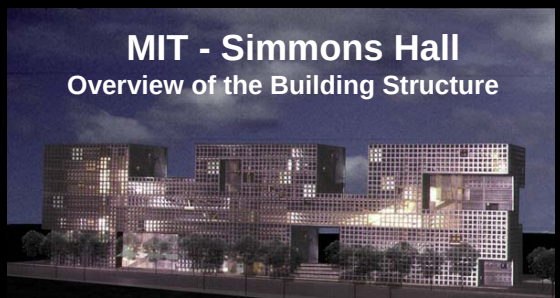
MIT - Simmons Hall
Overview of the Building Structure



James C. Parker, PE
Amy T. Stern, PE
Simpson Gumpertz & Heger

Wednesday September 24, 2003

Presentation Overview:

- Background & General Information:
  - Project Design Team & Construction Team
  - Architectural Features & Vision
  - Building Statistics
  - SGH's Role in Project
- Structural Design & Construction Issues:
  - Foundations
  - CIP Concrete Slabs, Beams, Walls, Elevators & Stairs
  - Exterior Precast Concrete Walls
  - Construction Scheduling
  - Special Inspections
- Questions & Answers

Project Design Team:

Owner: Massachusetts Institute of Technology - MIT (Cambridge, MA)

Consulting Project Managers: Casali Group (Cambridge, MA)

Design Architect: Steven Holl Architects (New York, NY)

Associate Architect: Perry Dean Rogers & Partners (Boston, MA)

Structural Engineers: Guy Nordenson and Associates (New York, NY)

Structural Engineers of Record: Simpson, Gumpertz & Heger (Watham, MA)

MEP Engineers: Ove Arup & Partners (Cambridge, MA)

Geotechnical Engineers: Haley & Aldrich (Boston, MA)

Civil Engineers: SEA Consultants, Inc. (Cambridge, MA)

Project Construction Team:

Construction Manager: Daniel O'Connell's Sons (Waltham, MA)

Concrete Subcontractor: S&F Concrete (Hudson, MA)

Rebar Subcontractor: Bart & Lund

Concrete Supplier: Aggregate Industries (Saugus, MA)

Precast Concrete Subcontractor: Bolduc (Quebec City, Quebec, Canada)

Precast Erector: Daniel Marr, Inc.

Special Inspections & Materials Testing Services:

Simpson Gumpertz & Heger (Arlington, MA)

Thompson & Lichtner Company, Inc. (Cambridge, MA)

"Community"

Even before ground was broken, *Progressive Architecture* magazine recognized Simmons Hall for the inventive ways in which it promotes community.

Excerpted from MIT website

"Openness"

"Open" is the word that was volleyed across the table most often in the extensive community-wide planning discussions for the newest undergraduate dormitory, Simmons Hall. And open it will be. Open to light and air, open to undergraduate and graduate students, open to faculty and artists-in-residence who will live, work, eat, study, and be entertained within its dynamic spaces.

Excerpted from MIT website

"Sponge Concept"

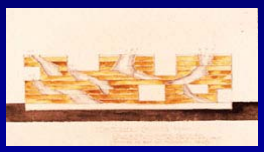
- "The residence is envisioned as part of the city form….with a concept of 'Porosity'."
- "The Sponge concept..transforms a porous building morphology via a series of bio-technical functions.

As written in SHA Schematic Design Narration

"The Lungs"

- "Air drawn up through main "Lungs" via slow RPM fans operated by roof top photovoltaic cells…."

