FL Polytechnic University – Innovation, Science & Technology Building

Flag Ship of the New College Campus

The Tulane Engineering Forum

Chris Christoforou, PE, LEED AP
Principal
Thornton Tomasetti

April 15, 2016
Project Introduction & Description

The Team - Santiago Calatrava

The Project

The Structure and the Innovative Special Features

- The Exposed Steel Cupola
- The Operable Louvers
- The Concrete Frame
- The Exterior Pergola
FL Polytechnic University – IST Building
Project Location

Lakeland, FL    Courtesy of Santiago Calatrava, LLC
The Team

Owner
Florida Polytechnic University

Design Architect
Santiago Calatrava,
Architect of record
Alfonso Arch

Contractor
SkanskaNuJak

Structural Engineer
Thornton Tomasetti

MEP Engineer
TLC Engineering

Steel Contractor/Erector
E&H Steel Corp.

Concrete Contractor
Liberty/Baker

Specialty Contractor
M.G.McGrath Inc.

Kinetics Consultant
Hardesty & Hanover, LLP

FL Polytechnic University – IST Building
The Project Team
FL Polytechnic University – IST Building Project Stats

Construction Cost: $98 Million (site development and building)
Building Construction Cost: $60 Million
Completion Date: 2014
Total Height when Louvers up: 129'-0"
Total Height when Louvers closed: 83'-0"
Number of Stories: 2
Building Area: 200,000 sf
FL Polytechnic University – IST Building
Working with Santiago Calatrava

- An Architect an Engineer and a Sculptor.
  - Architecture is Art
  - The site is the “canvas”
- The Structure **IS** the Architecture
  - Expose and showcase the structure
  - Often a “kinetic” element part of the project
- Nothing is left to Chance.
  - Modeling and.... more Modeling and Visualization
  - Extreme Attention to Detail and Proportions
  - Continuous Tweaking and Refinement
- Mock-ups:
  - Texture and Color of Concrete, Formwork Performance etc.
FL Polytechnic University – IST Building
Project Description

Building Cross Section
FL Polytechnic University – IST Building
Project Description

First Floor Plan
FL Polytechnic University – IST Building
Project Description

Second Floor Plan

- Office
- Commons
- Egress Stair
- Outdoor Terrace
Corridor Roof Plan
Low Concrete Roof Plan
FL Polytechnic University - IST Building Project Description

EARLY MORNING ON SUMMER DAY
FL Polytechnic University - IST Building Project Description

AT NOON ON SUMMER DAY

Diagram showing sunlight at noon on a summer day, impacting the building's design and structure.
FL Polytechnic University - IST Building
Project Description

LATE AFTERNOON ON SUMMER DAY
FL Polytechnic University – IST Building
Project Description

Operable Louver

HYDRAULIC CYLINDER

LOUVER ARM

PIPE LATERAL BRACING

STEEL STANCHION

CONDUITS AND PIPES

LOUVER FIN

LOUVER FIN

LOUVER ARM
Operable Louver
FL Polytechnic University - IST Building

Project Description

TT BIM Model - Isometric Overall Building
FL Polytechnic University – IST Building
Project Description

TT BIM Model- Transverse Section

- Cupola
- Concrete Roof
- Corridor Roof
- Outdoor Terrace
- Pond Wall And Bench
- Commons
Structure - Exposed Steel Cupola

It’s Function
• Supports the Glass Skylight
• Supports the Operable Louvers.

Development of Overall Shape
• The role of Innovative Tools
• Geometry
Structure-
Exposed Steel Cupola
Structure-Exposed Steel Cupola

Rib Profiles Studied

The image contains a diagram of a plate scheme and a truss scheme, along with a table of rib geometry. The diagram includes measurements and geometrical details relevant to the structural design of the cupola.
Structure-Exposed Steel Cupola

Final Rib Elevation
Grasshopper Model By TT
Structure-
Exposed Steel Cupola
Structure-
Exposed Steel Cupola

Cupola Rib Elevation and Plan View with Horizontal Bracing
Structure-Exposed Steel Cupola

Cupola Rib Base (Shoe) Connection

- BOTTOM PLATE OF ARCH FRAME SAME THICKNESS AS FLANGE OUTSIDE OF AREA OF BEARING
- POST INSTALLED NON-STRUCTURAL STEEL CLOSURE PLATES
- 3/4" PLATES IN LINE WITH VERTICAL FACES OF Arch FRAME
- 2" X 1" FITTED STIFFENER
- 7" X 1" FITTED STIFFENER
- 11" X 18" X 1.25" T BEARING PLATE BOTTOM PLATE OF ARCH
- 5/8" SOLE PLATE THICKNESS TO CLEAR BOLTS
- 5/8" SOLE PLATE THICKNESS TO CLEAR BOLTS
- 4-1/2" ANCHOR BOLTS
- CUPOLA TO SLIDE UNDERSELF WEIGHT
Structure-Exposed Steel Cupola

Analysis Model
Structure-
Exposed Steel Cupola

Field welded cupola steel arches.
Structure-Operable Cupola Louver

• Design-Built Contract

• Engineer’s Role
  • Develop Performance Criteria
  • Develop Geometry Constraints

• Contractor’s Role
  Detailing for Fabrication and Erection
  Verification of Performance Criteria
  Furnish Data for the Hydraulic System
Structure-Operable Cupola Louver

Study of the Moveable System

Central System with Moving Arch

Modeling Moving Arm
Structure-Operable Cupola Louver

Distributed System
Structure-Operable Cupola Louver

Wind Tunnel Test by Boundary Layer Wind Tunnel Laboratory

Figure 5c  Plan View of Partial Aerelastic Model of Louver System (Louver in "Up" Position) Showing Wind Angle Definition

(a) Louvers in "Down" Position

(b) Louvers in "Up" Position

Figure 6  Aerelastic Model in the Wind Tunnel Showing Louver Positions Tested
Criteria for Wind Load for Strength and Deflection:
Open for deflection 25 mph
Open for strength 40 mph
Locked down 110 mph

Evaluation of the Feather Structures of the Aluminum has been conducted by TT based on the following assumptions.

