Schenley Oval Project
Team Members

- Vincent DiCarolis (Project Leader, Construction Group)
- Jacob Bobak (Construction Group)
- Alex Farris (Structural Group)
- Kaixuan (Kevin) Li (Construction Group)
- Megan McNally (Structural Group)
- Tyler Roman (Construction Group)
- Nathan Sloan (Construction Group)
- Yizhen Yan (Construction Group)
- Jiangnan Zheng (Geotechnical Group)
Presentation Schedule

- Project Background
- Building Model/Utility Line
- Soil/Foundation Analysis
- Structural Analysis
- Cost Estimate
- Risk Analysis
- Scheduling & Staging
- Future Steps
Project Background
Schenley Park

- 456 acre municipal park operated by the Pittsburgh Parks Conservatory and the City of Pittsburgh
- Many of the facilities are provided by the City of Pittsburgh Department of Parks and Recreation (aka Citiparks)
- Located between Oakland, Greenfield, and Squirrel Hill
Schenley Oval

1. Disc Golf Course
2. Ice Skating Rink
3. Playground/Pavilion
4. Restrooms
5. Soccer Field, Track, Tennis Courts
6. Open Field (Used for soccer fields)
Need Assessment

● Need:
  ○ There is a lack of facilities for use by the public during sporting events at the Schenley Oval

● Approach:
  ○ Add a 1 story building at the sports complex at the Schenley Oval
  ○ Provide a rest area for the parents while their kids are playing sports
  ○ Benefits will include:
    ■ Food Concessions
    ■ Covered eating and relaxing area
    ■ View looking out at downtown
    ■ Storage for sports, kitchen, and other equipment
    ■ Restrooms
Site Location

- Close proximity to playground for easy supervision
- Nice view of the city
- Short walking distance to the soccer field/track
Public Feedback

- Discussed the scope with Sportsplex users
  - Enjoyed the Project Scope
  - Appropriate location
  - Gained knowledge on demand
    - March through October
    - Estimated 1,000 people during peak hours
Building Code/Zoning Laws

- Park District, P
  - No restrictions due to zoning law setbacks
    - 150’ between street and playground
- Allegheny County Health Department
  - Easily cleanable walls, ceiling, and floor
  - 2 separated ADA compliant restrooms
- 2012 IBC used for structural analysis
Building Operations

The building will

- Be open seasonally, (March - October)
- Hours will fluctuate around events
- Will be maintained with regular park building maintenance.
- Serving food, we will need an inspection from the Allegheny County Health Department
- The storage can be used for sports equipment, kitchen equipment, etc.
Building Model/Utility Map
Building Layout

● Design developed through discussions with team members, suggestions from Dr. Rizzo and responses from the Survey.

● Current design consists of Five sections
  ○ Indoor Kitchen - 750 ft²
  ○ Kitchen Storage room - 625 ft²
  ○ Sports Storage rooms - 925 ft²
  ○ Outdoor seating area (can be enclosed) - 1750 ft²
  ○ Restrooms - 250 ft²

● Overall dimensions are 85 ft x 50 ft - 4250 ft²
Building Orientation

● Changed from initial E-W orientation to N-S orientation.
● View for the city Skyline.
● Better view of the playground and soccer field.
● Away from direct wind.
North Elevation

Roof slope: 4/12

8' - 6''

50' - 0''

10' - 0''
East Elevation

50' - 0"
Structural Model
Architectural Model
Seating Area
Exterior Enclosure

- Easy system attachment and roll up
- Wind rated up to 35 mph
- UV inhibitors when sunny
- Safe to use with standing space heaters
Kitchen

- Refrigerator/Freezer
- Flat Top Grill
- Deep Fryers
- Sinks
- Countertop Space
- Food Machines
Rendering
Storage Rooms

- Kitchen Storage
  - Shelving
  - Refrigerators/Freezers

- Equipment Storage
  - Areas divided by chain link fence
  - 7 areas, 8 ft x 10 ft
Restrooms

- 2 ADA compliant restrooms
  - Male and Female
- Single stall
- Sink/Mirror
- Hand dryer
- Baby changing station
- More restrooms located nearby
Rendered Bathroom Model
Site Sewage Line

