RETROFIT OF HISTORIC WAREHOUSE TO NEW MEDICAL CLINIC IN TULSA, OK

STRUCTURAL

TEAM 2010-5

JACQUELINE BAYER
JEFFREY DOWGALA
LIAM HENDRICKEN
LAUREN MCNALLY

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INTRODUCTION

ASCE CHARLES PANKOW FOUNDATION ANNUAL
ARCHITECTURAL ENGINEERING STUDENT COMPETITION

(Circa 1927)
PROPOSED NEW DESIGN
INTRODUCTION

ASCE Charles Pankow Foundation Annual
Architectural Engineering Student Competition

- GOALS
  - INNOVATION
  - SUSTAINABILITY

- DESIGN FOCUS
  - EXISTING STRUCTURE
  - MEDICAL CLINIC NEEDS
  - TORNADO SHELTER
  - TRIAGE CENTER
PROJECT REQUIREMENTS

- DISCIPLINARY COORDINATION
  - ARCHITECTURAL
  - CIVIL
  - STRUCTURAL
  - MECHANICAL

- HISTORIC PRESERVATION

- DEVELOP SAFE DESIGN
  - DERIVED FROM CODES AND GUIDELINES
  - TORNADO SHELTER
  - TRIAGE CENTER
Codes & Standards

- Multi-Disciplinary
  - IBC, 2006
  - IEBC, 2006
- Wind and Earthquake Loads
  - ASCE 7-05
- Concrete Code
  - ACI 318-08
- Tornado Shelter Requirements
  - FEMA 361
- Sustainability
  - LEED V3 2009
# Project Management: Design Process

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<th>Activity</th>
<th>Due</th>
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<td>Architectural Design</td>
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<td>Site Design</td>
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<tr>
<td>Structural Design</td>
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<td>HVAC Design</td>
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<td>Tornado Shelter Design</td>
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<td>Building Integration</td>
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<td>Budget</td>
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<td>Sustainability</td>
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<tr>
<td>Write AEI Report</td>
<td>34</td>
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<tr>
<td>Review Drawings and Report</td>
<td>33</td>
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<tr>
<td>Submit AEI Draft to Professor Mitchell for Review</td>
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<td>Submit Diesel Draft to Professor Mitchell for Review</td>
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<tr>
<td>Make Changes to AEI Report</td>
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<td>Final Report Due to AEI</td>
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<tr>
<td>Make Changes to Diesel Report</td>
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<tr>
<td>Create Diesel Presentation</td>
<td>3</td>
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<tr>
<td>Practice Diesel Presentation</td>
<td>3</td>
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<tr>
<td>Presentation</td>
<td>1</td>
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<tr>
<td>Diesel Written Report Due</td>
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<td>Voice Team Finals Week</td>
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<td>Break</td>
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</table>

- Architectural Design
- Site Design
- Structural Design
- Mechanical Design
- Tornado Shelter Design
- Building Integration
PROJECT MANAGEMENT: DESIGN PROCESS

Concept Design → Analytical Model → Proposed Design → Final Design

- Architectural Site
- Structural
- Mechanical
- Tornado Shelter
SITE

- **LOCATION**
  - Tulsa, OK
  - Brady Arts District

- **SIZE OF SITE**
  - ~1 acre

- **SITE USE OBJECTIVES**
  - Parking
  - Small Park
EXISTING SECOND FLOOR
COMPETITION PROPOSED FIRST FLOOR
FINALIZED FIRST FLOOR

Lobby Enhancement

Tornado Shelter

Fire Stair Tower
DESIGN GOALS & PRIORITIES

- TORNADO SHELTER DESIGN
- DETERMINE CAPACITY OF EXISTING STRUCTURE
- DESIGN NEW LATERAL LOAD RESISTING SYSTEM
- EXTERIOR WALL REHABILITATION
- STRUCTURAL RETROFITS FOR ARCHITECTURAL & MECHANICAL DESIGN
  - SLAB AND WALL PENETRATIONS
DESIGN CHALLENGES

- Tornado Shelter in an Existing Structure
- Accommodate Architectural Changes to Building Layout
- Collaborating with Mechanical Engineers
  - Protect the Mechanical Needs of the Tornado Shelter
- Different Methods of Analysis to Confirm Results
INNOVATIVE DESIGN

