Loyola/Notre Dame Library
Baltimore, MD


Expansion & Renovation


Sandra M. Di Rupo | Construction Management | April 15th, 2008
Penn State Senior Thesis Presentation




Project Outline

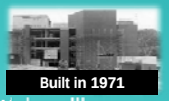
Project Overview
- Existing Conditions

Thesis Research
- Review of Sustainable U.S. Universities

Construction Depth
- Modular Curtain Wall Analysis

Mechanical Breadth
- Solar Shading Analysis

Lighting Breadth
- Daylight Study


Built in 1971




West Elevation

75,000 SF Renovation

25,000 SF Addition

- Addition Constructed in Phase I of V
- Thesis Analyses Concentrated on New Construction

Project Overview

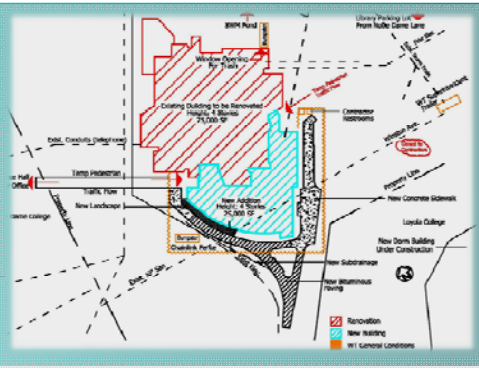
Owner: Loyola/Notre Dame Library

Overall Cost Estimate: $19,604,229

Project Size: 100,000 SF

Number of Stories: Four

Dates of Construction: October 2006-August 2008



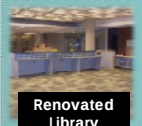
Library Features


3 Story Gallery


Curtain Wall


Study Area


Computer Lab


Renovated Library


Cyber Cafe

Project Overview

Project Team

OWNER
Loyola/Notre Dame Library

GMP
CM at Risk

LS
Architect

LS
Subcontractors

Mini Pile Foundations

Column Pour

Footing Pour

Slab Pour

Solar Parking Structure
Arizona State

5 Million Gallon Thermal Storage Tank
University of North Carolina

Use of Biodiesel B20 for Heating Fuel, Bowdoin College

Campus Retrofits

Energy Conservation Research

Comparing Energy Efficiency Efforts in 10 Universities Across the United States

1. Arizona State University
2. Bowdoin College
3. Massachusetts Institute of Technology
4. Northeastern University
5. Oregon State University
6. Penn State University
7. University of California
8. University of North Carolina
9. University of Vermont
10. University of Washington

http://www.endowmentinstitute.org/sustainability/

Generation of Electricity through Wind Power
Penn State

Used Motor Oil Reuse
University of Vermont

Variable Speed Drives save Millions of kWh
University of California

Reuse of Boiler Heat for Heating & Chilling Water
MIT

Post Research: Thesis Goals

Methods of Conserving Energy for the Library

1. **Sustainable Building Enclosures**
   - Construction Depth
     - Consider Schedule & Cost Savings Also

2. **Reducing Annual kWh Consumption**
   - Mechanical & Lighting Breadths

3. **Use of Renewable Resources**
   - Mechanical & Lighting Breadths

Existing: Stick Built Curtain Wall System

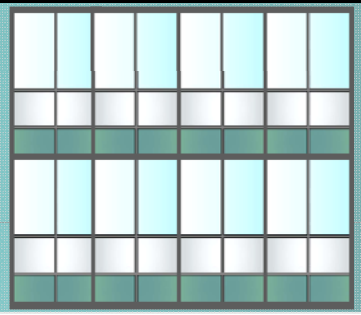



Modular Curtain Wall Analysis

Why Modular Curtain Wall Construction?

