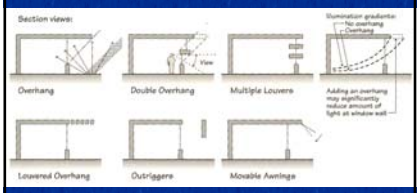
Ceiling Height = 9'-6" to 10'-0"



Daylighting Source Brightness Control

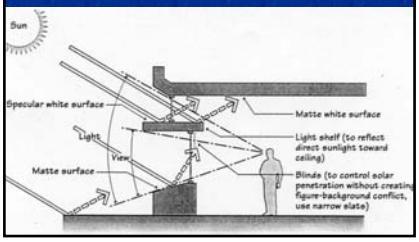
- **Sources**
  - Sun
  - Cloud
  - Sky
  - Reflected Daylight
- **Control Mechanisms**
  - tvis
  - Overhangs & Solar Shades
  - Window Treatments

Light Control



Light shelf design

Redirect light, don't reject the light!



Plenty of daylight…

Yet the lights burn inside..

Redirect Daylight

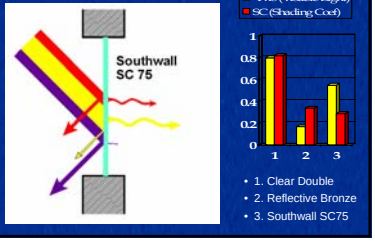
- Balance brightness, reduce contrast, increases visibility

(Adjacent classrooms)

Light Shelves with Sloped Ceilings & Multiple Source Daylight

Glazing Transmittance

Glass Types & Performance

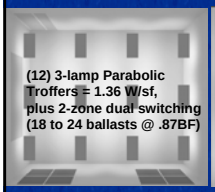


Lower Contrast and Enhance Uniform Distribution

- Reduce Inside to Outside Contrast
  - White frames
  - Use darker exterior objects
  - Splay/round jambs
- Increase Uniformity
  - Sculpt/slope ceilings
  - Use white/white/ matte surfaces
  - Spectrally neutral glass

Daylight integrated with electric lighting systems

Classroom Base Case & Recommended

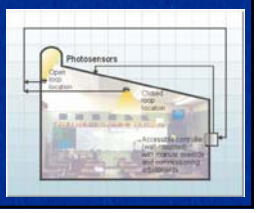


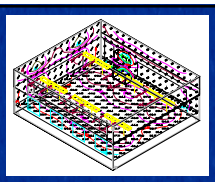
(12) 3-lamp Parabolic Troffers = 1.36 W/sf, plus 2-zone dual switching (18 to 24 ballasts @ .87BF)

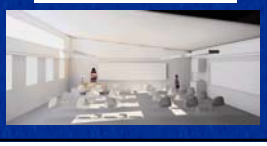
(12) 2-lamp Dir/Ind (Series 4) = 0.89 W/sf, with (6) Motorola 4-lamp dimming ballasts @ .96BF

Controls

- Occupancy Sensors
- Photo sensors
- Inboard outboard
- Shades and tubes
- Switching vs dimming







Presentation Contributions

- Steve Ternoey of “Light Forms”
- Victor Olgyay of the “Rocky Mountain Institute”

Case Studies

Zach Elementary School

Poudre School District

Fort Collins, Colorado

Architect: RB+B Architects, Inc. • Fort Collins, Colorado

Zach Elementary School

Fort Collins, Colorado

Zach Elementary School

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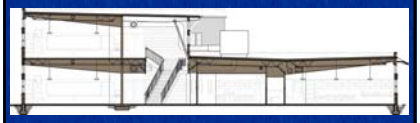