- Red - Site Location
- Yellow line - storm sewer
- Green Line - Sanitary sewer
- Private sewer Lateral not shown on map
- Blue Line - Water Distribution Main
Site Sewage Line

- Red - Site Location
- Yellow line - storm sewer
- Green Line - Sanitary sewer
- Private sewer Lateral not shown on map
- Blue Line - Water Distribution Main
Gas/Electricity Line

- PNGC Gas Line
- Duquesne Light Electricity Line
Utility tie-in

- All within close range of the building
  - Water distribution line < 50 ft
  - Electricity line < 50 ft
  - Sewer line ~ 150 ft
  - Gas line ~ 250 ft

- Excavation is required but no significant Geotechnical Challenges
Soil/Foundation Analysis
Soil Analysis

- U.S. Department of Agriculture (USDA) Soil Map
  - Gilpin silt loam => Poor subgrade
- Result of laboratory test
  - Direct shear test
    - Supporting soil cohesion: 10 kPa
    - Angle of internal friction: 25°
  - Unit weight test
    - \( \gamma = 125.5 \text{ lb/ft}^3 \)
Shallow Foundation

● Advantage:
  ○ Cost (affordable)
  ○ Construction Procedure (simple)
  ○ Material (mostly concrete)
  ○ Labour (does not need expertise)
Summary of Foundation Work

- Foundation consists of
  - Spread footings
  - Strip footings
- Size of footing based on settlement calculation from loadings
Spread Footing Final Design

- Designed using ACI 318-14
- Shear ultimate < factored shear capacity
- One way shear
  - Shear ultimate: 2.38 kip
  - Factored shear capacity: 21.35 kip
  - Assumed effective depth checks: 7.5"
- Two way shear
  - Shear ultimate: 7.73 kip
  - Factored shear capacity: 47.5 kip

<table>
<thead>
<tr>
<th>Load combination</th>
<th>1.9</th>
<th>ksf</th>
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<td>( f_c )</td>
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<td>Feet</td>
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<td>( \varphi )</td>
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</table>
Spread Footing Calculations

- **Flexure**
  - Mu: 2.58 kip-ft
  - Solve for area of horizontal rebar by using ultimate flexural
    - Area of rebar: 0.65in$^2$
    - Requires # rebar: 4#4 bars
- **Assumed Tension was controlling factor**
  - $\varepsilon_t = 0.037 > 0.005$
- **Transfer of column forces to the base**
  - Dowel reinforcement: 4#3 bars
Strip Footing Final Design

- Strip footing were design using the same process as spread footings.
  - Designed using ACI 318-14
- Generally controlled by minimum rebar requirements.
- Distance from the ground level to the footing base: 3 ft
- Ultimate bearing capacity: 9,600 lb/ft$^2$
- Allowable soil pressure: 3,200 lb/ft$^2$
Strip Footing Calculation

- Preliminary Member sizing
  - Assuming the footing thickness is equal to the thickness of wall
- Shear Capacity Check
  - $V_u < \phi V_c$ o.k.
- Flexural Reinforcement design
  - Provide #4 bars at 12in
- Shrinkage and Temperature Reinforcement
  - Provide 4#3 bars
- Dowel reinforcement
  - Provide 4#3 bars
Structural Analysis
ASCE Design Hazard Tool

- Ultimate Wind Speed: 115 mph
- Risk Category: II
- Elevation: 1046.3' (NAVD 88)
- Seismic Design Category: B
  - Sds: 0.117
- Ice Thickness: 0.75"
- Pg: 25 psf (~20” settled snow)
- Precipitation Intensity: 2.55 in./h

ASCE 7 Hazards Report

**Standard:** ASCE/SEI 7-10  
**Risk Category:** II  
**Soil Class:** D - Stiff Soil  
**Elevation:** 1046.25 ft (NAVD 88)  
**Latitude:** 40.430921  
**Longitude:** -79.944914
Dead Loads and Roof Live Loads for Design

- **Roofing**
  - Metal Deck: 2.5 (psf)
  - Insulation: 1.5 (psf)
  - Waterproofing: 0.7 (psf)
  - Wood rafters: 8 (psf)

