Erie on the Park

Chicago, IL

THESIS PROPOSAL

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Timothy Moore
Pennsylvania State University
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Faculty Advisor:
Walt Schneider

Executive Summary

Building Description

Erie on the Park is a 25 story condominium complex on W. Erie St. in the River North District of Chicago, IL. This building utilizes primarily steel systems. The floor systems are open-web steel trusses and the lateral system consists of braced frames.

Proposal

Since residential high-rise buildings are typically constructed with concrete systems, this building is unique in using a steel structural system. I propose to redesign this building using a flat-plate system and shear walls to resist the lateral forces, while still maintaining the grace of the floor to ceiling windows and the dynamic floor plans that the architect had originally designed for.

Solution

To accomplish this I intend to investigate both a reinforced concrete and a post tensioned flat plate system with a shear wall core around the stair wells and elevators so that the tenants views are not obstructed by exterior shear walls. If this sear wall core does not perform adequately I will investigate integrating it with a slab-frame system.

Breadth Topics

In conjunction with the redesign of the building's structural system I plan to investigate the impact to the overall project cost, the construction schedule, and general constructability concerns with changing the system to concrete. I also plan to explore a couple of the criteria that would gain this building certification as a LEED Design. In doing this I will determine the effect to project cost and material and system selection.

Table of Contents

Introduction

'Erie on the Park' is a 25 story, 290' condominium complex in the River North neighborhood of Chicago, IL. These condos owned and maintained by Smithfield Properties LLC were designed by Lucien Lagrange, an Architecture firm native to Chicago. Lucien Lagrange then enlisted Thornton-Tomasetti to design the structural system and Wooton Construction to be the general contractors.

These condominiums are considered mid to high end real estate. They are located just north of downtown Chicago providing an easy commute for those tenants who work near the Loop. The building has such amenities as an on-site indoor parking garage, fitness center, and a 24 hour doorman. The individual units come equipped with such things as granite counter tops and handmade European cabinets. Most of the units have their own terraces and the floor to ceiling windows provide exceptional views of the city.

Background

Foundation

The foundation is made-up of hardpan caissons and grade-beams. The caissons are drilled up to a depth of 85'. This depth is required to find soil with a net bearing pressure of 30 KSF. The caisson shaft diameters range from 30" to 54" and the bell diameters range from 4' to 11'. The grade beams average about 36"x60" with the larges width being 72" and the greatest depth of 100". The grade beams frame into the caisson caps, which have a width 6" larger than their respective caisson and a minimum depth of 3'. The size of the caps would increase to the width and depth of the largest grade beam framing into them. These three structural elements have concrete with a 28 day compressive strength of 6000 PSI, and use deformed rebar in accordance with ASTM A615.

Columns

There are concrete columns from the ground level to the third floor, an overall elevation of 40'. These columns are either circular with a 30" diameter or rectangular with dimensions varying from 26" to 36" on each side. The circular columns are toward the southern end of the building where they are only framing into concrete slabs. The rectangular columns are towards the northern end of the building and frame into a steel mezzanine half way between the ground and second floor. The 28 day compressive strength of the concrete is 8000 PSI.

At the third floor the concrete columns transition to steel W-shapes that continue the remaining 250’ to the roof. The columns are ASTM A992 Grade 50 rolled W14 steel shapes. The largest columns are W14x257 and are part of the lateral system. The columns that are primarily part of the gravity system are W14x132’s at the third floor down to W14x61’s supporting the roof. These columns were generally erected in two story lifts, which are about 21’.

Floor System

The first through third floors have a two-way, flat-slab system. The first floor is slab-on-grade and ranges between 10” and 12” thick. The second and third levels both have 12” thick slabs with 12”x24” beams running in the N-S direction along column lines 3 and 4 from column line E to H. The rebar in these slabs and beams are epoxy coated and the beams have a 28 day compressive strength of 6000 PSI. The mezzanine levels and floors 4-6 have steel girders and beams with a partially composite slab on steel deck. The beams are typically W18x35 and span 26’-4” in the E-W direction and the girders are W16x26 and span 18’-8” in the N-S direction. The deck is 4-½” of normal weight concrete on 3” 18 gage composite steel decking reinforced with 6x6xW2.1xW2.1 WWF. The seventh through 25th floors are steel joist construction where 14K6 joists, 2’ O.C., span 26’ between W12x108 beams that span 26’-4”. A 2” slab on 0.6C26 non-composite steel deck with 6x8xW1.4xW1.4 WWF. The roof is comprised of W21x26 beams 8’-8” O.C. spanning 26’ between W12x96 girders. The girders in turn span 26’-4”. On top of the beams is a 3” 22 gage, hot dipped galvanized steel deck.

