Ball State University Center For The Environment – 4th Year Capstone Project

An Honors Thesis (HONRS 499)

By

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Abstract

The natural environment functions in a sustainable way. To move towards a more efficient built environment, we need to reflect on how nature does it first. This project focuses on systems similar to a phototropic sunflower. With the technology available today, we can embrace and design similar systems to work more effectively.

With my thesis I want to investigate technology and natural systems. The natural environment functions in a sustainable way. To move towards a more efficient built environment, we need to reflect on how nature does it first. With the technology available today, we can design similar systems to work more effectively. I am interested in systems similar to a heliotropic sunflower. Using new technologies, louvers, sunshades, and photovoltaic panels could move based on the sun's angle and movement – maximizing their efficiency. The Center for the Environment at Ball State is a great way to explore how to incorporate these systems into new architecture.

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Ann J. Ross
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Ball State University Center for the Environment

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The Center for the Environment at Ball State is also a great opportunity to explore how the surrounding community can be influenced by architecture. This building will correspond with the American College & University Presidents Climate Commitment (ACUPCC). A goal of the ACUPCC is to, “exercise leadership in their communities and throughout society by modeling ways to minimize global warming emissions, and by providing the knowledge and the educated graduates to achieve climate neutrality.” This building will serve as a representation to the public for the future of sustainable architecture. Even though this is a fabricated project, the process and means of identifying this building as a public icon for sustainable design is educating and memorable.
Forward thinking in new technologies, although always morphing into something different, has always influenced architecture. Architects use the technologies and tools of their time to influence their design. The builders of Mesa Verde used simple tools, but their vernacular architecture is influenced by their knowledge of the environment around them. The architects of early skyscrapers used the new material of steel to make their structures significantly taller. Contemporary architects now have more technology available than ever. Our heritage encourages us to move forward and develop architecture that is better because of it.
Ball State University
Center for the Environment
4th Year Capstone Project
Ann J. Ross
Precedent Analysis

Micro Electronics Park Duisburg, Germany
Norman Foster 1988-1996

“Our work in Duisburg is not about a single emblematic building. It has more to do with the collective power of diverse interventions.”
- Norman Foster

Foster designed an alternating series of pavilions and atria beneath a continuous curved roof. He wanted his work to demonstrate that technology could be used to achieve green ends. The tapered plans of the pavilions and the curved profile of the section use a habitable environmental buffer (reliance upon naturally induced air circulation) until extreme weather occurs when secondary mechanical units take over.

“... the modernist idea of a fully glazed building with the goal of energy efficiency.”

Architectural Philosophy
Proposed Site Plan

Ground Floor Plan

Section

Site, Primary Floor Plan and Section; Photographs
Precedent Analysis

Connective Tissue
- Rear Spine and Atria

Served Spaces
- Offices, Conference Rooms,
  And Laboratories

Service Spaces
- Mechanical and Utility

Morphological / Volumetric Organization
Precedent Analysis


Geometric and Dimensional Orders
The primary structure consists of columns on the North East side and load-bearing concrete walls on the South West side. The concrete serves as a thermal mass.
Precedent Analysis

Natural Illumination

Material Layers
- Steel, Glass, Wood

Thermal Mediator

Heavy Basement Supports
Light Structure on Top

Enclosure Organization
This building relies on naturally induced air circulation. Air comes into the building through the atria and also from an air intake in the park. When extreme conditions occur, the mechanical units take over.

Foster designed the building to use cross and stack ventilation to move air across the space.
Precedent Analysis

- Section
- Extruded Section
- Unit
- Repetition of Units

Idea Conception and its Transformation
Architectural Intent

To move towards a more efficient built environment, we need to reflect on how nature does it first. This project focuses on systems similar to a phototropic sunflower. With the technology available today, we can embrace and design similar systems to work more effectively.

The natural environment functions in a sustainable way.

- Water up to leaves
- Microfibrils: similar to glass reinforced plastic
- Lotus plant: water repellent
- Air: solar chimney
- Cradle to cradle: remaking the way we make things

Effective, efficient, beautiful.
Architectural Intent

Protection
- Energy leaves to roots, trunk, branches
- Growth (rings)

Strength
- Energy
- Roots to leaves

Phototropism
- Sustaining leaves
- Cantilevered branches
- Slender column
- Pin

Gather
- Systems
- Flow
Architectural Intent

- Beauty Fruit
- Heliotropism: Moves with Sun
- Fibonacci Ratio: Maximizes Daylight
- Leaves Collect Rainwater

Rainwater collecting roofs

Half Green Roof?