- **Ceiling**
  - Acoustic Fiber Board: 1 (psf)
  - Gypsum Board: 2.75 (psf)
  - Mechanical Duct Allowance: 4 (psf)

- **Live Load (Roof Maintenance)**
  - Minimum Reduced Load = 12 (psf)
Wind Loads

Elevation View

-11.69 psf

-12.52 psf

18.66 psf

-11.69 psf

Plan View

-15 psf

-15 psf
Main Roof Layout

- Girders: 12” x 24” Douglas Fir-Larch
- Beams: 4” x 16” Redwood
- Shaded Area: 3/8 in. plywood sheathing
- Connections:
  - Simpson Strong Ties
  - Angled Steel Plates
  - Rotafix Structural Adhesive
Truss Framing Connections

- 45-degree Skewed Face-Mount Hangers
- Fasteners: Structural Connector Screws
Structural Checks - Main Roof Frame

Girders:
- Flexure (capacity = 3773 psi)
  - 2394 psi < 3773 psi
- Shear (capacity = 338 psi)
  - 318 psi < 338 psi
- Compression (capacity = 1300 psi)
  - 680 psi < 1300 psi

Beams:
- Flexure (capacity = 3997 psi)
  - 3636 psi < 3997 psi
- Shear (capacity = 318 psi)
  - 46 psi < 318 psi
- Compression (capacity = 1850 psi)
  - 205 psi < 1850 psi
Outside Roof Layout

- All Members are Douglas Fir-Larch
- Girder: 16” x 22”
- Outer Beams: 10” x 10”
- Inner Beams: 12” x 12”
Structural Checks - Outside Roof Frame

Girder:
- Flexure (capacity = 3510 psi)
  - 3419 psi < 3510 psi
- Shear (capacity = 338 psi)
  - 123 psi < 338 psi

Outer Beams:
- Flexure (capacity = 3773 psi)
  - xx axis: 3596 psi < 3773 psi
  - yy axis: 800 psi < 3773 psi
- Shear (capacity = 338 psi)
  - 41 psi < 338 psi

Inner Beams:
- Flexure (capacity = 3773 psi)
  - 3714 psi < 3773 psi
- Shear (capacity = 338 psi)
  - 51 psi < 338 psi
Wall Arrangements in Masonry Buildings

● Based on building model, a cellular wall arrangement will be the most appropriate option for our project.
● Other design considerations:
  ○ Robustness of the building
  ○ Serviceability
  ○ Frost resistance of the blocks
  ○ Dimensional changes
  ○ Fire Resistance
  ○ Mortar
  ○ Reinforcement
Structural Design - Concrete Masonry Walls

- Used Unit Strength Method
  - 8 inch medium weight hollow CMU
  - Type S Mortar
- Check Compressive Strength
- Determine Quantity and Size of Rebar
CMU Wall Compression Check

- Axial Force/Wall = 56 Kips
  - Includes Weight of Sliding Snow ~ 5 Kips
- Compressive Strength = 65 kips
  - Includes Safety Factors
- 65 > 56 Kips, Compression Check Passes
Rebar Size and Quantity - Tensile Check

- Wind Pressure on CMU Wall Creates Tensile Stress
- Rebar Needed to Resist Tensile Force
- Max Moment from Wind = 2790 lb-in
  - Area of Steel Needed = 1.67 in²/ft
Rebar Selection

- Chosen Rebar Parameters:
  - Rebar Spacing = 16 in.
    - Area Needed = 2.23 in.²
  - Choose #14 Rebar
    - Area = 2.25 in.²
Steel Column Design - Porch

- Porch columns need to be designed to resist flexure.
- Sources of Flexure:
  - Wind when partition is closed - lateral force
  - Moment from Axial Loads
- Columns designed as Beam - Columns
Beam-Column Design - Axial Loads

- Factored Load = 57.565 psf
  - From ASCE 7-10 Load Combinations
- Tributary Area of Middle Column = 437.5 ft²
  - Columns were designed to be the same to maximize constructability
- Weight of Girder = 4.05 Kips
- Controlling Axial Load (Pnt) = 27.2 Kips
Beam-Column Design - Flexure