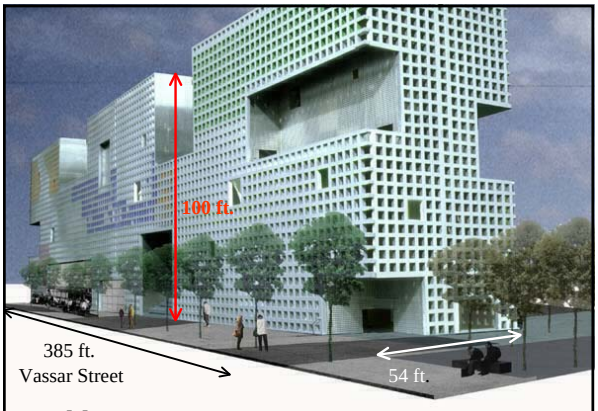
As written in SHA Schematic Design Narration



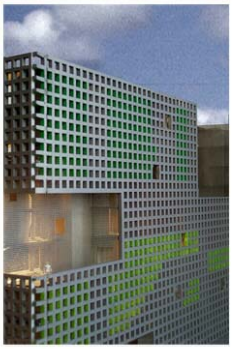
Building Statistics:

- The dorm contains 350 student beds:
  - 253 single and double rooms
  - 17 suites for housemaster, assistant housemaster, visiting scholars and graduate resident advisors
- Approximately 180,000 square feet
- Construction schedule of 22 months
  - Groundbreaking: November 2000
  - Occupancy: September 2002

Site 229-243 Vassar Street



Building Dimensions:



Terraces

SGH's Roles:

- Engineer of Record
- Developed and designed foundation solution for difficult site
- Led design development of "Perfcon" exterior frames.
  - Resolved critical detailing issues
  - Studied constructibility
  - Studied alternate material solutions (VE session)
  - Developed means and methods of analysis and design
- Provided construction documents and specifications
- Full-time engineering site presence, special inspections and construction administration
- Facade consulting, peer-review and water testing

Simmons Hall – Structural Design & Construction Issues

Foundations, CIP Concrete, PC Wall Panels, Scheduling, Special Inspections, & Exterior Cladding

Foundation & Sitework Issues:

- Concern: Approx. 200' soft compressible Boston Blue Clay underlying the project site:
  - Differential settlements
  - Heave during excavation
- Solution: Floating Mat "Raft" Foundation
  - Pre-construction soil stresses = post-construction soil stresses (ie. weight of soil = weight of building)
  - Finite Element software package used to Analyze/ Design Mat Foundation to prevent differential settlements

Foundation & Sitework Issues - Cont':

- Water Table:
  - Mat foundation approx. 10' below water table
  - Dewatering wells used to keep excavation dry until basement was complete
- Proximity to Working Railroad Tracks
  - Excavation Shoring to prevent settlement of tracks
  - Sheet Piling around perimeter of site with cross-lot bracing
- Contaminated Soils
- Bad Weather

Looking East Down Vassar St. 20 October 2000

Sitework:

Looking West Along Vassar St. 7 November 2000

Foundation Work:

Casting Mud Mat
15 December 2000

Application of Waterproofing
5 January 2001

First Pour of 4' Mat Foundation
18 January 2001

Mat Foundation

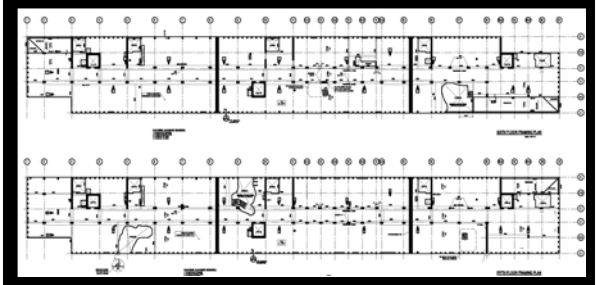
Stay-In-Place Form

January & February 2001:
Bad Weather Causes
Project Delays

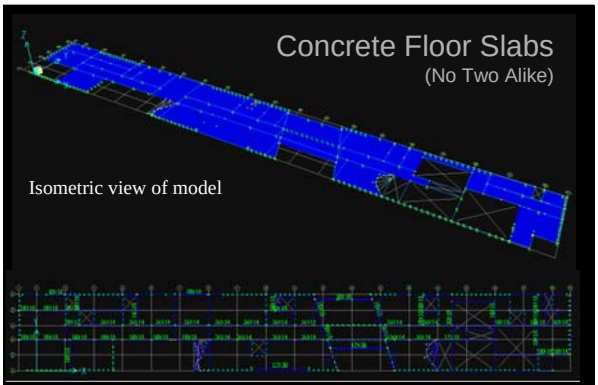
Cast-In-Place Concrete Floor Slabs & Beams