1. Enhanced Efficiency
2. Field Labor Savings
3. Considerable Schedule Reductions

Proposed: Modular Curtain Wall System

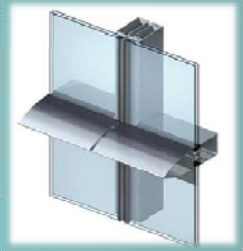


Existing: Kawneer Wall System

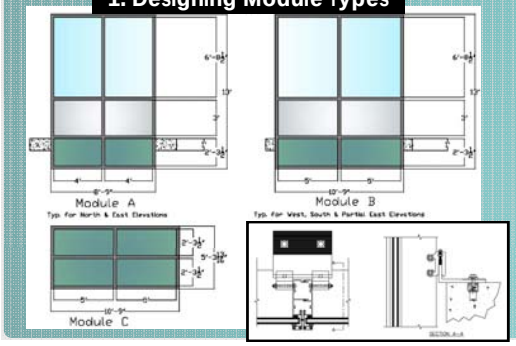
Enhanced Efficiency

- Factory-Assembled, Sealed and Glazed
- Eliminates Poor Assembly on Site
- Testing Performed In Factory
- System Much More Airtight
  - Controlling Energy Loss
  - Acoustics
- Wall System Works the Way it Was Designed

Proposed: VistaWall Modular System

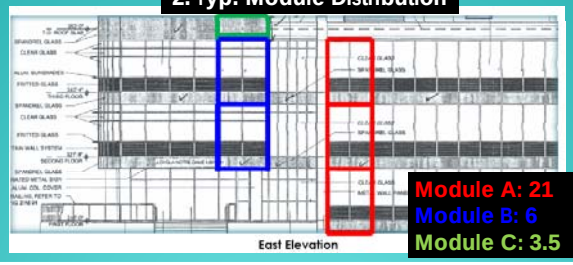


1. Designing Module Types



The Modules

2. Typ. Module Distribution



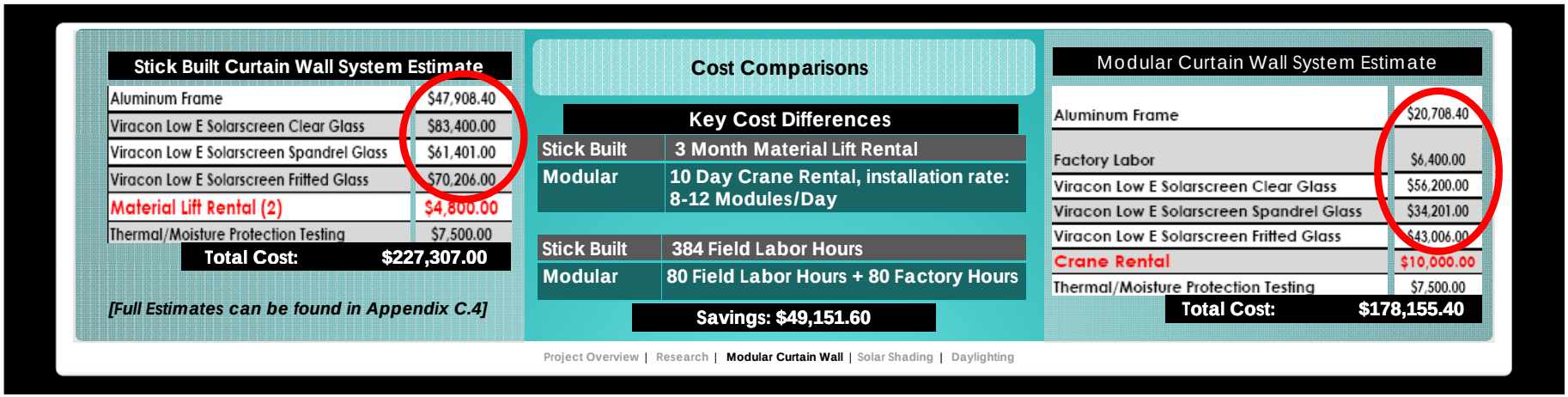
Module A: 21
Module B: 6
Module C: 3.5

3. Total Number of Modules Needed

Total Number of Modules		Total Area of Curtain wall Glass	
Module A		Clear Glass	
• (27) full modules		• 3,750 SF	
• (3) ½ modules		Fritted Glass	
Module B		• 1,674 SF	
• (32) full modules		Spandrel Glass	
• (2) ½ modules		• 1,353 SF	
Module C			
• (16) full modules			
• (2) ½ modules			
78.5 modules		6,777 SF Glass	