- Max moment from lateral forces must be calculated
  - Distributed Lateral Wind Load (P lt) = 0.65 Kips/Ft
  - Max Moment from Lateral Forces (M lt) = 7.41 Kip*Ft
Beam-Column Design - Flexure

- Factored moment from Axial Loading must be calculated
  - Using ASCE 7-10 Load Combinations
  - Factored Moment (Mnt) = 19.5 Kip-Ft
- Example below showed for moment caused by Roof Live Load
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Beam-Column Design - Member Selection

- Columns are fixed at base and pinned at girder:
  - $K = 0.8; \ KL = 8'$
- To account for second-order effects, $Mr$ and $Pr$ are calculated using amplification factors.
  - $Mr = 27.0 \text{ Kip-Ft}$
  - $Pr = 33.8 \text{ Kips}$
- Select HSS 5.5X0.375 (weight = 20.55 lb/ft)
  - $Mn = 32 \text{ Kip-Ft}$
  - $Pn = 194 \text{ Kips}$
Connection

- HSS member was used to fit a special connection designed to connect steel columns to wooden girders.
- Simpson Strong Tie Steel Column Cap
- Girder Dimensions:
  - W = 16”
Connection

- Axial Loads:
  - Corner Column: 13.6 Kips
  - Middle Column: 27.2 kips

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<th>W (in.)</th>
<th>Girder</th>
<th>Nails²</th>
<th>Lally Column Outside Diameter (in.)</th>
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Connection Details

● Steel column will be attached to connection with 4 Quik Drive self-tapping screws
● Middle column will be a spliced condition, but exceeds axial loading for spliced condition
  ○ Additional bracing will be installed to transfer axial loads to the column
Cost Estimate
Estimating Method

- Unit price estimating
- Quantity takeoffs
- Unit price includes *material* and *labor* cost
- Quantity x Unit Price = Cost
- Unit prices obtained from “2018 Building Construction Costs”
Supervision Estimate

Key Items

- Project Manager = $33,800
- Project Engineer = $16,900
- Superintendent = $19,500
- Operator = $11,400
- Survey Crew = $1,680

Supervision Total = $84,900
Activity Estimate

Key Items

- Interior Roofing System = $54,600
- Exterior Roofing System = $23,500
- CIP Concrete = $21,300
- CMU Block Construction = $19,900
- Backfilling = $10,900

Total Activity Cost = $191,500
Permitting Estimate

- Building = $2,075
- Electrical = $497
- HVAC = $165
- Fire Alarm/Sprinkler = $95
- Signs = $106
- Land Operations = $880

**Total = $3,800**

*Data taken from the City of Pittsburgh 2018 Fee Schedule*
Equipment Estimate

Key Items
- Excavator = $22,620
- Rough Terrain Crane = $10,800
- Skid Steer = $6,370
- Concrete Pump Truck = $2,150
- Dump Truck = $2,205
- Electric Generator = $1,365

Equipment Total = $48,500
Miscellaneous Items

Field Office
- Furnished Field Trailer = $2,900

Temporary Support Facilities
- Electricity, Fuel Bill
- Drinking Water
- Temporary Toilet
- Total = $14,100

General Support Items
- Safety - Drug Test/PPE
- Dumpsters
- Total = $7,500

Kitchen
- Equipment = $21,900

Risk
- Contingency = $22,500

Misc Total = $68,900
Estimating Summary

- Project Estimate
  - Supervision = $84,900
  - Activity = $191,500
  - Permitting = $3,800
  - Equipment = $48,500
  - Miscellaneous = $68,900