PV's

Solar Aquatic Machine

Cisterns
The building will accommodate the following uses and spaces:

**1.0 Multi-Use Suite**

4,000 sq. ft.

These spaces will be used during the day for lectures for large classes, for evening banquets, for evening lectures by prominent "environmentalists" and for plenary sessions for symposia.

1.1 Auditorium (Seating for 150 in chairs or for 120 sq. ft)

1.2 Stage Area

540 sq. ft.

1.3 Stage Activity Prep Area (Quasi-Green Room)

1.4 Meals Serving Area (For catered meals brought by truck)

1.5 Storage for Tables and Chairs

sq. ft.

1.6 A-V Room (For "state of the art" A-V)

1.7 Coat Room (For 150 coats)

120 sq. ft.

1.8 Reception Area

800 sq. ft.

(Outside of the auditorium can be combined with an atrium or other common space)

**2.0 Exhibit Suite**

1,440 sq. ft.

2.1 Exhibit space

1200 sq. ft.

2.2 Exhibit storage

240 sq. ft.

**3.0 Library**

1,200 sq. ft.

**4.0 Classrooms**

2,880 sq. ft.

4.1 Four classrooms @ 240 sq. ft. (Capacity: 24 ea.)

4.2 Four classrooms @ 480 sq. ft. (Capacity: 48 students ea.) 1,920 sq.

These classrooms will be used as break-out rooms during symposia.

**5.0 Laboratories**

1,920 sq. ft.

Four laboratories @ 480 sq. ft. (Capacity: 24 students ea)

**6.0 Model Fabrication Suite**

480 sq. ft.

6.1 Fabrication area

480 sq. ft.

6.2 Technician’s Office

120 sq. ft.

**7.0 Computer Lab**

960 sq. ft.

24 Stations

**8.0 Director’s Office Suite**

480 sq. ft.

8.1 Director’s Secretary plus waiting area

240 sq. ft.

**9.0 General Office Suite**

2,000 sq. ft.

9.1 General Office (One secretarial position, plus areas for copying and storage and waiting seating)

9.2 Office for Campus Sustainability Coordinator

9.3 Two person office for Coordinator of Clustered Minors in Environmentally Sustainable Practices and Coordinator of "Green" Initiatives

9.4 Technician’s Offices

120 sq. ft.

9.5 Conference Room for eight w/ Kitchenette

7.41 “Living Machine” Technician

120 sq. ft.

9.6 General Storage

120 sq. ft.

9.7 Unisex disabled-accessible toilet
**Program Development**

**Existing NREM Labs:**

- The existing NREM Labs contain wooden cabinet storage for glass beakers, chemicals, and equipment.
- The center of the lab space has a countertop with a water trough sink in the center and work space surrounding it.
- This center space has access to water, gas, and vacuum.
- The lab space currently has little circulation space throughout the room.
Concrete is a sustainable material because it has a very low inherent energy requirement, is produced to order as needed with very little waste, can be made with recycled materials.

Use of coal ash, rice-husk ash, wood ash, natural pozzolans, GGBFS, silica fume, and other similar pozzolanic materials can reduce the use of manufactured Portland cement clinker; and, at the same time, produce concrete that is more durable.

"Greener" concrete also improves air quality, minimizes solid wastes, and leads to sustainable cement and concrete industry.
Site Analysis / Design
HYPOTHESIS: We are watching people’s paths after they get off the shuttle. More people will walk to TC.

CONCLUSION: More people walk to TC from the shuttle.
Environmental Systems

Solar Aquatic System

**Used for:**
- irrigation of plants, both indoor planters and exterior landscapes
- flushing toilets
- groundwater recharge

**Require:**
- sunlight, oxygen, bacteria, algae, plants, snails and fish
  - Anodonta Freshwater clams can individually filter as much as 40 liters/day removing 99.5% of waste
  - Marsh plants include bulrush, cattail, water iris, and reeds
- Round tanks may be used to maximize circulation
- Pumps and fans are necessary to circulate and aerate water
  - Biofilter of humic materials and bark may be used after initial filtration of solids to reduce odors

**Warm Climates**
- May be outside, Temperature encourages biological activity

**Temperate Climates**
- Greenhouse is necessary to maintain water temperatures to prevent plant life from winterizing

**Cold Climates**
- Supplemental heating may be required

1. **Aeration**
   - Air is diffused into waste water which helps naturally forming and supplemented commercially produced bacteria breaks down organic chemicals into carbon dioxide and water. The bacteria also helps breaks down nutrients for other organisms later in the process

2. **Nitrification**
   - Plants, bacteria, and algae metabolize nitrates, ammonia, and phosphates which snails and plankton begin to digest the sludge.