Assumption:

1) Back span to tied arch of 7.5'.
2) Distance from stanchion pivot to hydraulic of 3'.
3) Total peak combined deflection of L/60.
4) Wing deflections in cantilevered condition based on 25 mph service wind condition.
5) Wing strength in cantilevered condition based on 40 mph wind condition.
6) Wing strength and deflection in locked condition (leather down) base on 110 mph wind condition.
7) Material: 6063-T6 Alloy with $F_s = 15$ksi
Structure-Operable Cupola Louver

Performance Criteria by TT

Key Parameters Provided in Performance Criteria

Wind Load
Service Performance
Overall Member Geometry
Material Specification
Tonnage Estimate

Aluminum Feather Evaluation Summary
8-9-2011

USF - POLYTECHNIC
SKETCH: SK-5-R2
Structure-
Operable Cupola Louver

Louver Arm Profiles and Geometry

ZONE 1
ZONE 2
ZONE 3

HSS 18" x 1/8"

HSS 18" x 1/4"

HSS 18" x 1/4" w/ I-Shape
Structure-
Operable Cupola Louver

Operable Louver Arm Aluminum Extrusion

HEAVY EXTRUSION

HEAVY EXTRUSION WITH STIFFENERS

LIGHT EXTRUSION

SCALE 1/4

ALUMINUM IS NOT SHOWN FOR CLARITY

HYD CYLINDER CLEVIS DETAILS NEEDED

SECTION 4-A
SCALE 1/10

SINGLE PIECE FORMED RP
Structure-
Photo of Cupola Steel looking from the Commons
Structure
Photo of Cupola Steel looking from the Commons
Structure-
Photo of Cupola Steel looking from the Commons
Structure-
Photo of Louvers looking from the Roof
Structure-
Photo of Pistons and Louvers looking from the Roof
Structure—The Concrete Frame

It’s Function
• The “bones” of the Structure.
• Supports all Gravity and Lateral loads
• Collecting and Distributing these loads to the Foundations.

Series of Portal Frames

Attention to the Exposed frame
• The Details and Sequence of Construction
• Formwork techniques
• Concrete Design Mixes
Structure: The Concrete Frame

- 18"X48" WALL COLUMN
- 18"X96" WALL COLUMN
- STEEL CUPOLA RIB TYP
- ROOF CHORD REINF.
- ROOF DRAG REINF.
- "98'-0"

Thorton Tomasetti
Structure-The Concrete Frame

- Wall Columns
- Tie Beams Between Wall Columns
- Second Floor Framing
Structure -
The Concrete Frame

- Perimeter Column and Strip Footing
- Pond Retaining Wall
- Grade Beam
- Ring Beam Column and Footing
- Corridor Column and Strip Footing
Structure - The Concrete Frame

Typical Concrete Frame Section
Structure - The Concrete Frame

Construction Sequence - Stage 1
Structure - The Concrete Frame

Construction Sequence – Stage 2
Structure-
The Concrete Frame

Construction Sequence – Stage 3
Structure - The Concrete Frame

Construction Sequence – Stage 4
Structure-
The Concrete Frame

Construction Sequence – Stage 6
Structure-
The Concrete Frame

Concealed Construction Joint
Structure-
Photo of Cupola Steel looking from the Commons

Concealed Construction Joint
Structure-
Photo of Portals looking from Corridor
Structure-Photo of Portals looking through the Slot
Structure-
Photo of Lobby rakers looking from Lobby floor
Structure-
Photo of Lobby looking from grand stair
Structure-
Photo of Lobby looking from Lobby floor
Structure-The Concrete Frame

Expansion Joint in Second Floor Slab
It’s Function
• A Shading Element above the Outdoor Terrace

Folded Arches
• Spanning from the Pond wall to the Upper Roof.

Another Design-Built element
• Aluminum structure
Structure-
The Exterior Pergola

Architectural Model of the Exterior
Performance Criteria:
Wind load
Deflection criteria
Geometry of component
Material Specification

Structure - The Exterior Pergola

Analysis Model for Pergola by TT
Structure-
The Exterior Pergola

Pergola Detailing
Structure-Photo of Pergola from the upper Terrace
Structure-
Photo of Pergola from outside the front entry
Structure - Photo of Pergola Base from the Arcade
Structure - Photo of Building from the Cuseway
Aerial (Drone) Video

Courtesy Indie Atlantic Films/Vimeo Videos
Thank you!

Chris Christoforou, P.E.
Thornton Tomasetti
744 Broad Street
Newark, NJ 07102-3802
T 973.286.6100
F 973.286.6101