Total = $397,600
Risk Analysis
## Risk Assessment

<table>
<thead>
<tr>
<th>What can go wrong</th>
<th>Probability (%)</th>
<th>Estimated Cost</th>
<th>Contingency</th>
<th>Can we prevent it?</th>
<th>Plan</th>
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<tbody>
<tr>
<td>Inclement weather</td>
<td>90%</td>
<td>$4,000.00</td>
<td>$3,600.00</td>
<td>No</td>
<td>Use float days</td>
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<td>Equipment not available to buy</td>
<td>40%</td>
<td>$4,500.00</td>
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<td>Yes</td>
<td>Lease as an alternative</td>
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<td>Delayed deliveries</td>
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<td>$5,000.00</td>
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<td>No</td>
<td>Reassign workers to other tasks.</td>
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<tr>
<td>Design errors</td>
<td>30%</td>
<td>$6,000.00</td>
<td>$1,800.00</td>
<td>Yes</td>
<td>Submit RFI to designer</td>
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<tr>
<td>Poor subsurface conditions</td>
<td>30%</td>
<td>$4,000.00</td>
<td>$1,200.00</td>
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<td>Inspect soil and do necessary work to make it usable</td>
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<tr>
<td>Flooding</td>
<td>25%</td>
<td>$4,000.00</td>
<td>$1,000.00</td>
<td>No</td>
<td>Halt construction and use pumps to pump water out of site</td>
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<tr>
<td>Equipment breaks</td>
<td>25%</td>
<td>$4,000.00</td>
<td>$1,000.00</td>
<td>No</td>
<td>Rent equipment so supplier can send out backup equipment. accept the waiting period</td>
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<tr>
<td>Material shortage</td>
<td>25%</td>
<td>$3,000.00</td>
<td>$750.00</td>
<td>Yes</td>
<td>Find alternative material or find a new supplier</td>
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<tr>
<td>Theft of equipment</td>
<td>20%</td>
<td>$5,000.00</td>
<td>$1,000.00</td>
<td>Yes</td>
<td>Have work area fenced in and locked at the end of each day</td>
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<tr>
<td>Vandalism</td>
<td>20%</td>
<td>$3,000.00</td>
<td>$600.00</td>
<td>Yes</td>
<td>Put up fences around construction area and lock at the end of each day.</td>
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<tr>
<td>Water shortage/electricity blackout</td>
<td>20%</td>
<td>$2,000.00</td>
<td>$400.00</td>
<td>No</td>
<td>Shut down temporarily, if outage continues accept lost time</td>
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<tr>
<td>Material arrives broken/ not to standards</td>
<td>20%</td>
<td>$4,000.00</td>
<td>$800.00</td>
<td>No</td>
<td>Return material. Find new supplier if problem not quickly fixed</td>
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<tr>
<td>Cost escalation</td>
<td>20%</td>
<td>$8,000.00</td>
<td>$1,600.00</td>
<td>No</td>
<td>Have a conservative const estimate so if it does escalate, it wont be a problem</td>
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</table>
# Risk Assessment

<table>
<thead>
<tr>
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<th>Contingency</th>
<th>Can we prevent it?</th>
<th>Plan</th>
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<tr>
<td>Project manager ill/absent</td>
<td>20%</td>
<td>$5,000.00</td>
<td>$1,000.00</td>
<td>No</td>
<td>Next highest ranking personnel in charge</td>
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<tr>
<td>Damage existing utilities</td>
<td>10%</td>
<td>$10,000.00</td>
<td>$1,000.00</td>
<td>Yes</td>
<td>Call utility company. ASAP</td>
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<tr>
<td>Failed final inspection</td>
<td>10%</td>
<td>$5,000.00</td>
<td>$500.00</td>
<td>Yes</td>
<td>Do bi-weekly inspections so that there would be no problems</td>
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<tr>
<td>Fire</td>
<td>10%</td>
<td>$5,000.00</td>
<td>$500.00</td>
<td>Yes</td>
<td>Call 911. Brief workers on Emergency response Plan</td>
</tr>
<tr>
<td>Incomplete set of drawings provided</td>
<td>10%</td>
<td>$5,000.00</td>
<td>$500.00</td>
<td>Yes</td>
<td>Make sure proper drawings are obtained prior to work being performed.</td>
</tr>
<tr>
<td>Owner is late with payments</td>
<td>10%</td>
<td>$7,500.00</td>
<td>$750.00</td>
<td>No</td>
<td>Continue construction unless issue continues to persist</td>
</tr>
<tr>
<td>Strikes</td>
<td>10%</td>
<td>$5,000.00</td>
<td>$500.00</td>
<td>No</td>
<td>Delay costs until there is a settlement</td>
</tr>
<tr>
<td>Fire</td>
<td>10%</td>
<td>$5,000.00</td>
<td>$500.00</td>
<td>Yes</td>
<td>Call 911. Brief workers on Emergency response Plan</td>
</tr>
<tr>
<td>Incomplete set of drawings provided</td>
<td>10%</td>
<td>$5,000.00</td>
<td>$500.00</td>
<td>Yes</td>
<td>Make sure proper drawings are obtained prior to work being performed.</td>
</tr>
<tr>
<td>Owner is late with payments</td>
<td>10%</td>
<td>$7,500.00</td>
<td>$750.00</td>
<td>No</td>
<td>Continue construction unless issue continues to persist</td>
</tr>
<tr>
<td>Strikes</td>
<td>10%</td>
<td>$5,000.00</td>
<td>$500.00</td>
<td>No</td>
<td>Delay costs until there is a settlement</td>
</tr>
<tr>
<td>Job-site injury</td>
<td>5%</td>
<td>$15,000.00</td>
<td>$750.00</td>
<td>No</td>
<td>Call 911 if serious. Report injury to OSHA. Hold weekly safety meetings.</td>
</tr>
<tr>
<td>Job-site injury</td>
<td>5%</td>
<td>$15,000.00</td>
<td>$750.00</td>
<td>No</td>
<td>Call 911 if serious. Report injury to OSHA. Hold weekly safety meetings.</td>
</tr>
</tbody>
</table>
Risk Assessment Final Cost

