SOLUTIONS FOR THE BUILT WORLD

Lee County Courthouse
“Cathedral of the Prairie”

Restoration of Historic Concrete and Masonry Structures
Significant Problems

- Constructed in 1900
- Reportedly Underpinned with Concrete Footing in 1911
- Repairs in 1979
- Restored in 2001-2004 via the Texas Historical Commission’s Courthouse Program
  - Site Drainage Repairs
  - Steel Tension Tie Straps around Portico Walls
  - Balcony Repairs
- WJE Assessment in 2008
Foundation Plan

- Shallow, Unreinforced Masonry Spread Footing
- 6-Wythe Masonry Wall
- Supporting 37 Feet of 4-Wythe of Masonry Wall
Typical Floor Plan

- Central stair
- Connecting Arches
Second and Third Floor Plan

- Grand Courtroom
- Balcony
Structural System

- Typical Masonry Walls
- Reinforced Cindercrete Slabs w/ Integral Beams and Joists
  - Joists
    - 4-inch Channels with Upturned Legs
    - Slight Arch
  - Beams
    - 12-inch Deep I-Shapes Embedded in Cindercrete
  - Supported at Ends
    - Load Bearing Walls
    - 12-inch I-Shapes for Longer Spans
Cracking of Masonry & Finishes

West Elevation

Background  Assessment  Repair Approach  Conclusions
Out-of-Plane Walls

Background

Assessment

Repair Approach

Conclusions
Out-of-Plane Walls

Survey Data: Southwest Portico Elevation

<table>
<thead>
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<th>Relative Height on Wall (ft.)</th>
<th>Relative Out-of-Plane Deflection (in.)</th>
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Background  Assessment  Repair Approach  Conclusions
Geotechnical Investigation

- Fat Clay Soil on Site
- Plasticity Index between 32 and 64
- *Medium to Very High* shrink/swell potential
- Varying Moisture Level and Liquidity Index between Interior and Perimeter
What is going on?

- Relatively Stable Central Core
- Perimeter Movement Due to Poor Drainage and Expansive Clay Soil
- Unreinforced Masonry Spread Footing Unable to Transfer Tensile Stresses & Differential Movement
- Uneven Settlement Causing Out-of-Plane Wall Movement
Challenges of Repair

• Registered Historical Landmark
  – Repairs Must Be Consistent with Secretary of Interior’s Standards
• Courthouse Open for Business
  – Noise, Vibrations, Safety, etc.
• Courthouse Employees Constantly Indicating Movement
  – Actual or Perceived??
• Accommodate Court Schedule
• Unforeseen Conditions
Real-Time Monitoring

- **Crack Gauges**
  - Simple / Effective
  - 6 Total Gauges / Monitored Periodically
  - Locations: All Floors

- **Remote Sensing System**
  - Real-Time Monitoring
  - LVDT Sensors
    - 2 at Attic (East & West)
  - Tilt Sensors
    - 2 at Attic / 2 First Floor Walls
Perimeter Foundation

- Drilled Shafts
  - 25-Feet Deep
  - Load Transfer to Brittle Masonry Footing?

- Spread Footing
  - Continuously reinforced concrete footing
  - Resist local shrinking and swelling
Continuous Spread Footing

Arching Action

Provision for continuous mortared masonry footing, TYP.

Existing masonry wall & stepped footing.

2" min. BASF LA-40, TYP.

T.O. MASONRY

2' CLEAR TOP & SIDES

T.O.S.C.

(12) #8 CONT. EQ. SPACED AT TOP & BOTTOM, TYP.

(2) #4 STIRRUPS CENTERED IN BEAM AT 10" O.C., TYP.

UNDISTURBED SOILS

#5 U-STIRRUP AT BOTTOM W/#5 STIRRUP CAP AT TC SPACED AT 10" O.C., TYP.

Background  Assessment  Repair Approach  Conclusions
“Leg and Leg” Approach

Excavate ➔ Dowels ➔ Lap Reinforcement ➔ Stirrups ➔ Placement ➔ Grout Strip

- **Background**
- **Assessment**
- **Repair Approach**
- **Conclusions**
“Leg and Leg” Approach

Excavation

Underpinning Reinforcement
“Leg and Leg” Approach

Cast Segments

Doweled Reinforcement

Background Assessment Repair Approach Conclusions
Grout Strip at Interface

2- to 4-Inch Grout Strip

Pump with Non-Shrink Grout

Bond to Masonry Footing
Exterior Corners

Background

Assessment

Repair Approach

Conclusions
1911 Concrete Underpinning
Step Transitions at 1911 Footing

**Background**

**Assessment**

**Repair Approach**

**Conclusions**
Voids in 1911 Footing
Voids in 1911 Footing

1. Temp. & Shrinkage Steel
2. Fill Void with Repair Material
3. Install New Underpinning

Background
Assessment
Repair Approach
Conclusions
Step Transitions at 1911 Footing

Step at curved portico

Step with voids

Background Assessment Repair Approach Conclusions
Exterior Corners

Shoring at Corner Segment

Corner Reinforcement

Background  Assessment  Repair Approach  Conclusions
South Wall Stabilization - Design

• Deflections / Lateral Load
• Mechanically Anchor Floor to Exterior Walls
  – Access to Main Elements (Core)
  – Locations – What Levels?
Tension Ties at Portico Walls?

- Need to Preserve Historic Finishes
- Want to Avoid Unsightly Repairs
- Steel Tie Rods with Plates or Straps?
- Steel Tie Rods Used at Upper Levels
Portico Second Level
Portico Roof Level

- Use Existing Steel I-Shapes as Tension Ties
- Anchor to Exterior Wall
- Use Concrete Beam at Interior Wall
Concrete Beam at Interior Wall

Background

Assessment

Repair Approach

Conclusions
Concrete Beam at Interior Wall

Background

Assessment

Repair Approach

Conclusions
Portico Roof Level

Background

Assessment

Repair Approach

Conclusions
Portico Roof Level

Background

Assessment

Repair Approach

Conclusions
Portico Roof Level

Background

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Successful Stabilization?

[Graph showing Total Crack Gauge Movement (mm) versus Date (Month-Year) with different gages representing various locations.]

- Gage B - Jury Bathroom
- Gage 1 - County Clerk
- Gage 2 - Northwest Portico (1st Floor)
- Gage 3 - Northwest Portico (2nd Floor)
- Gage 4 - North Office
- Gage 5 - Northeast Portico (2nd Floor)

Background
Assessment
Repair Approach
Conclusions
Conclusions

- Concrete Provided Unique Benefits for Repair
- 1911 vs. 2011 Concrete Underpinning
- Integral Concrete Beam to Stabilize Wall