Structural Analysis and Redesign of
Lynde and Harry Bradley School of Technology & Trade
Milwaukee, Wisconsin

Jon Hill – Structural Option

Spring 2005 Senior Thesis
Presentation Outline

- Background Information
- Proposal
- Structural Redesign
- Façade Analysis
- Construction Study
- Conclusions
Background Information

Project Team

Owner:
Lynde and Harry Bradley Technology & Trade School Commission

Occupant:
Milwaukee Public Schools

Architect:
Hammel Green & Abrahamson, Inc.

Structural / Plumbing / Electrical Engineer:
Hammel Green & Abrahamson, Inc.

HVAC Engineer:
IBC Engineering Services, Inc.

Construction Manager:
Hunzinger – Clark Joint Venture
Background Information

Project Description

Function: High School

Size: 280,000 SF

Stories: 5 Total
   (1 below grade / 4 above grade)

Cost: $50 Million

Site Location

4th & National
Background Information

Project Description

Function: High School

Size: 280,000 SF

Stories: 5 Total
(1 below grade / 4 above grade)

Cost: $50 Million

First Floor
Background Information

Project Description

Function: High School

Size: 280,000 SF

Stories: 5 Total
   (1 below grade / 4 above grade)

Cost: $50 Million

Second Floor
Project Description

Function: High School

Size: 280,000 SF

Stories: 5 Total
(1 below grade / 4 above grade)

Cost: $50 Million

Third Floor
Background Information

Project Description

Function: High School

Size: 280,000 SF

Stories: 5 Total
(1 below grade / 4 above grade)

Cost: $50 Million

Fourth Floor
Background Information

Architecture

Expresses State-of-the-Art Technology

Flexible Design to facilitate current and future technologies

Green Design Concepts

  Natural Daylighting
  Recycled Building Materials
  Energy-efficient steam heating/cooling System

Barrel Vault Roof

  Spans over 100 feet
  Supported by tension cables & smartbeams
Background Information

Existing Structure

Cast-in-Place Concrete

Spread Footings

Square Columns
16” – 24”

Pan & Joist System
32’ x 30’ bays
20” pan depth / 5” joist width
5” slab

Open Web Steel Joists
Flat Roof / Barrel Vault Roof

Jon Hill – Structural Option
Bradley Tech High School
## Proposal

| Structure Redesign: | Design an acceptable structural alternative |
| Façade Analysis:   | Investigate a new façade design               |
| Cost & Constructability Comparison: | Evaluate alternate system                       |
| Project Criteria: (design goals) | Limit impact on exterior architecture |
|                     | Minimal change to interior environment        |
|                     | Provide a usable alternate structural system  |

Jon Hill – Structural Option

Bradley Tech High School
Structural Redesign

Option 1
Cast-in-Place Two-Way Slab with Drop Panels
  Good for square bays
  System not used efficiently due to its depth and weight

Option 2
Composite Steel System
  Fits any floor plan
  Easy to construct
  Main members need to be fireproofed

Steel System was chosen
Structural Redesign

Design Criteria

- AISC LRFD 3rd Edition Specifications
- Original design loads used
- Column / Foundation layout unchanged
- RAM Structural System used for design
- Vaulted Roof Modeled in RISA and supporting loads placed on RAM model

Size Restrictions

Columns
- 16x16 W14
- 20x20 W18
- 24x24 W21

Beams
- Maximum System Depth of 25”
Structural Redesign

Gravity Design

Composite Deck
  Floor: Vulcraft 1.5" VLR Steel Deck (21 gage) – 4½" Concrete Cover
  Roof: Vulcraft 3” Roof Deck (18 gage)

RAM Model Created
Structural Redesign

Gravity Design Layouts – 2nd Floor
Structural Redesign

Lateral Design

ASCE 7-02 Specifications

System that allows gravity loads and lateral loads control

Limit Drift to H/400

Barrel Vault Roof resists applied lateral loads internally

Initial Design based on drift analysis

Frames limited to interior spans
   Braced elements interfere with open floor plan
Structural Redesign

Lateral Design

Frame Layout Reduces Building Torsion

Jon Hill – Structural Option

Bradley Tech High School
Structural Redesign

Lateral Design

North / South Direction
Simple Moment Frames

East / West Direction
Standard Braced Frames
Braced Members within Moment Frames
Structural Redesign

Lateral Design

Braced Members within Moment Frame
Structural Redesign

Checks

Stress Check
  RAM Frame
  Frame members increased due to stress values

Gravity Connection Check
  User Entered Data (HGA)

Lateral Connection Check
  Ram Frame

Final Drift Analysis
  Story Drift << H/400
  Building Drift << H/400
Structural Redesign

Results

Steel Gravity System
  Effectively frames floor openings
  System depth acceptable

Combination Lateral System
  Resists applied forces
  Reduces building torsion
  Maintains open floor plan
Façade Analysis

Original Façade
One-wythe brick face supported by concrete backup

Supported by angles tied into concrete on each level

Alternate Façade
One-wythe brick face
with steel stud backup

Supported by angles tied into edge beams on each level
Façade Analysis

Investigation

Façade Problems

- Poor flashing / waterproofing design
  - water penetration to interior of building
  - corrosion of anchors or steel stud system
  - deterioration of gypsum sheathing

- Poor or missing flashing at windows or other penetrations

Damage to system
- brick damaged by freezing water
- mildew damage
Façade Analysis

Investigation
Design / Construction Considerations

- Match the durability of waterproofing and flashing to that of the other wall components.
- Protect the water sensitive gypsum sheathing by use of waterproofing.
- Provide through-wall flashing and weep details at each floor level.
- Maintain a wall cavity
- Prevent condensation and air flow inside the stud wall.
- Coordinate the various trades needed to install the wall and its flashing.
- Windows and doors must be tied into weather barrier and the exterior face of the wall.
# Construction Study

## System Comparison

<table>
<thead>
<tr>
<th>System</th>
<th>Total Cost</th>
<th>Construction Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete</td>
<td>$2,878,591</td>
<td>186 Days</td>
</tr>
<tr>
<td>Steel</td>
<td>$2,158,904</td>
<td>148 Days</td>
</tr>
<tr>
<td>Savings</td>
<td>25%</td>
<td>25.7%</td>
</tr>
</tbody>
</table>

Cost and Construction Time decreased by ~ 25%

Jon Hill – Structural Option

Bradley Tech High School
Conclusions

Met Design Goals
  Limited impact on exterior and interior architecture

Alternate Steel System
  Not a better design but equally as effective
  Could save at most 25% of cost and construction time

Able to create a professional design that is a viable option for Bradley Tech
Acknowledgements

Thank You

Professionals
Gordon Pierce
Mathew Mikolainis
Jeff Millmann
Dean Rutila
Peter Nelson
Craig Allender
Andreas Phelps

Thesis Advisor
Dr. Linda Hanagan

Peers
Kara Prince
Ashley Byrne

Thesis Supervisors
Kevin Parfitt
Jonathan Dougherty

Jon Hill – Structural Option

Bradley Tech High School
Questions ?