- Our total estimated risk cost = $22,500
- This is roughly 6% of our final cost.
Funding

- Pittsburgh has a seven year capital budget that ranges from (2018-2024).
- After contacting the city, they informed us that we wouldn’t be able to start this project until the spring of 2025.
- One of the cities main goals in the current budget is to restore parks such as:
  - Homewood Park
  - South Side Park
  - Arsenal Park
- Confident that our project will be accepted and incorporated into the new capital budget starting in 2025.
Schedule & Staging
Schedule

● The Pre-construction Phase
  ○ Completed
    ■ Meeting with shareholders/financial leaders/public
    ■ Site Surveying
  ○ Future
    ■ Environmental Site Assessments
    ■ Construction plans and other document reviews

● The Construction Phase
  ○ Site Work
  ○ Foundation Construction
  ○ Building Construction
  ○ Utilities Installation
  ○ Punchlist/Final Cleaning

● The construction should be completed in 13 weeks
Schedule P6

- Schedule broken down into dozens of activities
- Activities separated into various WBS
- Activities connected together with FS & SS logic ties
- Each activity is resource loaded
Site Logistics
Equipment Staging

- Material & equipment will be stored on site
- Excess material stored in staging area
- Fencing set up around staging area and on site for loss prevention
- Security cameras already in place on light poles
Traffic

- Construction will have low impact on traffic
- Traffic will remain open
  - Flagging used when necessary
- Access road is Overlook Drive, the Northern Entrance
  - (~38 ft width including parking)
- Larger vehicles will access using East entrance
Future Steps
Solar Power

● Panel Requirement
  ○ 2,000 kWh during active months
  ○ 400 W per panel
  ○ 35 Panels required

● Cost
  ○ $2.50 per Watt
  ○ $35,000

● Savings
  ○ $170 per month
  ○ $2,000 per year
  ○ Pennsylvania Net Metering
Spatial Requirement for Solar Panels

- Space for maintenance
- 35 Panels
  - 750 SF
- Current roof design
  - 650 SF per side
- 2 Sided (Gable) roof design
  - 1200 SF per side
- Mono-pitched
  - 2300 SF
Final Thoughts
Additional Steps

● Funding
  ○ Alternative sources of funding
    ■ Community Support
    ■ Sports Organizations

● Leasing food services
  ○ Reduce costs to the city
Summary
Resources and Thank You

- Dr. Rizzo
- Professor Sebastian
- Dr. Bunger
- Dr. Oyler
- Dr. Stephens
- Dr. Sachs
- Engineering Library
- Cindy (Soccer Organizer)
- Sue (Citiparks)
- Julie Asciolla (PWSA)
- David Homrich (President of Sunrise Energy)
Thank You
## Roof Live Load Table