Zach Elementary School

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Fossil Ridge High School

Poudre School District
Fort Collins, Colorado

Architect: RB+B Architects, Inc. • Fort Collins, Colorado

Fossil Ridge High School
Fort Collins, Colorado

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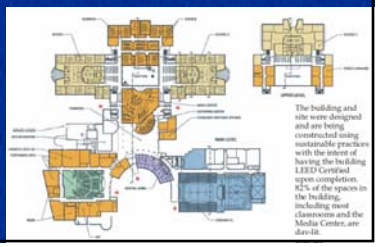
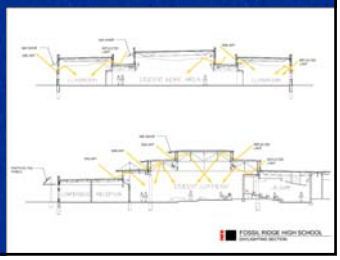
Plan
1800 students, 292,000 square feet

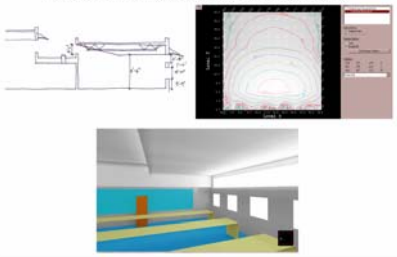


Fossil Ridge High School
Fort Collins, Colorado

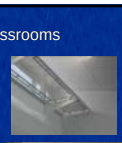


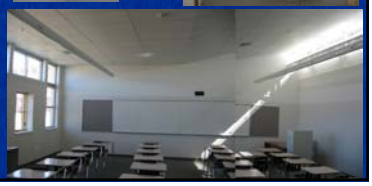
South and west shading strategies

Proposed South Facing Classroom Section
December 21 at Noon, Sky Conditions: Cloudy