- Slabs span predominantly North-South (3 span condition)
  - 9" slabs in outer bays
  - 6" slabs in corridor to accommodate MEP in ceiling
- Must accommodate atrium voids and numerous MEP openings
- Analysis/Design using FEM software package
  - "SAFE" - Efficient Design of Complex System

Concrete Floor Slabs:



Concrete Floor Slabs
(No Two Alike)

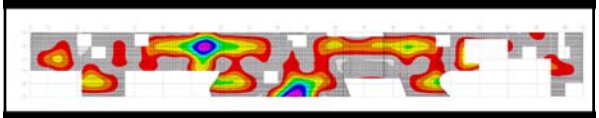


Isometric view of model

Plan view of model

Safe Model of Floor Slab

Judicious use of state-of-the-art software aids in design……



Safe model- output of slab deflections.

Safe Model Deflections

CIP Floor Slabs

Pour #3 1st Floor Slab
9 May 2001

Typical Reinforcement

CIP Floor Slabs

2nd Floor - Pour #1
29 May 2001

3rd Floor- Pour #1
10 July 2001

CIP Floor Slabs & Beams

5th Floor - Looking
West Down Corridor

Atrium #5D

Lateral Load Resisting Systems:

- Transverse Direction:
  - CIP Reinforced Concrete Shear Walls:
    - 3 Elevator Cores (10'x10'x128')
    - 6 - 11" thick x 20' Long Shear Walls x 118' tall
  - East and West Exterior Precast Walls
- Longitudinal Direction:
  - North and South Exterior Perfcon Walls
  - Intermediate Concrete Moment Frames on Interior Grid lines B & C