Area Calculations Available in Summary Book

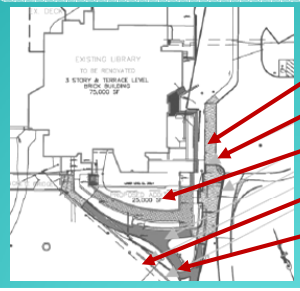
According to VistaWall Curtain Wall, 8-12 modules may be placed per day. Only 7-10 Days to Erect!


Stick Built Curtain Wall System Estimate
Aluminum Frame $47,908.40
Viracon Low E Solarscreen Clear Glass $83,400.00
Viracon Low E Solarscreen Spandrel Glass $61,401.00
Viracon Low E Solarscreen Fritted Glass $70,206.00
Material Lift Rental (2) $4,800.00
Thermal/Moisture Protection Testing $7,500.00
Total Cost: $227,307.00
[Full Estimates can be found in Appendix C.4]
Cost Comparisons
Key Cost Differences
Stick Built 3 Month Material Lift Rental
Modular 10 Day Crane Rental, installation rate: 8-12 Modules/Day
Stick Built 384 Field Labor Hours
Modular 80 Field Labor Hours + 80 Factory Hours
Savings: $49,151.60
Modular Curtain Wall System Estimate
Aluminum Frame $20,708.40
Factory Labor $6,400.00
Viracon Low E Solarscreen Clear Glass $56,200.00
Viracon Low E Solarscreen Spandrel Glass $34,201.00
Viracon Low E Solarscreen Fritted Glass $43,006.00
Crane Rental $10,000.00
Thermal/Moisture Protection Testing $7,500.00
Total Cost: $178,155.40
Project Overview | Research | Modular Curtain Wall | Solar Shading | Daylighting

Existing Stick Built curtain Wall Schedule

Curtain Wall Construction + 8 Saturdays	60 Days	6/7/07- 8/29/07
Sidewalks	23 Days	7/13/07–8/14/07
Brick pavers	5 Days	8/15/07-8/21/07
Re-spread Topsoil	2 Days	8/15/07-8/16/07
Remove Sediment Controls	3 Days	8/17/07-8/21/07
Landscape Seeding Furnishing	10 Days	8/17/07-8/30/07

Schedule Comparisons



Task Delays

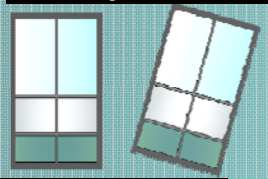
- Paved Walkways
- Brick Pavers
- Final Grading & Landscape
- Site Furnishings
- Concrete Sidewalks

Proposed Modular Curtain Wall Schedule

Curtain Wall Construction (+8 Saturdays)	12 Days	6/7/07- 6/22/07
Sidewalks	23 Days	6/8/07–7/10/07
Brick Pavers	5 Days	7/11/07-7/16/07
Re-spread Topsoil	2 Days	7/11/07-7/12/07
Remove Sediment Controls	3 Days	7/13/07-7/16/07
Landscape, Seeding, Furnishings	10 Days	8/19/07-8/1/07

ONE MONTH SAVED!

Advantages of Modular Curtain Wall



Simple Construction + Field Labor Reduction

Off Site Testing

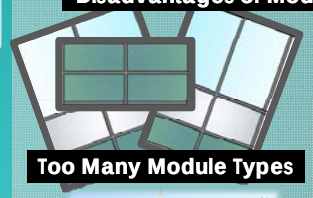
Cost Savings: $49,151.60!