Classrooms





Fossil Ridge High School

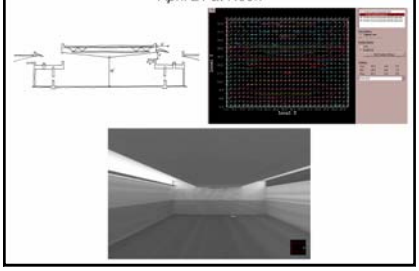
Fort Collins, Colorado

Fossil Ridge High School

Fort Collins, Colorado

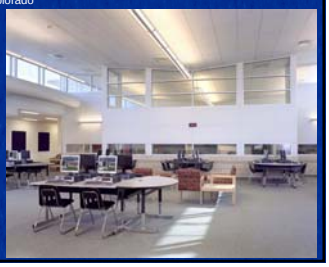
Proposed Student and Teacher Workspaces

April 21 at Noon



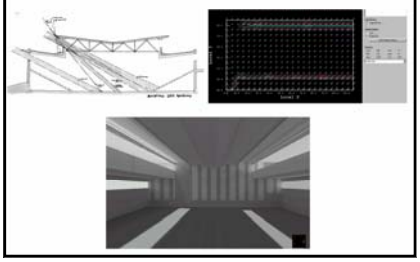
Fossil Ridge High School

Fort Collins, Colorado



Gymnasium

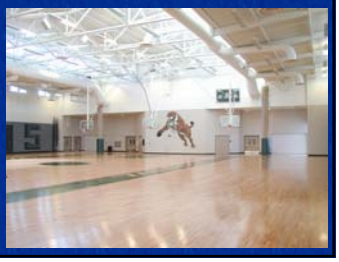
November 21 at Noon



Gymnasium

Fossil Ridge High School

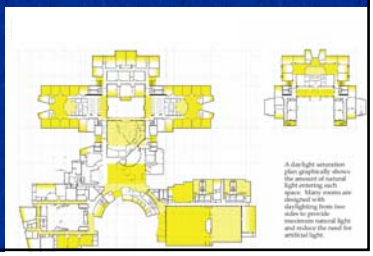
Fort Collins, Colorado



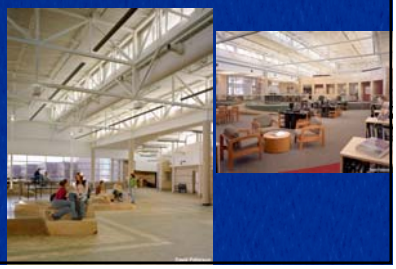
Fossil Ridge High School

Fort Collins, Colorado

Daylight Contribution Plan



Lounge and Media Center

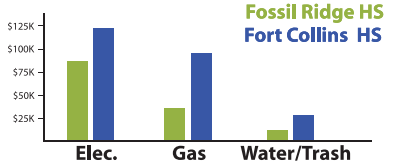


Integrated Photovoltaic material at entrance

Fossil Ridge High School

Fort Collins, Colorado

Annual Energy Comparison 2004 - 2005



Total first year savings : $105,310 or 2.6 teachers

New Campus for Northern Colorado Water Conservancy District

Berthoud, Colorado

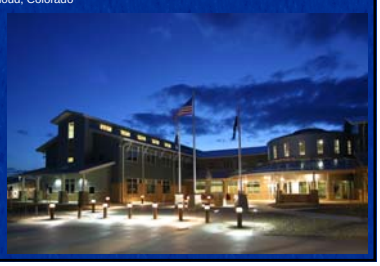
Architect: RB+B Architects, Inc. • Fort Collins, Colorado

Northern Colorado Water Conservancy District

Berthoud, Colorado

Northern Colorado Water Conservancy District

Berthoud, Colorado



Northern Colorado Water Conservancy District

Berthoud, Colorado

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Northern Colorado Water Conservancy District

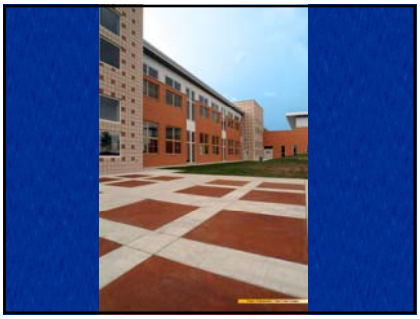
Berthoud, Colorado

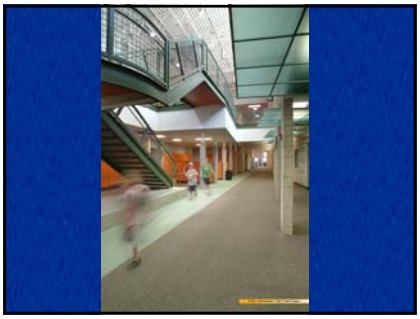
Kinard Junior High School

Poudre School District

Fort Collins, Colorado

Architect: RB+B Architects, Inc. • Fort Collins, Colorado





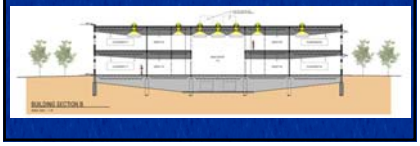

MUSTANGS!

New Prototype Elementary School

Douglas County School District
Castle Rock, Colorado

Architect: RB+B Architects, Inc. • Fort Collins, Colorado

Douglas County Prototype Elementary School



Douglas County Prototype Elementary School

Douglas County Prototype Elementary School

Bigelow Chapel United Theological Seminary

New Brighton, Minnesota

Architect:
Hammel, Green and Abrahamson • Minneapolis, Minnesota

Bigelow Chapel, United Theological Seminary

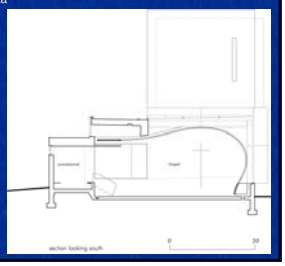
New Brighton, Minnesota

Bigelow Chapel, United Theological Seminary

New Brighton, Minnesota

Bigelow Chapel, United Theological Seminary

New Brighton, Minnesota



Bigelow Chapel, United Theological Seminary

New Brighton, Minnesota

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Bigelow Chapel, United Theological Seminary

New Brighton, Minnesota

And the jist is..

light is a formgiver

A design issue