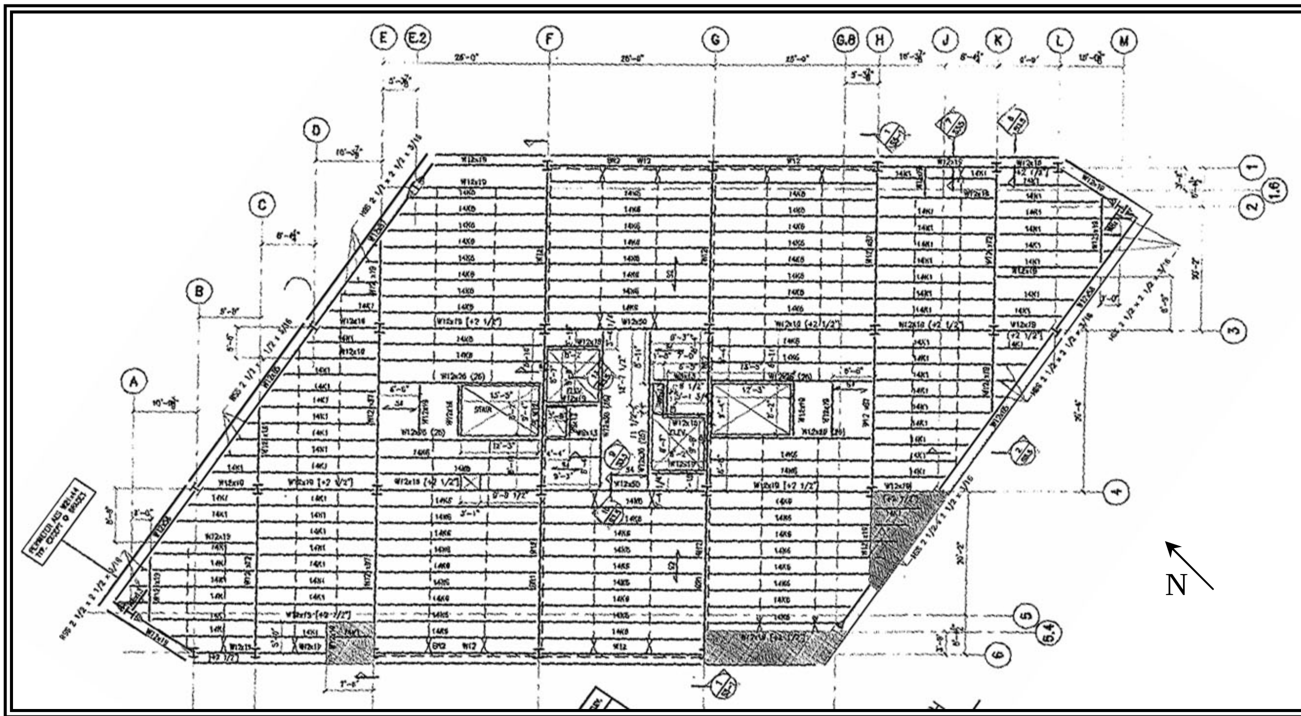

Figure 1: Typical Floor Plan

Lateral System

The lateral system between the ground level and the third level is comprised of cast-in-place concrete shear walls with a 28 day compressive strength of 8000 PSI. There are two 27’, 18” thick shear walls running in the E-W direction. There are three running in the N-S direction with lengths of 26’, 29’-4”, and 52’ which are also 18” thick. These walls resist the lateral loads transferred down from steel brace frames on the upper floors. The braced frames, made up of W8 and W10 shapes, distribute the shear load through large three story steel chevrons that can be seen in the building’s façade.