<table>
<thead>
<tr>
<th>Flat roof section:</th>
<th>Sloped roof section:</th>
</tr>
</thead>
<tbody>
<tr>
<td>F=</td>
<td>F=</td>
</tr>
<tr>
<td>&lt;4</td>
<td>4</td>
</tr>
<tr>
<td>At=</td>
<td>At=</td>
</tr>
<tr>
<td>1750</td>
<td>1750</td>
</tr>
<tr>
<td>R1=</td>
<td>R1=</td>
</tr>
<tr>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>R2=</td>
<td>R2=1.2 -.05 F</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Lr =20R1R2</td>
<td>Lr =20R1R2</td>
</tr>
<tr>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>
# Snow Load:

<table>
<thead>
<tr>
<th>Flat Roof</th>
<th>Sloped Roof:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ce = 1</td>
<td>Cs = 0.95</td>
</tr>
<tr>
<td>Ct = 1.2</td>
<td>Pf (psf) = 21</td>
</tr>
<tr>
<td>Pg(psf) = 25</td>
<td>Ps(psf) = Cs*Pf: 19.95</td>
</tr>
<tr>
<td>Is = 1</td>
<td></td>
</tr>
<tr>
<td>Pf(psf) = 0.7<em>Ce</em>Ct<em>Pg</em>Is: 21</td>
<td></td>
</tr>
</tbody>
</table>
### Side Wall, Closed Case:

<table>
<thead>
<tr>
<th>Ext. Pres. Coefficient, $C_p$:</th>
<th>-0.7</th>
<th>Fig. 27.4-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Pressure, $P = qh^*G^*C_p-qh(GCpi)$</td>
<td>$-14.98065581$</td>
<td>Eq. 27.4-1</td>
</tr>
</tbody>
</table>

### Windward Roof, Closed Pitched Case (Negative):

<table>
<thead>
<tr>
<th>Ext. Pres. Coefficient, $C_p$:</th>
<th>-0.5</th>
<th>Fig. 27.4-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Pressure, $P = qh^*G^*C_n-qh(GCpi)$</td>
<td>$-11.69457647$</td>
<td>Eq. 27.4-1</td>
</tr>
</tbody>
</table>

### Windward Wall, Closed Case:

<table>
<thead>
<tr>
<th>Ext. Pres. Coefficient, $C_p$:</th>
<th>0.8</th>
<th>Fig. 27.4-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Pressure, $P = qz^*G^*C_p-qh(GCpi)$</td>
<td>$18.65841953$</td>
<td>Eq. 27.4-1</td>
</tr>
</tbody>
</table>

### Roof, Open Flat Case (case A): $D<h$

<table>
<thead>
<tr>
<th>Ext. Pres. Coefficient, $C_n$:</th>
<th>-0.8</th>
<th>Fig. 27.4-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Pressure, $P = qh^*G^*C_n$</td>
<td>$-13.14431736$</td>
<td>Eq. 27.4-3</td>
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</table>

### Leeward Roof, Closed Pitched Case:

<table>
<thead>
<tr>
<th>Ext. Pres. Coefficient, $C_p$:</th>
<th>-0.55</th>
<th>Fig. 27.4-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Pressure, $P = qh^*G^*C_p-qh(GCpi)$</td>
<td>$-12.51609631$</td>
<td>Eq. 27.4-1</td>
</tr>
</tbody>
</table>
Solar

- 2000 kWh/month or
  - 16,000 kWh over 8 months
  - 17,000 kWh per year
- 1240 kWh/kW/year
  - 14 kW / year
- 400 W / panel
  - 35 Panels Required

- 35 Panels
  - 1,100 SF
- Current roof design (4 sides)
  - 500 SF per side
- 2 Sided roof design
  - 1,200 SF
  - Limited by panel dimensions
- 1 Slope roof design
  - 2,300 SF
  - No Configuration Restrictions
What Would Need to Happen

- Roof Redesign (Single Slope)
  - Use Standing Seam Roof
    - S-5 Seam Clamp at $5 per clamp
    - $300 Total