CIP Basement Walls

Interior Basement Shear
Wall & Columns

Exterior Foundation
Wall with Areaway

Elevator Core Walls in Basement

Elevator #2
Reinforcing Steel

Honeycombing in Elevator Boundary Element

CIP Shear Wall Detailing

Typ. Shear Wall Reinforcement

Boundary Element Abuts Precast Wall Panel

Architecturally Exposed Concrete Wall: B-B Plywood Form Finish

Architecturally Exposed Concrete Wall: Board-Form Finish

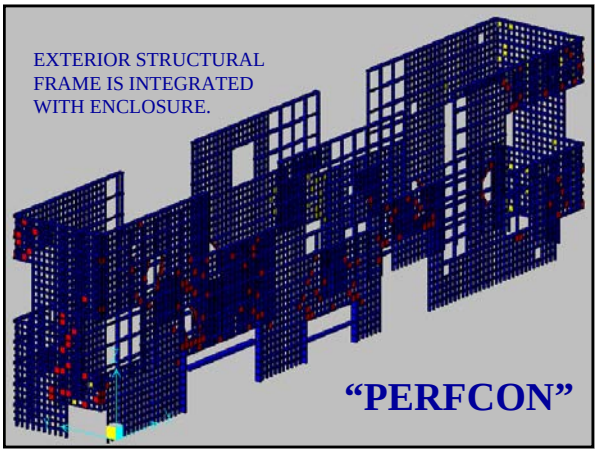
Finished Wall

Formwork

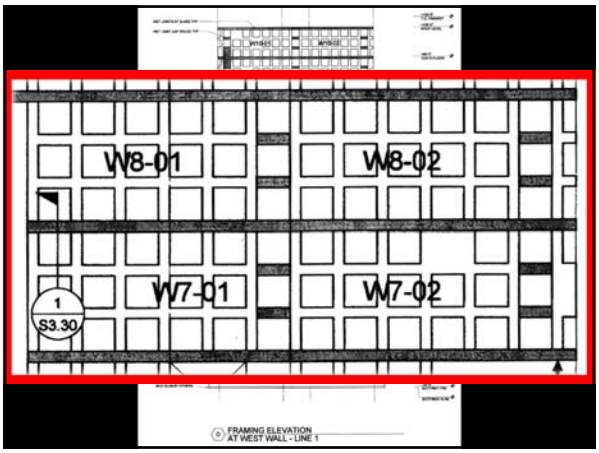
Precast Concrete Wall Panels

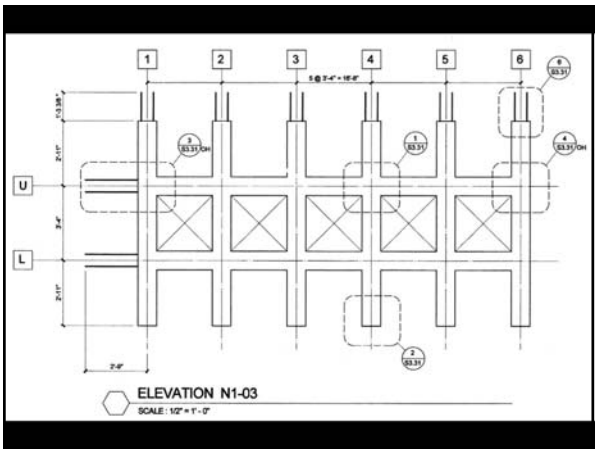
- Structural & Architectural Functions
  - Gravity and Lateral Load Resisting Systems
  - Interior Face is Architecturally Exposed
- Approx. 290 Panels Total (10 Stories)
  - Typically 10’ tall x 20’ long
- Vertical Connection:
  - NMB Splice Sleeve with 1” dry-pack joint
- Horizontal Connection
  - CIP Wet Joints with Barlock Couplers

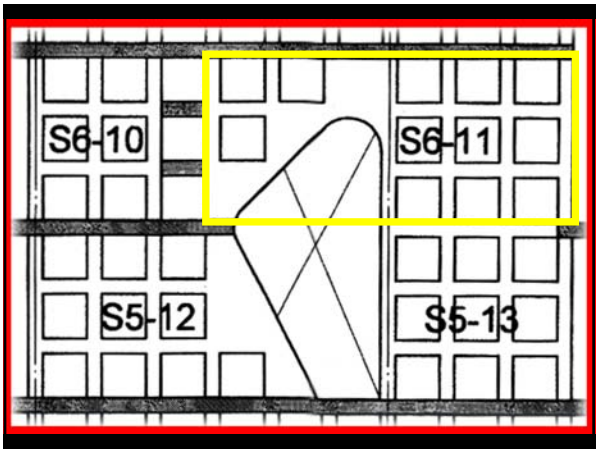
EXTERIOR STRUCTURAL FRAME IS INTEGRATED WITH ENCLOSURE.

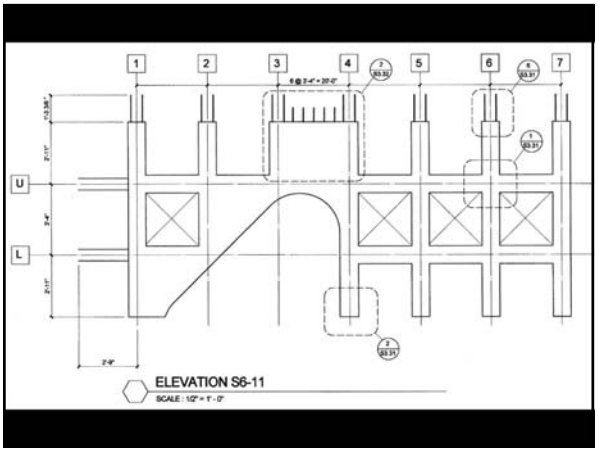


“PERFCON”









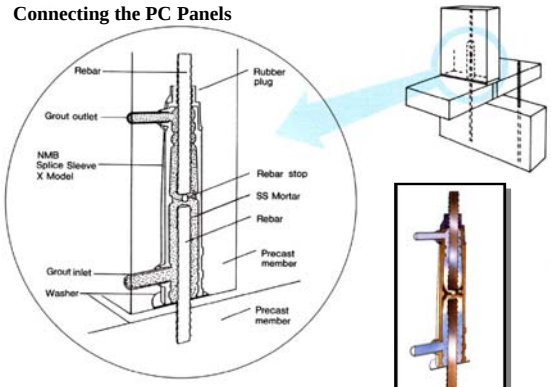
South Wall Elevation - Color Coded Rebar Sizes Based on Stress

