TEAM PROCESS
A SE MEP CM LCFM

Coming together is beginning
Keeping together is progress
Working together is success. (Henry Ford)

Integrated solutions!

1. Explain ideas/suggestions clearly – don’t expect us to read your mind
2. Be on time and prepared – if you have problems let us know in advance
3. Set realistic goals in terms of finishing tasks – we respect if you are overworked
4. Give every idea a chance
5. Give feedback and be open to feedback
6. Trust your team-mates and help build trust
7. Invite other disciplines to input on your task
TEAM PROCESS
A SE MEP CM LCFM

COORDINATION
Promoting effective coordination

COLLABORATION
Facilitating teamwork and collaboration

COMMUNICATION
Creating a supportive working climate

Optimization Results
Responsibility Activities
Co-Creation Social

Weekly Team Meetings
Organized TERF-Space

Project Management Tool
TEAM PROCESS – AN EXAMPLE

A SE MEP CM LCFM

DESIGN PROCESS

Collect information

Define the challenges for the site/project

Present ideas in Terf

Take Feedback

Improve the Design

Brainstorm with Team

Analysis

Integrated Design Solutions

Collect information

Define the challenges for the site/project

Present ideas in Terf

Take Feedback

Improve the Design

Brainstorm with Team

Analysis

Integrated Design Solutions
SITE
A SE MEP CM LCFM

San Juan, Puerto Rico
CLIMATE CONDITIONS

Hot humid climate zone
Warmest month: August
Coolest month: December
Average sunlight hours: 8 hrs
Average relative humidity: 76%
No cold season

Predominant wind direction are East & North East
Average wind speed ~ 8 mph

Average annual temperature 79 °F
Average rain ~ 64 inches
CHALLENGES

**A SE MEP CM LCFM**

- **Hurricane Season**
  June - November, every year.

- **Earthquakes**
  Everyday Puerto Rico moves, but is estimated that every 100 years there is a BIG earthquake. The last one was on 1918.

- **Precipitations**
  May - September, are the most rainy months every year.

- **Sahara’s Dust**
  April - October, every year.
We will work with the weather conditions instead of fighting them!
BIG IDEA BIRD
SE MEP CM LCFM

PUERTORRICAN PARROT
BIRD FLOOR PLANS
A SE MEP CM LCFM

Ground Floor
- Labs
- Small Classrooms
- Seminars
- Storage
- Bathrooms
- Mech Room
- Vertical Circulation
- Shaft
BIRD SECTION A-A
A  SE MEP CM LCFM
BIRD SECTION BB
A SE MEP CM LCFM
BIRD ELEVATIONS
A SE MEP CM LCFM

NORTH ELEVATION

SOUTH ELEVATION

EAST ELEVATION
Principal Entry – North Facade
BIRD VISUALIZATION
SE MEP CM LCFM
LOAD INFORMATION
A SE MEP CM LCFM

Based on ACSE 7-2010 Ed

Earthquakes

0.2s SRA = 1.0 g
1.0s SRA = 0.4 g
Critical Damping 5%

Wind

Hurricane season
V = 160-170 mph
Wind pressure = 39 psf
<table>
<thead>
<tr>
<th>Type</th>
<th>Uniform Load / psf</th>
<th>Concentrated Load / k</th>
<th>Corresponding Island Building</th>
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<tr>
<td>Office</td>
<td>50</td>
<td>2</td>
<td>Faculty Offices; Department Chair's office; Administrative Assistants; Student offices</td>
</tr>
<tr>
<td>Lobbies</td>
<td>100</td>
<td></td>
<td>Administrative Assistants; Student offices</td>
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<tr>
<td>Corridors</td>
<td>100</td>
<td>1</td>
<td>Faculty Lounge</td>
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<tr>
<td>Roof</td>
<td>40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Classrooms</td>
<td>40</td>
<td>1</td>
<td>Large Classroom; Small Classroom; Seminar Rooms</td>
</tr>
<tr>
<td>Storage</td>
<td>250</td>
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<td>Storage rooms</td>
</tr>
<tr>
<td>Stairs and exit ways</td>
<td>100</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Assembly areas and theaters</td>
<td>100</td>
<td></td>
<td>Auditorium</td>
</tr>
<tr>
<td>Lab</td>
<td>200</td>
<td>1</td>
<td>Instructional Labs</td>
</tr>
<tr>
<td>Other</td>
<td>50</td>
<td></td>
<td>Technical Support; Server Room</td>
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</tbody>
</table>
Big Idea 1: Bird