- 2-WAY CONCRETE SLAB
  - REVERSE ENGINEERING
  - CAPACITY ANALYSIS
- COMPUTER ANALYTICAL MODEL
  - SAP2000
  - CALIBRATED WITH HAND CALCULATIONS
ASSUMPTIONS

- **Maximum Capacities of 2\textsuperscript{nd} Floor and Roof** to be 250 psf and 70 psf, respectively.
- **Exterior Wall Composition and Details**
- **Existing Concrete Allowable Compressive Strength** 1,200 psi
- **Existing Reinforcement Steel**
  - Rebar Allowable Stress 16,000 psi
- **Drilled Pier Foundation System to Bedrock**
**Design Parameters**

- **Non-Tornado Shelter Design Wind Speed:** 90 MPH
  - Importance Factor 1.15

- **Tornado Shelter Design Wind Speed:** 250 MPH
  - Use ASCE 7-05 Pressure Calculations
SAP2000 MODEL

- Columns – Frame Elements
- Slabs – Shell Elements
- Column Capitals – Rigid Links
GRAVITY LOAD STRUCTURAL SYSTEM

- **Direct Design Method – Hand Calculation**

- **SAP2000 Computer Model within 20% of Hand Calculations**
gravity load structural system

- minimum area of steel adequate for demand
  - existing slab
  - existing columns
- slab reinforcement
  - #7’s at 6” o.c. for 2nd floor
  - #7’s at 9” o.c. for roof
- actual working stress capacity
  - pending field testing
  - second floor: 350 psf live load
  - roof: 175 psf roof live load
**Lobby Enhancement**

- **Remove second floor slab above lobby**
- **Effective column length increased**
- **No additional reinforcement needed for exterior columns**
- \( \rho_g < 0.01 \) All Cases
TORNADO SHELTER DESIGN

- Loads from FEMA 361 Guidelines and ASCE 7-05
- Design Wind Speed 250 MPH
- Loads Applied to Entire Structure
- Max Uplift on Roof ≈ 200 PSF
Tornado Shelter Design

- Computer Model (SAP2000) for Demand
- Roof Able to Withstand Tornado Wind Forces
  - Von Mises Stress Plot
  - Top and Bottom Rebar Near Column Capitals
Uplift Capacity

- Soils and Foundation System
  - Geotechnical Engineering Report Provided
- Uplift Capacity Limited Due to Low Skin Friction From Clay Soil
- No Net Uplift Forces
**Tornado Shelter Wall Design**

- **Walls Between Columns**
- **Shear Walls: 8” Grouted Masonry Infill**
  - Walls with #6 @ 24”
- **Penetrations**
  - 6 Doors
  - 1 Elevator Door
  - 2 - 18” x 18” Louvers
**Exterior Wall Rehabilitation**

- **Exterior Masonry To Remain**
- **New Backup Wall Designed**
- **Two-Types of Walls**
  - **Shear Walls**: 8” grouted masonry infill walls with #6 @ 24”
  - **4-1/2” Deep Steel Studs with 12 Gauge Wall Thickness AT 16” O.C.**
Lateral Load Resisting System

- Tornado Shelter Walls Designed as Shear Walls
- Center of Rigidity Matches Center of Gravity
  - Reduce Torsional Effects
SUSTAINABILITY

- LEED V3 2009
  - Silver Certification (55 Points)
- Existing Building
  - Material Conservation
- Recycled Construction Materials
## Client Budget

<table>
<thead>
<tr>
<th>Budget</th>
<th>Cost</th>
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<tbody>
<tr>
<td>Construction</td>
<td>$3,227,825</td>
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<tr>
<td>Furnishings</td>
<td>$775,000</td>
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<tr>
<td>Design</td>
<td>$330,000</td>
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<tr>
<td>Permitting Fees</td>
<td>$10,000</td>
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<tr>
<td>Lawyer &amp; Bond Costs</td>
<td>$50,000</td>
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<tr>
<td>Site Acquisition</td>
<td>$0</td>
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<tr>
<td><strong>Total:</strong></td>
<td>≈ $4,400,000</td>
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</tbody>
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INTEGRATION AND COLLABORATION

- **COORDINATION**
  - Architectural, Structural, Mechanical, etc.
- **TORNADO SHELTER**
- **NEW BACKUP WALL CONSTRUCTION**
- **BUILDING INFORMATION MODELING: REVIT 2010**
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