SUSTAINABLE SCHOOL DESIGN:
THE NEXT TIME AROUND

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Radnor Township School District
Wayne, Pennsylvania 19087
TOGETHER WE CAN MAKE A DIFFERENCE
RADNOR ELEMENTARY SCHOOL 2001
RESEARCH

- Orientation of Building
- Windows and Doors
- Low/No VOC Products
- Flooring Systems
- Acoustical Considerations
- Stormwater Management
- Traffic Flow
- Indoor Air Quality
- Life Cycle Costing
- Luminaires & Lamps
- Construction Waste Recycling
- And More…
THE CONSTRUCTION PROCESS
PROTECTED OVER 100 TREES
RADNOR ELEMENTARY SCHOOL

RECYCLING OF EXISTING HOME
Heat flows outward from Earth's interior. The crust insulates us from Earth's interior heat. The mantle is semi-molten, the outer core is liquid and the inner core is solid.
RADNOR ELEMENTARY SCHOOL SAVES
OVER 40,000 GALLONS OF OIL PER YEAR
Radnor Elementary School
Solar Photovoltaic System
56 Millennia MST-43MV Panels and Xantrex STXR2500 Inverter – 2100 kWh/Year
BENEFITS OF GREEN

- Reduce Absenteeism
- Elimination of Staff Complaints
- Saving $$$
- Reduce Environmental Impact
- Teach Children
- Improve Indoor Environment
- Gain Community Support
RADNOR MIDDLE SCHOOL
DESIGN CRITERIA: KIDS FIRST

THE BEST POSSIBLE EDUCATIONAL ENVIRONMENT
- High Performance Building
- Availability of Technology
- Researched Design Details

SECURITY
- Student Supervision
- Access Control
- Community Friendly

FLEXIBILITY
- Team Teaching Clusters
- Modular Spaces
- Relocatable Partitions
- Systems Designed for Change
LEED – BASED DESIGN

LEED: Leadership in Energy and Environmental Design

- Sustainable Sites
- Water Efficiency
- Energy & Atmosphere
- Materials and Resources
- Indoor Environmental Quality
- Innovation & Design Process

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<th>LEVEL</th>
<th>POINTS</th>
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<tr>
<td>Certified</td>
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<tr>
<td>Silver</td>
<td>33-38</td>
</tr>
<tr>
<td>Gold</td>
<td>39-51</td>
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<tr>
<td>Platinum</td>
<td>52-69</td>
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POROUS PAVING
POROUS PAVING

Clean uniformly graded coarse aggregate, AASHTO No. 3

Choker Course: AASHTO No. 57
Sufficient to fill large aggregate space

Bed depth varies, generally 12” - 36”

Non-woven Geotextile on bed bottom and sides

Uncompacted Subgrade

PERVIOUS ASPHALT PAVEMENT WITH SUBSURFACE INFILTRATION BED

Riverjacks open into Recharge Bed

Uncompacted subgrade is critical for proper infiltration

Uniformly graded stone aggregate with 40% void space provides stormwater storage and groundwater recharge

Filter Fabric lines the subsurface bed
Area Percentages of Systems:

- High Emissivity Asphalt Shingles 34%
- Vegetated Roof 20%
- High Albedo 46%
- Total High Emissivity Roof 100%
VEGETATED ROOF

DETAIL

- GRAVEL EDGING 2" THICK, 1'-6" MIN WIDE
- ALUMINUM EDGING
- SOIL MEDIA -2 1/2"
- KILLDEER AND YOUNG, N.I.C.
- FILTER FABRIC
- DRAINAGE PLATE
- RETENTION & PROTECTION FABRIC
- SBS MODIFIED MEMBRANE ROOF SYSTEM
- 5" RIGID INSULATION
VEGETATED ROOF INSTALLATION
COMPLETED VEGETATED ROOF
COMPLETED VEGETATED ROOF
MATERIALS

Terrazzo Floors with Recycled Glass Aggregate

100% post-recycled glass
Glass crushing process
Processed post-recycled glass
Mixing process: 100% recycled glass/epoxy resin matrix
Trowel — grind — polish
Finished surface

Agrifiber Board - Rapidly Renewable Material
RECYCLED GLASS TERRAZZO FLOOR
INDOOR AIR QUALITY AT RMS

- Indoor Air Quality Management Plans
  - Construction and Post-construction
- Thermal Comfort and Air Exchange
  - Exceed the ASHRAE 90.1-1999 Standard
- Low Volatile Organic Compounds (VOC’s)
  - Reduce/Eliminate Off-gassing
- Increased Ventilation at Key Rooms
  - Copier Rooms, Computer Areas, etc.
- Individual Control of the Environment
  - Operable Windows and Thermostat Control
- Digital Systems Controls
  - Temperature Control
  - Security/Lighting Control
  - CO2 Monitoring
  - Automatic Ventilation Shut Down
US DEPARTMENT OF ENERGY BUILDING
LIFE CYCLE COSTING