Modular Curtain Wall Conclusions

- ★ Enhanced Efficiency & Higher Quality
- ★ Cost of Field Labor Reduced
- ★ Considerable Schedule Reductions

- X Cost of Factory Labor Introduced
- X Smooth Coordination w/Subs & Manufacturers
- X Crane Introduced, Increased Cost & Risk
- X Too many Modules?
- X Project Too Small or Complex for Modular System?

Disadvantages of Modular Curtain Wall

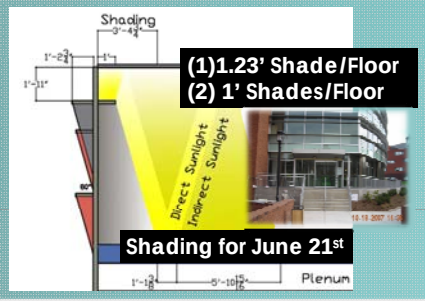


Too Many Module Types

Mobile Crane

Project Type/Size

EXISTING SOLAR SHADES



Solar Shading Analysis

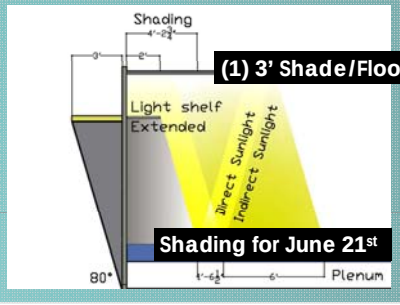
Problems

1. Solar Shade Form Does NOT Follow Function
2. Energy Savings Not Being Maximized
3. Cost of Cooling is Higher b/c of This

Proposal

- Alternative 1: Existing 1.23' & 1' Sunshades
- Alternative 2: Proposed 3' Sunshades
- Alternative 3: Proposed 3' Sunshades with Enthalpy Wheel

PROPOSED SOLAR SHADES



Alt. 1 Shade Ratio: 44.33%
Alt. 1 Solar Heat Gain in June: 4,235,000 BTU
Alt. 1Solar Heat Gain in Dec: 6,579,685 BTU
Alt. 1 Total Solar Heat Gain: 76,300,000 BTU

1. Sun Angle Calculations

Sun Table for Baltimore, MD			W 76°40”0’ , N 39°11”0’
At Noon	Altitude	Azimuth	Clear Days
June	74.08	6.1	8
Dec.	27.51	0.54	8

[Azimuths and Altitudes Calculated from http://www.susdesign.com/sunangle/]

Alternative 2: Three Feet Sunshades

2. Shading Calculations for Proposed Shades

Overhang Length	3’	3’	3’	Ave: 4.64’

Shade Length= tan (90 – Altitude) X (pi/180)

Total Shade Area: 519.14 SF X 1 Story = 519.14 SF/Floor

Total Window Area: 2,912 SF

Shade Ratio: 3 X (519.12/2912)= 53.48%

3. Proposed Solar Heat Gain

Overhang Length	3’ (PER FLR)
Heat Gain (June)	3,120,000
Heat Gain (Dec)	4,925,000
Annual Heat Gain	56,900,000

19,400,000 BTU’s Saved Per Year From Solar Heat Gain Alone

Alternative 1: Existing Building Design Criteria *(As calculated and provided by James Posey Associates)*	
Interior	Summer - 75°F Winter - 70° F
Exterior	Summer - 95° F Winter - 0° F
Interior Load	Lighting – 1.5 Watts/SF Miscellaneous – 1.0 Watts/SF
Ventilation Load	15 CFM of outside air per person
People Density	50 SF per person
Wall "U" coefficient	0.28 BTU/(Hr)(SF)(°F)
Roof "U" coefficient	0.08 BTU/(HR)(SF)(°F)
Glass transmission coefficient	0.76 BTU/(HR)(SF)(°F)
Glass solar factor	0.75 BTU/(HR)(SF)(°F)
Total Cooling Capacity (BY DESIGN)	**1,356,000 BTU/(HR)(SF)(°F) 113 Tons**

Save on Cooling Energy Too?