Concrete

Steel

<table>
<thead>
<tr>
<th>Lateral System</th>
<th>STEEL</th>
<th>CONCRETE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shear Wall Cores</td>
<td>Shear Wall Cores</td>
</tr>
<tr>
<td>Cantilever Solution</td>
<td>Tappered I-beam; Diagonal Bracing</td>
<td>Pre-stressed Composite Slab</td>
</tr>
</tbody>
</table>
Big Idea 1: Bird - Concrete

Stiffness center: heart
Radial Frame: artery
Shear Wall: muscle

Strong bird in all directions
Concrete | Basement

Typ. Section Dimensions
- Beam: 10” x 24”
- Comp. Slab: 8”
- Shear Wall: 12” thick
- Column: φ2’
Concrete | Third Floor
A SE MEP CM LCFM

Typ. Section Dimensions
- Beam: 10” x 24”
- Comp. Slab: 8”
- Shear Wall: 12” thick
- Column: φ2’
Typ. Section Dimensions

- **Beam**: W 16 x 36
- **Comp. Slab**: 6"
- **Shear Wall**: 12"
- **Column**: W 14 x 96
- **Auditorium Girder**: W 32 x 50
STEEL OPTION
A SE MEP CM LCFM | Second Floor

Typ. Section Dimensions
- Vertical bracing column: W 24 x 68
- Cross Bracing: W 16 x 36
- Tapered Beam: Depth varies from 18'' to 21''
STEEL OPTION
A SE MEP CM LCFM | Vertical Load Path

Load
Reactions
STEELE OPTION
A SE MEP CM LCFM | Lateral Load Path

Lateral Force & Torsion
Resisting Component
STEEL CANTILEVER SOLUTION
A  SE  MEP CM  LCFM

Tapered I Beam

<table>
<thead>
<tr>
<th></th>
<th>Start Depth</th>
<th>End Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth</td>
<td>18''</td>
<td>12''</td>
</tr>
<tr>
<td>Depth</td>
<td>21''</td>
<td>16''</td>
</tr>
</tbody>
</table>

HSS 8 x 8 x ½ Diagonal Bracing
CONCRETE CANTILEVER SOLUTION

A SE MEP CM LCFM

Prestressed Slab

Composite Slab
SHADE STUDY

A SE MEP CM LCFM

March 10 am – 8 pm

June 8 am – 10 pm

December 11 am – 7 pm
SOLAR SHADING STRATEGIES

- External solar shading
- Landscaped shading - surrounding trees
- Electronically tintable glass for classroom/auditorium windows
OPTION # 1 – WATER BASED SYSTEM
A SE MEP CM LCFM

Radaint ceiling cooling panels

DOAS (dehumidification of outdoor air)

Underfloor air distribution

PRO

CONS

Cooling evenly distributed
Condensation problems

Installations are hidden
High installation cost

Lower ceiling height

Displacement ventilation

Diagram showing air handling unit (AHU) and PV panels with air supply, return, and chilled water.
OPTION # 2 – AIR BASED SYSTEM

A SE MEP CM LCFM

VAV system delivers air and cooling

DOAS system (Dehumidification of outdoor air)

VAV system overhead distribution

PRO

Humidity control

Simple solution

CONS

High electricity costs

More ductwork

Displacement ventilation
AIR DISTRIBUTION - DUCTING
A SE MEP CM LCFM

Ground floor

1st floor

2nd floor
INTEGRATION WITH STRUCTURAL SYSTEM
A SE MEP CM LCFM

PROBLEMS

- Penetration in W shape beams
- Opening in shear walls

SOLUTIONS
Concrete + Water based system

Steel/concrete + Air based system

Slab to slab height: 12'