Precast Concrete Panel Mock-Up

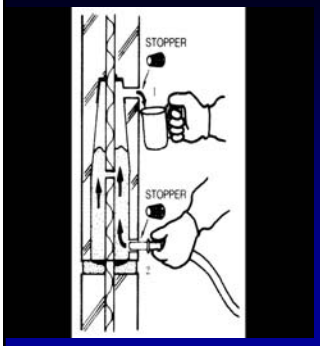
Precast Panel Production
October 2000

Erecting Panel
7 November 2000

Connecting the PC Panels



NMB Grout Sleeves



Grout Sleeve Filling

Tension Testing

Horizontal "Wet-Joint" Connection Alternatives

Typical Lap Splice

Dowel Bar Substitutes (Threaded Couplers)

Mechanical Couplers

Barlock Transition Couplers Used in Building #7 - #9 Rebar

ZAP Screwlok Coupler Used in Mock-Up

Testing Barlock Couplers:

Precast Concrete Wall Panels

Transportation

Storing PC Panels

Precast Concrete Wall Panels

Sinco-wilson sleeves to gain tolerance

Grouting & Dry-Packing

PC Erection

Miscellaneous Precast Concrete Elements

PC Long-Span Beams

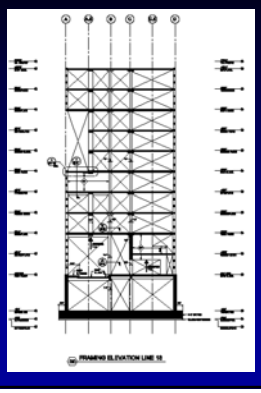
PC Prestressed Planks

PC Prestressed Bleachers

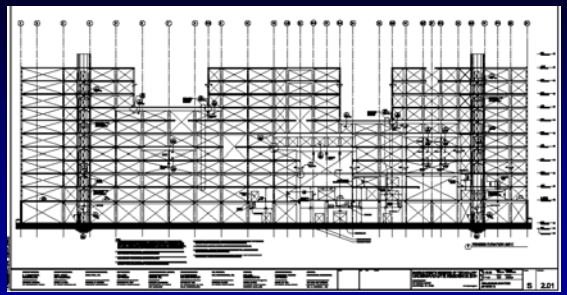
Interior Concrete Frames:

- Gravity Load Resisting System:
  - Several transfer beams for discontinuous columns
  - Vierendeel trusses used for long-span heavily loaded sections
  - Hangers used to suspend floors from transfers above
- Lateral Load Resisting System:
  - Intermediate Concrete Moment Frames resist lateral loads (wind and seismic) in longitudinal direction

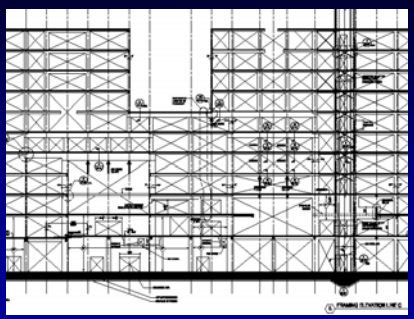
Transverse Building Section



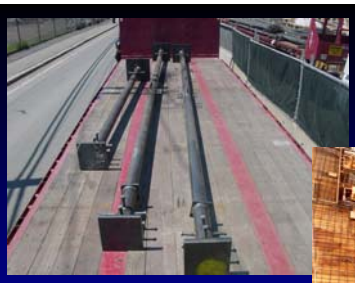
Interior Elevation - Grid Line C

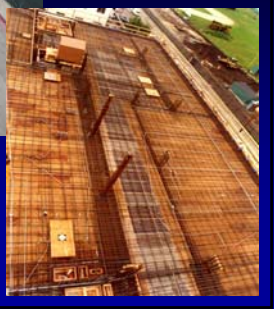


Interior Transfers on C-Line:



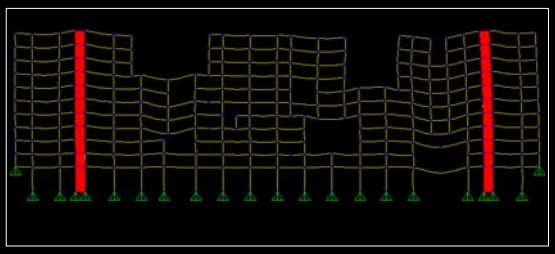
Steel Pipe Hangers





1 - Single-story hanger
2 - Two-story hangers

5th Floor - Pour #1
Top of 2-story hangers



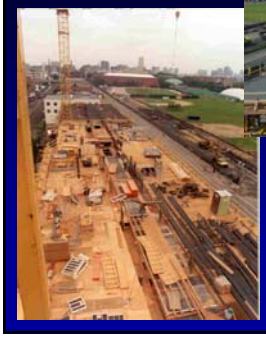
LONGITUDNAL BUILDING SECTION

Sap Model Frame Line B

Construction Schedule (DOC):

- Extremely Critical to MIT
  - Students MUST be able to occupy building in September 2002
- Schedule Established by DOC (Const. Mgr.)
  - Fast-Track Schedule - Critical Path Method
  - Bad Weather in Jan. & Feb. 2001 caused major delays
  - 9-Day Schedule per Floor to make up for delays
  - SGH full time site presence to resolve structural issues, perform inspections and answer RFI's immediately
  - Premiums paid for working Saturdays and overtime
  - Precast structure "topped-out" in November 2001
  - Majority of the interior fit-out completed in December 2002

Construction Schedule



<u>9-Day Schedule Per Floor</u>
1. Slab Formwork
2. Reinforcement (with MEP)
3. Cast Concrete Beams & Slab

Construction Schedule - Cont.

4. Erect Precast Wall Panels
5. Cast Walls & Columns
6. Repeat Steps 1 - 5

Special Inspections & Materials Testing

SGH Rebar Inspections

Thompson & Lichtner
Concrete Testing

CIP Atrium Stairs:

Atrium #2B

Atrium #1A

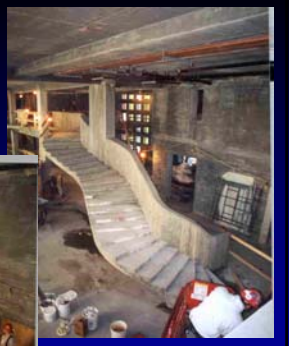
CIP Atrium Stairs:

Atrium #5B
Scissor Stair

Atrium #4A

The "Grand Stair"

Before



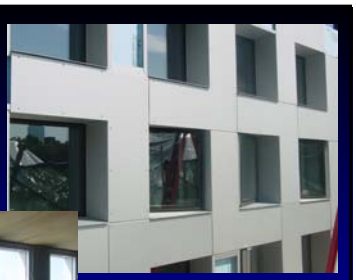
After

Exterior "Skin"

- Approximately 6,000 Windows
  - Large percentage are Operable
- Aluminum Cladding & Waterproofing System
  - Designed by Project Architects (SHA & PDR)
  - Peer Reviewed & Water-Tested by SGH
  - Tight tolerances for installation
  - Window jambs, heads and sills are colored to mimic stress contours in the precast wall panels
- Glass Curtain Walls
  - Dining Area & Night Cafe

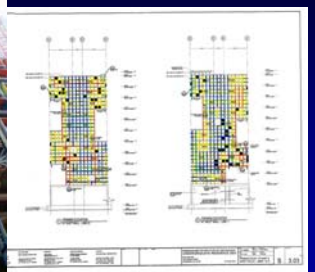
Mockup Room:

Interior Windows



Exterior Cladding

Exterior "Skin"




Completed
Exterior "Skin"


Grand Stair & Typical Hallway


Student Lounge


Questions?