![Bar chart showing the costs of design, maintenance, construction, and utilities.]
HVAC SYSTEMS

- Geothermal Heat Pumps
- WSHP Boiler/Tower
- Chiller/Boiler/Tower (4pipe)
- Rooftop/DX/Gas Heat
### LIFE CYCLE COMPARISON 30 YEARS

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<td>Geothermal HP</td>
<td>Best</td>
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<td>Lowest</td>
<td>Lowest</td>
<td>Best</td>
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<td>WSHP Boiler/Tower</td>
<td>2\textsuperscript{nd} Best</td>
<td>2\textsuperscript{nd} lowest</td>
<td>2\textsuperscript{nd} Lowest</td>
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<td>3\textsuperscript{rd} Best</td>
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<tr>
<td>4 PIPE</td>
<td>3\textsuperscript{rd} Best</td>
<td>Highest</td>
<td>3\textsuperscript{rd} Lowest</td>
<td>Highest</td>
<td>2\textsuperscript{nd} Best</td>
</tr>
<tr>
<td>ROOFTOP DX/GAS HEAT</td>
<td>Worst</td>
<td>Lowest</td>
<td>Highest</td>
<td>3\textsuperscript{rd} Lowest</td>
<td>Worst</td>
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GEOTHERMAL HVAC

- Lowest Life Cycle Cost
- Reduced Mechanical Room Space
- Reduction Of Fossil Fuel Use
- No Boiler Stack Emissions
- Elimination of Oil or Gas Components
- Possible Site Limitations
Sound-Proof Lining

HEAT PUMP

ONE PER CLASSROOM

“Old Design” Unit Ventilator
ACOUSTICS AT RMS

- Acoustics at Radnor Elementary Independently Tested by Project Team
  - Acoustics at RMS to Meet or Exceed
- Comply with the American Disabilities Act
  - ANSI/ASA S1.60-2002 -35 dBA
- Classrooms Acoustically Modeled by Consultant
- Classroom Finishes Enhance Acoustics
  - Carpet, High NRC Ceiling Tile, Tack surfaces
- Minimize HVAC Noise
  - Heat Pump Closets Lined with Acoustical Insulation
- Pass Through Noise Between Rooms Minimal
  - Wall Materials have Superior NRC Ratings
LIGHTING DESIGN CONSIDERATIONS
FOR CLASSROOMS

DIRECT / INDIRECT LIGHTING FIXTURES
Uses Ceiling as Reflector
Eliminates Glare

FULL-SPECTRUM LAMPING
MULTIPLE FIXTURE SWITCHING
Illumination Control by Teacher

OCCUPANCY SENSORS
Shuts Down Lighting in Unoccupied Spaces

DAYLIGHTING CONTROLS
Light Level Dimming
Building Orientation
Daylight Modeling
Sunshades
Efficient Window Glazing
EXPLORE THE POSSIBILITIES…

- **HVAC**
  - Displacement Ventilation
  - Raised Floor Distribution
  - Thermal Mass Techniques
  - Radiant Heating Technologies

- **ELECTRICAL**
  - On-site Generation
  - Combined Heat & Power
  - Emergency Generation Peak Shaving
  - Photovoltaic Technologies
  - Wind Power

- **PLUMBING**
  - Gray Water Recycling
  - PEX Piping
  - Solar Hot Water
  - Waterless / Low-Flow Technologies
ADDITIONAL SUSTAINABLE PROCESSES

- Construction Waste Management
- Green Cleaning Program
- Design for efficient maintenance
  - Reduced Variety of Lamping
  - Anticipate Need for Facility Changes
  - Streamlined Receiving and Distribution
  - Anticipate Waste and Recycling Disposal
  - Concentrated Utility Distribution
WHY DESIGN TO GREEN BUILDING STANDARDS?

- Utility Rebates for Energy Efficiency
- Improvement in Student Performance
- Reduced Operating Costs
- Healthier Buildings
- Better Daily Attendance
- Reduced Liability Exposure
- Enhanced Indoor/Outdoor Environmental Impact
- Incorporates Best Building Technologies
RECOMMENDATIONS

Full Commissioning
Independent Life Cycle Analysis
Thorough Operator Training
Ongoing Verification of Operability and Efficiency
Operations Data Sharing and Analysis
Avoid Proprietary Systems