Slab to slab height: 12'
BIG IDEA – THE AIR CUBE
A SE MEP CM LCFM

100' x 100'  x 3  + ATRIUM  +Cantilever  Green Facade
Purification of the AIR
AIR CUBE FLOOR PLANS
A SE MEP CM LCFM
AIR CUBE SECTION A-A
A SE MEP CM LCFM
AIR CUBE SECTION B-B
A SE MEP CM LCFM
AIR CUBE ELEVATIONS

A SE MEP CM LCFM

SOUTH ELEVATION

WEST ELEVATION

EAST ELEVATION
AIR CUBE VISUALIZATION
A SE MEP CM LCFM

ATRIUM
STRUCTURAL Challenges
A SE MEP CM LCFM

• **Big Atrium:** 30’x30’ out of 100’x100’ Rigid Floor Assumption Affected

• **Cantilever:** 10’

• **Hanging Facade:** Integration With Structural System
### Structural Systems

**Concrete**

**Steel**

<table>
<thead>
<tr>
<th>Lateral System</th>
<th>STEEL</th>
<th>CONCRETE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shear Wall</td>
<td>Shear Wall</td>
<td></td>
</tr>
<tr>
<td>Tapered I-beam; Diagonal Bracing</td>
<td>Pre-stress Composite Slab</td>
<td></td>
</tr>
</tbody>
</table>

**Diagonal Bracing**

**Composite Slab**
Typ. Section Dimensions

- Normal inverted T Beam: 18''
- P.T. Slab: 9''
- Shear Wall: 12''
- Long Span inverted T Beam: 21''
- Square Column: 24''
Typ. Section Dimensions

- Normal inverted T Beam: 18''
- P.T. Slab: 6''
- Shear Wall: 12''
- Long Span inverted T Beam: 21''
- Square Column: 24''
- Tapered cantilever beam: 21''
GRAVITY LOAD PATH
A SE MEP CM LCFM | Concrete

Mastan2 Structural Analysis
LATERAL LOAD PATH
A SE MEP CM LCFM

Lateral Force & Torsion
Resisting Component

120'
**VERTICAL LOAD INFO & MEMBER SIZE**

**Steel**

<table>
<thead>
<tr>
<th>Slab load</th>
<th>Roof load</th>
<th>Live load</th>
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</thead>
<tbody>
<tr>
<td>100 psf</td>
<td>40 psf</td>
<td>40 psf</td>
</tr>
</tbody>
</table>

- **Corner Column**
  
  
  \[(100 \times 2 \times 1.2 + 40 \times 1.6) \times \frac{35}{2} \times \frac{20}{2} = 53.2k\]

  Floor 1,2: W24X207

  Floor 3: W24X162

- **Center Column**
  
  \[(100 \times 2 \times 1.2 + 40 \times 1.6) \times \frac{20}{2} \times \frac{20}{2} = 30.4k\]

  Floor 1,2: W21X147

  Floor 3: W21X101

- **Beam**

  W 21 X 68
SYSTEM PERFORMANCE | STATIC

Frame Moment distribution

Column Axial Force

Slab Stress distribution

Wall Stress distribution
## SYSTEM PERFORMANCE | DYNAMIC

A SE MEP CM LCFM | Steel

<table>
<thead>
<tr>
<th></th>
<th>Without Taper Rib</th>
<th>With Taper Rib</th>
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<tbody>
<tr>
<td><strong>Mode 1</strong></td>
<td><img src="image1" alt="Diagram" /></td>
<td><img src="image2" alt="Diagram" /></td>
</tr>
<tr>
<td><strong>Mode 2</strong></td>
<td><img src="image3" alt="Diagram" /></td>
<td><img src="image4" alt="Diagram" /></td>
</tr>
</tbody>
</table>
Steel Floor Plan