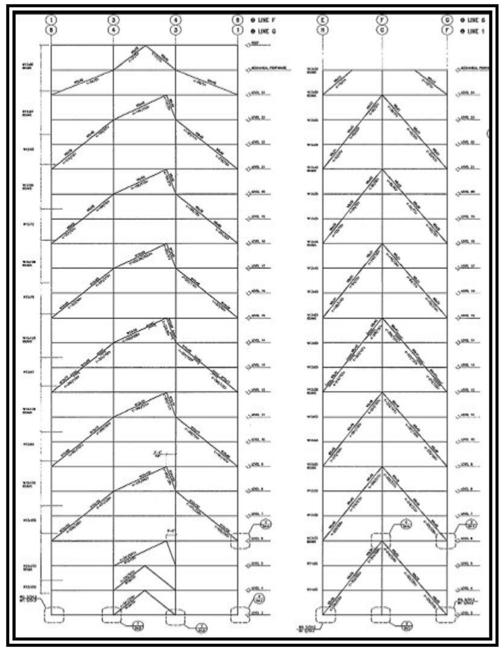

Figure 2: (Left) East-West Braces (Right) North-South Braces

Problem Statement

Due to the needs of the client, companies involved and their drive to provide quality products, the design of this building is the most efficient system for the requirements of this project. This was found to be true when investigating alternate floor systems for Technical Report 2 and checking the lateral systems against the wind and seismic loading prescribed in ASCE-7 02 for Technical Report 3. Because of this I intend to propose a material alteration of the structural system of both the gravity and the lateral systems from a steel system to a concrete system. In lieu of this alteration I will redesign the floor and lateral systems using concrete instead of steel and determine whether it is a more efficient system based on the criteria of overall cost, construction time, and serviceability. To do this I will use loads and code requirements from the IBC, IRC, ICC, ASCE-7, ACI, and a number of other codes.

Problem Solution

Floor System

Alternate 1: The first floor system that will be investigated is a two-way flat plate reinforced concrete system. This system will consist of a 9” reinforced concrete slab that frames into 30” square columns. The floor to floor height will remain the same as the original design at 10’-8” which leaves a ceiling cavity of 5” for any MEP equipment.

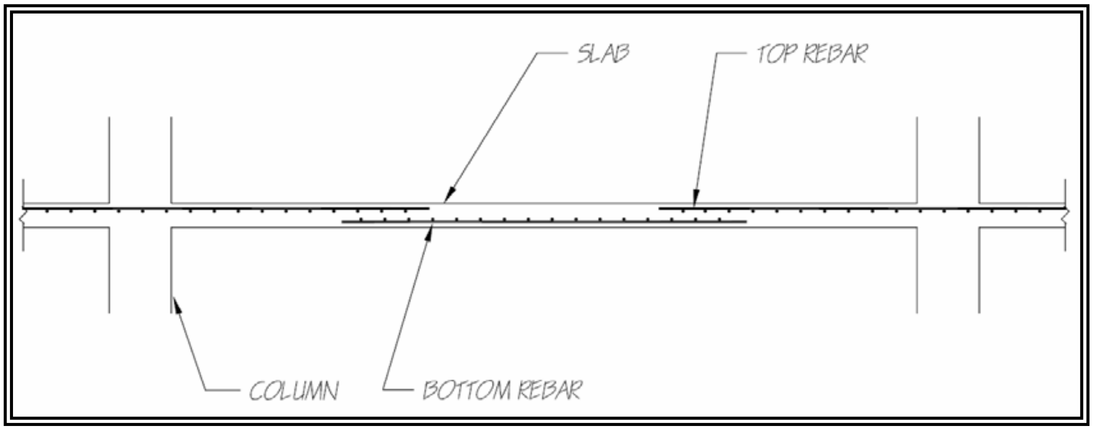

Figure 3: Cross Section of Two-way Flat Plate System

Alternate 2: The second floor system investigated will be a two-way post tensioned flat plate concrete system. It is the intent of this system to reduce the thickness of the floor slab to provide a larger ceiling cavity for MEP equipment. Reducing the thickness of the floor slab will reduce the dead loads into the columns and the punching shear in the slab and thus allow for smaller column sections.

<u>Lateral System</u>

The alternative lateral system that will be investigated is concrete shear wall positioned around the elevator core and stairwells that continues from the foundation through all levels of the building to the roof. If this does not provide enough lateral stiffness for the building I will also investigate the integration of a slab-frame system with the central core shear walls.