Alternative 1: Cooling energy savings calculation

Net Total Energy: 1,356,000 BTU/Hr
916,493,760BTU/month
4,582,468,800 BTU/year (May-Sept)

1 kWh = 3,413 BTU, 4,138,977,600 BTU X (1 kWh/3,413 BTU)

1,342,651.28 kWh per year at $0.09/kWh

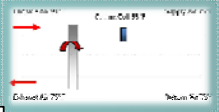
Annual Cooling Energy Cost: $120,838.61

Alternative 2: 3' Shades

1,149,716 BTU/HR
95 Tons of Air Needed

$109,143.86 Annually

Alternative 3: 3' Shades + 0.80 eff. Enthalpy Wheel



935,786 BTU/HR
78 Tons of Air Needed

$88,835.24 Annually

[Loads Calculated in TRANE,TRACE, Appendix D.2-4]

South Elevation With New Solar Shades

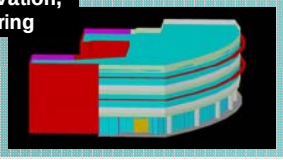
Solar Shading Conclusions

- Energy Savings Maximized in Alternatives 2 &3
- Cooling Costs Reduced by 27% Annually
- Geometry of Shades Now Allow for Form to Follow Function

Close up South Façade with New Solar Shades

East Elevation, CAD Rendering

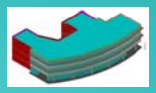
Southwest Elevation, CAD Rendering



Daylight Study

Perform Daylight Study to Check for

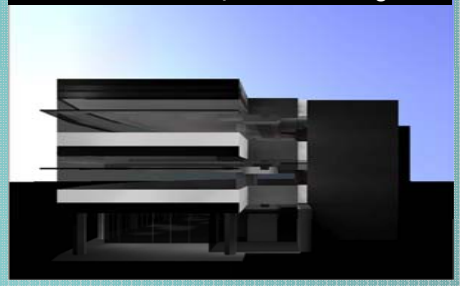
1. **Sufficiently Illuminated Spaces**
   - While Reducing the Need to Turn Lights on During Day



2. **Direct and Indirect Daylight Exposure**
   - Will Extending Light Shelves Make a Difference?

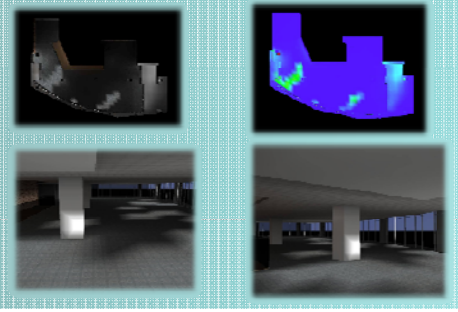
3D AutoCAD Model Imported into AGI Lighting Software