A SE MEP CM LCFM | Big Idea 2: Cube | Steel

Typ. Section Dimensions

- Beam: W 21x 68
- Comp. Slab: 8''
- Shear Wall: 12''
- Column (Center): W24X 207->162
  (Corner): W21X 147->101
LATERAL & TORSIONAL RESISTANCE SYSTEM

Steel

Resistance in y-direction

Resistance in x-direction

Torsion Resistance
To sustain soil pressure

Retaining Wall

Column

12'

$A_{min} = \frac{P_{col}}{\beta_{soil}} = \frac{53.2k}{5ksf} = 10.64 \text{ ft}^2$

$A_{footing} = 4 \times 4 = 16 \text{ ft}^2 > A_{min}$
INTEGRATED FAÇADE (Air Challenge)

Initial Idea (Leaf + air purify) → 2/19 Crit → Prefabricated Panels

20’

Grasshopper to generate geometry

Python programming for parametric design
FUTURE DEVELOPMENT

Decouple Façade System as Non-structural
- Light Structure Air cube
- Patterned voronoi with various arrangement

CNC Prefabricated Voronoi Panels easy to replace

Solar Façade Panel  Air Purifying Facade
SMART BUILDING SYSTEMS
A SE MEP CM LCFM

Lighting control
HVAC systems
Weather data
Monitoring
Security
Efficient maintenance
Safety
SHADE STUDY
A SE MEP CM LCFM

March 10 am – 8 pm
June 8 am – 10 pm
December 11 am – 7 pm
OPTION # 1 – PASSIVE VENTILATION
A SE MEP CM LCFM

- Passive ventilation with operable ceiling fans
- Controlled ecosystem in facade to dehumidify the air
- Displacement ventilation

PRO
- Use of passive strategy
- Less ductwork
- Lower electrical use

CONS
- Challenging to control

PV PANELS
PLANTS AS BIOFILTER

Improves aesthetical value

Improve microclimate and air quality

Local plants

Dehumidification of air

Students taking care of maintenance
→ decrease vandalism risk

Ficus Rubber  Fern  Common Ivy  Sansiviera  Spider Plant
MECH. VENTILATED AREAS
A SE MEP CM LCFM

Underground level

Ground floor
OPTION # 2 – AIR BASED SYSTEM

VAV system delivers air and cooling

DOAS (Dehumidification of outdoor air)

VAV system overhead distribution

Displacement ventilation

PRO
Humidity control
Simple solution

CONS
High electricity costs
More ductwork
Lower ceiling height in offices

PV PANELS
AIR DISTRIBUTION - DUCTING
A SE MEP CM LCFM

Ground floor  1st floor  Intermediate  2nd floor

- AIR SUPPLY
- RETURN
- SHAFT
Concrete + Passive ventilation

Steel/concrete + Air based system

Slab to slab height: 10'

Slab to slab height: 10'
OFF SITE LOGISTICS

A SE MEP CM LCFM
EQUIPMENT

A SE MEP CM LCFM

Site
- Esmo Gruas Hidraulicas
- BlueLine Rental

Cranes

Excavators and Man lifts
MATERIAL PROCUREMENT
A SE MEP CM LCFM

Materials
- Site
- Marxuach Precast Solutions
- Steel and pipes Inc.
- Acha Trading
- United Glass Co.
- Cemex
- Commercial Plastics Corp
- Tesoro en Maderas
Training of workers.

Water provided to improve health.

Construction Activity
Pollution prevention

Waste Diversion Plans

Traffic Management Plan
CONSTRUCTION PHASING
A SE MEP CM LCFM

Labs are located in the ground floor after coordination with A.

Façade on the side of user entry completed.

Temporary cooling provided for the labs.

Lab Areas cordoned off.

User Entry
Mech Room
Labs
Toilets
Ground Floor Plan

Construction Entry
Labs located on the ground floor.

Façade on the side of user entry completed.

Labs occupied by May 5th.

Temporary cooling provided for the labs.