Solution Method

<u>Floor System</u>

The flat plate systems will be designed in accordance with ACI 318-05, chapters 13 and 18, by using the equivalent frame method. A gravity load analysis will be done utilizing ETabs. Live loads will be determined from ASCE7-05 and implemented based on a range of pattern loadings. These loading patterns are the full live load on all spans, full and half loads on alternating spans, and three-quarter loading and no load on alternation spans. The floor systems will be designed for their required strength as well as for serviceability requirements such as limited deflections (l/360).

<u>Lateral System</u>

The lateral system will be analyzed for the wind and seismic loading schemes set forth in chapters 6 and 9 in ASCE7-02. The lateral loads determined from these industry accepted procedures will then be inputted into an ETabs model of the building where the forces in each component will be calculated. The wall will then be designed based on the worst load combination of gravity and lateral forces.

Breadth Options

The redesign of the building's structural system using concrete instead of steel inherently requires a number of breadth topics to be investigated. The first is a construction management investigation of the difference in the overall cost of the building, and how the construction schedule will be altered due to the different construction materials.

The second breadth study will be one where designing this building to become LEED certified is investigated. This will look into what is required in the way of costs, materials, and different designs to satisfy a couple (3-4) of the 69 items that are part of the requirements to become LEED certified. This study will also look at which requirements are already satisfied and which ones could be cost effective options that if implemented would earn 'Erie on the Park' certification as a LEED design.

Tasks & Tools

Phase I. Two-way floor system analysis

- Task 1. Determine Superimposed Loads
  - a) Determine superimposed dead loads from Arch & MEP plans
  - b) Determine live loads from ASCE-7
- Task 2. Establish trial member sizes
  - a) Establish minimum slab thicknesses from ACI 318
  - b) Use CRSI Handbook to get initial component sizes
- Task 3. Refine floor systems
  - a) Use PCI design guides
  - b) Use ACI 318 Equivalent Frame analysis to determine member sizes

Phase II. Main Lateral Force Resisting System

- Task 1. Verify Wind and Seismic Loads
  - a) Use ASCE-7 chapter 6 Analytical Procedure for wind loading
  - b) Use ASCE-7 chapter 9 Equivalent Lateral Force Procedure for seismic loading
- Task 2. Determine loads on structural components
  - a) Input previously determined lateral loads into ETabs
  - b) Determine loads from each loading scheme and find worst combination
- Task 3. Design lateral system components
  - a) Determine the required concrete sections
  - b) Layout rebar using either hand calcs or PCA COL

Phase III. Breadth Studies

- Task 1. Construction Management
  - a) Cost comparison between new and original structural systems

b) Schedule comparison

Task 2. LEED Design

a) Determine criteria to investigate

b) Determine cost and design implications

Time Table

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9
Task 1: Determine Gravity Loads on Floor Systems	■								S
Task 2: Design RC and PT Flat Plate Floor Systems	■	■	■						P
Task 3: Determine Wind and Seismic Loads			■						R
Task 4: Build 3-D Model of Building in Etabs			■	■					I
Task 5: Calculate Member Loads due to Lateral Forces				■	■				N
Task 6: Design Shear Wall and Slab-Frame Systems					■	■	■		G
Task 7: Investigate Construction Cost and Schedule Implications due to Redesign of Structure							■	■	B
Task 8: Investigate the Certifying Criteria of LEED Design									R
Task 9: Compile Final Report									E
Task 10: Create Final Presentation									A
Task 11: Present to Faculty									K
Task 12: Remember what it means to be in college									!

	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16	Week 17
Task 1: Determine Gravity Loads on Floor Systems	S								F
Task 2: Design RC and PT Flat Plate Floor Systems	P								I
Task 3: Determine Wind and Seismic Loads	R								N
Task 4: Build 3-D Model of Building in Etabs	I								A
Task 5: Calculate Member Loads due to Lateral Forces	N								L
Task 6: Design Shear Wall and Slab-Frame Systems	G								S
Task 7: Investigate Construction Cost and Schedule Implications due to Redesign of Structure	B								
Task 8: Investigate the Certifying Criteria of LEED Design	R	■	■						W
Task 9: Compile Final Report	E		■	■					E
Task 10: Create Final Presentation	A			■	■				E
Task 11: Present to Faculty	K					■			K
Task 12: Remember what it means to be in college	!						■	■	!