East Elevation, AGI Rendering

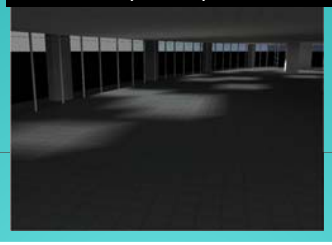


Daylight Comparisons, First Floor

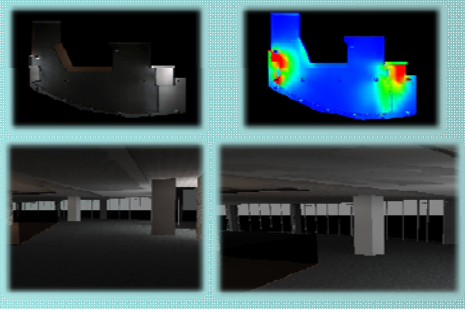
First Floor in Winter, 12:00 PM



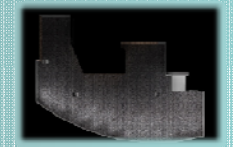
First Floor, Winter, 12:00 PM

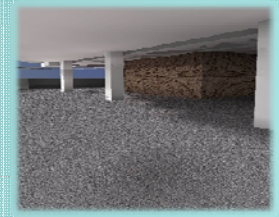


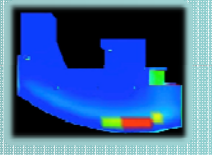
First Floor in Summer, 12:00 PM



Second Floor, Existing, Winter, 12:00 PM

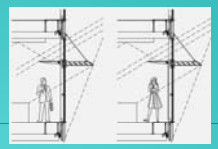




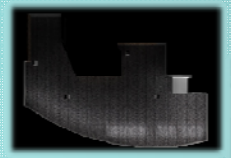


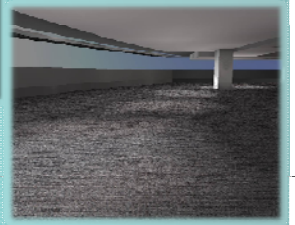
Daylight Comparisons, Second Floor, Winter

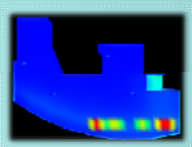
Direct Sunlight is Minimized in Winter



Second Floor, Proposed, Winter, 12:00 PM

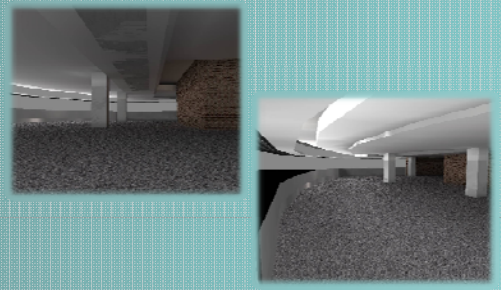






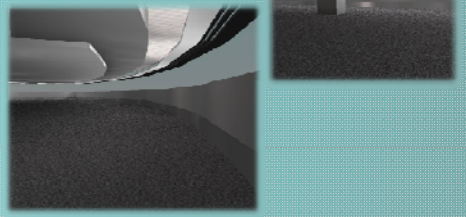
Daylight Comparisons, Second Floor, Summer

Second Floor, Existing, Summer, 12:00 PM

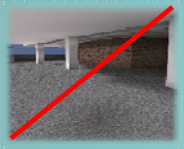


First Floor, Summer, 12:00 PM

Second Floor, Proposed, Summer, 12:00 PM



Pros for the library's Gallery Spaces, 2nd & 3rd Floors

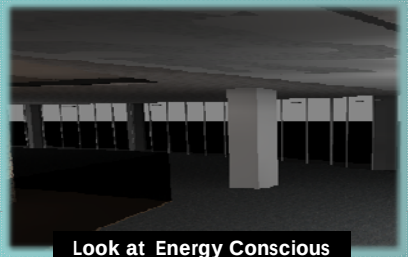


Reduced Direct Sunlight Exposure

Daylight Study Conclusions

- Direct Sunlight is reduced
- Solar Shading Re-design Adequate for Gallery Spaces, Saving on Cooling Energy
- Use of Light Shelves is Necessary to Reduce Direct Sunlight Exposure

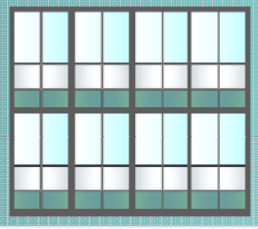
Recommendations



Look at Energy Conscious Lighting Controls

Modular Curtain Wall

Not only a Sustainable Building Enclosure, but also Saves Project Time & Money!



Thesis Goals Met!

Solar Shade Re-Design + Enthalpy Wheel

With these two Energy Saving Alternatives, the Library has potential to save 27% on Annual Energy Costs!

Daylight Distribution

New Solar Shade Design Still Allows More than Adequate Daylight on the second & 3rd floors.

Acknowledgements

The Whiting-Turner Contracting Company
Stephen Lambertson & Eliane Huber

The Loyola/Notre Dame Library
John McGinty

Architectural Engineering Faculty Consultants

My Family & Fellow AE Students for all of their Constant Support

Questions/Comments