Lab Areas cordoned off.
TARGET VALUE DESIGN
A SE MEP CM LCFM

Concrete Cube

Steel Cube

- A Substructure: 9%
- B Shell: 35%
- C Interiors: 4%
- D Services: 17%
- E Equipment and Furnishing: 2%
- F Specialty Construction: 11%
- G Building Sitework: 9%
- H General Conditions: 13%

- A Substructure: 9%
- B Shell: 38%
- C Interiors: 4%
- D Services: 20%
- E Equipment and Furnishing: 2%
- F Specialty Construction: 8%
- G Building Sitework: 6%
- H General Conditions: 13%
<table>
<thead>
<tr>
<th>BIRD</th>
<th>AIR CUBE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Concrete</strong></td>
<td><strong>Steel</strong></td>
</tr>
<tr>
<td>Water based cooling</td>
<td>Air based ventilation</td>
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<tr>
<td><strong>Location &amp; Transportation</strong></td>
<td><strong>Energy &amp; Atmosphere</strong></td>
</tr>
<tr>
<td>Sustainable Sites</td>
<td>Material &amp; Resources</td>
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<tr>
<td>Water Efficiency</td>
<td>Indoor environmental quality</td>
</tr>
<tr>
<td>Integrative Process</td>
<td>Innovation</td>
</tr>
<tr>
<td>Regional priority</td>
<td><strong>Total</strong></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
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<td>6</td>
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<td>10</td>
<td>10</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>Achievable Points</strong></td>
</tr>
<tr>
<td>53</td>
<td>110</td>
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<tr>
<td><strong>MAX.</strong></td>
<td><strong>MAX.</strong></td>
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</table>

| **Concrete** | **Steel** |
| **Passive ventilation** | **Air based ventilation** |
| **Achievable Points** | **Achievable Points** |
| Integritive Process | 1 |
| Location & Transportation | 16 |
| Sustainable Sites | 10 |
| Water Efficiency | 11 |
| Energy & Atmosphere | 33 |
| Material & Resources | 13 |
| Indoor environmental quality | 16 |
| Innovation | 6 |
| Regional priority | 4 |
| **Total** | **Achievable Points** |
| 56 | 55 |
| **MAX.** | **MAX.** |
RISK ANALYSIS
A  SE  MEP  CM  LCFM

- Hurricanes
- Earthquakes
- Vandalism
- Inflation & interests rates
- Material & resources input

LIKELY HOOD

IMPACT LEVEL

CONSEQUENCES
- Non availability/reduced availability
- Repair & Replacement costs
- Cleaning costs
- Delays
RISK MANAGEMENT
A SE MEP CM LCFM

TRADITIONAL RISK MANAGEMENT
- Looks at risks individually
- Silo-based processes

... NEW WAY OF THINKING
- Consider risk interaction
- Supported by a ‘risk culture’ in Team Island
- Neutralize risk – and even find profit in them
- Systematic, structured and timely RM

BENEFITS
- Reduce Risk Costs
- Consist Risk Management Decision
- Increased Transparency
RISK MANAGEMENT
A SE MEP CM LCFM

RISK

Earthquakes
Use of Base isolation & damping devices

Hurricanes
Hurricane Netting System

Vandalism
Security and surveillance cameras

STRATEGIES

Use of local materials

CHANCES

REDUCE RISK OF INTERRUPTION OF OPERATIONS
REDUCE REPAIR-/REPLACEMENT COST
REDUCE CLEANING AND REPAIR COST
REDUCE DELAYS

Material & resources input
LIFE CYCLE COST
A SE MEP CM LCFM

<table>
<thead>
<tr>
<th></th>
<th>LCC over 25 years</th>
<th>LCC per sf/year</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Mio. US$</td>
<td>US$</td>
</tr>
<tr>
<td>BIRD-</td>
<td>22.23</td>
<td>605</td>
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<tr>
<td>Concrete</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIRD-</td>
<td>22.75</td>
<td>618</td>
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<tr>
<td>Steel</td>
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<tr>
<td>AIR CUBE-</td>
<td>20.86</td>
<td>526</td>
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<tr>
<td>Concrete</td>
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<td></td>
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<tr>
<td>AIR CUBE-</td>
<td>21.36</td>
<td>539</td>
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<tr>
<td>Steel</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
STRATEGIES FOR OPTIMIZING LIFE CYCLE COST

A SE MEP CM LCFM

OPTIMIZE THE FINANCIAL STRUCTURE

COLLABORATION!!!