3. **Nutrient Removal, Solid Reduction**
   - The surface plants use materials to grow while their roots provide habitat for zoo plankton which aid in water filtration

4. **Filtration, Denitrification**
   - Solids are filtered through sand and stone substrate while marsh plants reduce bacteria and convert nitrate into nitrogen gas and water

5. **Disinfection**
   - ultraviolet light at the discharge point
Environmental Systems

GALLONS OF WASTE WATER PER PERSON PER DAY < 40 GALLONS

DIST. TANK

SOLAR TANKS

RADIAL FLOW SETTLER

REAL LIFE

LAGOON

SOLAR TANKS

IN - AMMONIA / GIVE OXYGEN / SOLAR MASS ABOVE

MARSH - ANOXIC - NO OXYGEN STAVES PROTOZOA,

ALL GRAVITY SYSTEM?

CASCADE WATERFALLS

* SPELUCATED CLEAN FOR PUBLIC DISPLAY

MARSH

LIVING MACHINE (SOLAR-AQUATIC)
Environmental Systems

- Solar Tanks
- Biofilters
- Distribution Tank
- Radial Flow Settler
- Lagoon & Marsh

Waste → Anaerobic Process → Aerobic Process → Recycle
Principles of Sustainability

NORTH & SOUTH BETTER THAN E+W AVOIDING E+W WINDOWS?

SIDE LIGHTING
TOP LIGHTING

LIBRARY SHELF LIFE NOT LONG ENOUGH FOR SUN FADE DAMAGE (10 YEARS)

DIFFERENT LIGHT FOR DIFFERENT PROGRAMS
GLOSSY MAGAZINE VS. BOOK, WARMTH
IF A WINDOW DOESN'T OFFSET ELECTRICITY,
THEN IT ISN'T AGGRESSIVE DAYLIGHTING.

DAYLIGHTING
EXPERIENCE OF TIME
COLOR
NAVIGATION
WARMTH

DAYLIGHTING DRIVES FOOTPRINT & FLOOR PLAN
2.5 H - HEIGHT OF WINDOW STARTS AT TASK PLANE; EQUALS LIGHT INTO SPACE

TEST W/ OVERCAST SKY
ADJUST FOR CLEAR SKY - GLARE

20% DAYLIGHT FACTOR FOR 75% OF WHOLE

KAHN
AALTO
MAZDIA
Principles of Sustainability

GREEN WALL PROVIDES BARRIER FROM WEST SUN & GIVES SOOTHING VIEWS

SLANTED CEILING DIRECTS MORE LIGHT INTO THE SPACE

SOLAR LIGHTS LET IN LIGHT

30' MAX FOR DAYLIGHTING

8-5

7/18

12/31
Principles of Sustainability
Life Safety

EGRESS

* Safety area on landing by door for wheel chairs waiting area

GREEN HOUSE/SOLAR LIVING MACHINE

COOLING SYSTEMS

ON PUBLIC BUILDINGS

13 Stairs max between landings
7" riser
11" run
44" min. stair width

SPACE PER PERSON

<table>
<thead>
<tr>
<th>AREA</th>
<th>(ft^2)</th>
<th>MINIMUM EXITS BASED ON USAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auditorium</td>
<td>7</td>
<td>2 exits min. required where occupant load is:</td>
</tr>
<tr>
<td>Classrooms</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td>Mechanical Area</td>
<td>300</td>
<td>30</td>
</tr>
</tbody>
</table>

MINIMUM EXITS BASED ON USAGE

2 exits min. required where occupant load is:

50
50
30
Wall Sections/ Building Assembly
Detailing
Space Development
Site Context
Final Sections

Section A-A

Section B-B
Final Elevations

West Elevation

East Elevation
**Final Floor Plans**

**First Floor**

- Auditorium
- Stage
- Mechanical Room
- A/V Room
- Table/Chair Storage
- Green Room
- Food Prep
- General Office
- Director's Office
- Exhibit Space
- Reception Area
- Solar Aquatic System
- Water Collection Cisterns
- Coat Room