COMPARE ROOM SCHEDULE WITH REQUIREMENTS TO PROMOTE EFFICIENCY

GENERATE ADDITIONAL INCOME

LCFM

SE
CM
A
MEP
LCFM
SUMMARY - TARGET VALUES

A SE MEP CM LCFM

BIRD - Concrete

**CONSTRUCTION COST:**

$9,203,000

TVD

LCC

$22,230,000
SUMMARY - TARGET VALUES

A SE MEP CM LCFM

BIRD - Steel/concrete

CONSTRUCTION COST:

TVD

$9,564,000

LCC

$22,750,000
SUMMARY - TARGET VALUES
A SE MEP CM LCFM
AIR CUBE - Concrete

CONSTRUCTION COST:
$ 8,615,000

STV

LCC
$ 20,860,000
SUMMARY - TARGET VALUES

A SE MEP CM LCFM

AIR CUBE - Steel/concrete

TVD

CONSTRUCTION COST:

$ 8,813,000

LCC

$ 21,360,000

STV
STV PROGRESS
A SE MEP CM LCFM

1. Choice of material
2. PV Panels on roof
3. Team Target

STV evolution - CARBON (Kg CO2)

- Bird Concrete
- Bird Steel/Concrete
- Cube Concrete
- Cube Steel/Concrete
- Target

- February 29
- March 3rd
- March 6th
- WQ Presentation
- SQ Presentation
DECISION MATRIX
A SE MEP CM LCFM

OPTIONS

Bird Concrete
Bird Steel /C
Air Cube Concrete
Air Cube Steel /C

CRITERIA

1. Challenge Integration
2. Sustainability
3. Integrated Solution
4. Life Cycle Costs
5. Site Relations
6. Constructability
7. Concept Clarity
8. Flexibility & Adaptability
9. Aesthetic Value
10. Risk Management
11. Prefabrication & Modularization

DECISION
based on criteria which were defined & weighted in cooperation with the owners
DECISION MATRIX
A SE MEP CM LCFM

RATING BY OWNERS AND TEAM

<table>
<thead>
<tr>
<th></th>
<th>Reached Points</th>
<th>Ratio to max. points %</th>
<th>Annual Rent US$</th>
<th>Value for Cost* Points</th>
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</thead>
<tbody>
<tr>
<td>BIRD-Steel /C</td>
<td>187</td>
<td>47</td>
<td>910,000</td>
<td>41</td>
</tr>
<tr>
<td>BIRD-Concrete</td>
<td>192</td>
<td>48</td>
<td>880,000</td>
<td>58</td>
</tr>
<tr>
<td>AIR CUBE-Concrete</td>
<td>293</td>
<td>73</td>
<td>830,000</td>
<td>124</td>
</tr>
<tr>
<td>AIR CUBE-Steel/C</td>
<td>291</td>
<td>72</td>
<td>850,000</td>
<td>109</td>
</tr>
</tbody>
</table>

* = Ratio to max. x (1Mio. $ - Annual rent) / 100,000
WHY IS THIS OPTION THE BEST?

- Compact structure
- Rent: 830,000 US$/year
- TVD: 8,215,000 US$
- Integrated Design (Façade system)
- Air quality challenge
AIR QUALITY CHALLENGE
A SE MEP CM LCFM

Clean construction

Indoor environment

Air cleaning façade material
Thank you!

Renate, Owner, Mentors and many others...

WINTER CYBER PRESENTATION

NIRUPAMA KOTCHARLAKOTA
NATHAN HILL
ANNA BURISCH
CAMILA HERNANDEZ
CHRISTINE BAUMER
WENJIN SITU
LI DENG

3-11-2016