NORTHSIDE PIERS
BROOKLYN, NY

Updated Senior Thesis Proposal

Jeremiah Ergas
AE 481W – 5th Year Thesis
Pennsylvania State University
Structural Option

January 17, 2008

Faculty Consultant: Dr. Ali Memari

Table of Contents

Executive Summary

Building Description

Northside Piers, a 29-story condominium tower located in Brooklyn, New York, is being built with a concrete structure. It consists of two-way flat plate slabs, shear walls around the central core, and a pile foundation. The floor system is designed to have an exposed finish over the bedroom and living rooms. The columns follow an irregular grid. They are located around the perimeter of the building with a few interior columns.

Proposal

An alternative floor system will be studied that must be 8" thick or less in order to match the existing depth. The floor must meet all strength and serviceability criteria determined by ACI 318-05.

A post-tensioned slab system will be studied as a possible alternative to the current design. Factors considered will include varying slab thickness, load balancing percentages and directions, concrete strength, and tendon strength. Punching shear will be dealt with by altering column scheme, adding drop panels, or adding shear reinforcement.

The system will be designed using RAM Concept, which will be verified by hand calculations. With a new slab thickness, the lateral loads and gravity loads must be recalculated, and the other structural components must be redesigned. The columns and foundation will be redesigned using hand calculations. The shear wall will redesigned using ETABS, while looking for any possible optimization of the existing design.

Construction Schedule and Cost Breadth

Switching the floor systems from conventional reinforcing to post-tensioning will create major changes in the construction schedule and overall cost of the building. This study will involve creating a construction schedule and performing a cost analysis for the original system and the new post-tensioned system.

Mechanical Risers Breadth

The sizes of mechanical ducts are often constrained by the structure and the architecture's allowances for openings. This is why it is important to have an understanding of how much duct size relates to the overall efficiency and cost of the mechanical system. In this study, the size of the major risers of the building will be increased in order to see how much the size of the fan exhaust system will decrease. If the change is significant, it may be a more efficient to modify the architecture in order to accommodate the larger riser size.

Background

Architecture

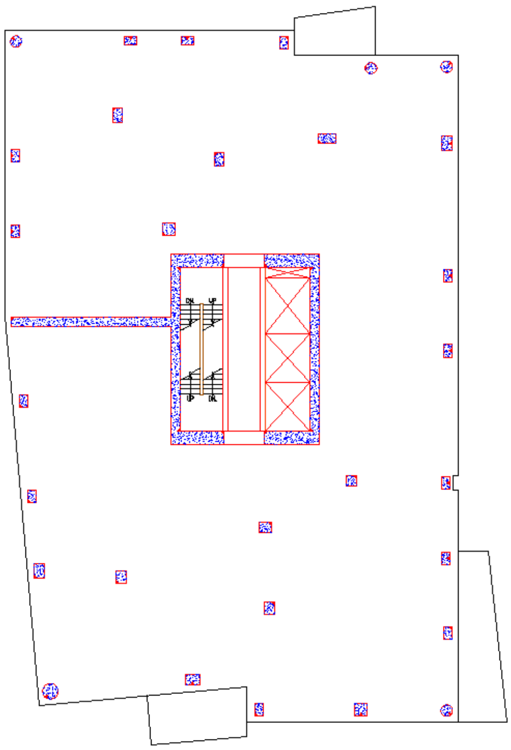
Northside Piers is a building currently being constructed on 164 Kent Ave. in the Brooklyn, New York area. It is a 29-story condominium tower built directly off of the East River across from Manhattan Island. It tops off at a height of 317 feet. The building features a glass cladding system that allows for floor to ceiling windows for uninhibited views of New York City. Transportation throughout the building is provided by a central elevator shaft and stairwell. The 27 floors that are dedicated to the condominium units are all very similar with only minor variations. The ground and cellar floors are used for mostly lobby, storage, and utility spaces.

Foundation

The columns sit on top of a foundation of 200 ton piles that are at about ten feet below grade. Grade beams run along the perimeter of the building. The highest concentration of piles is directly underneath the central core of the building in order to transfer the high moments to the ground below.

Floor System

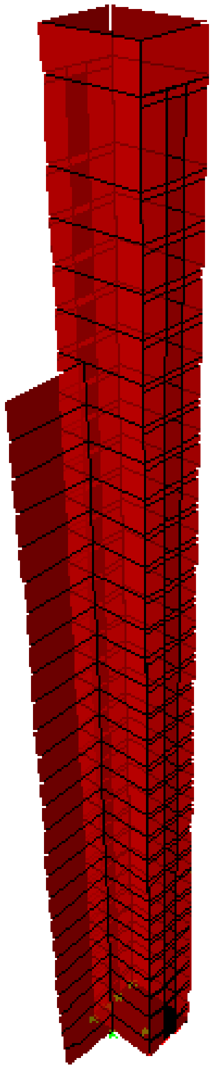
Almost the entirety of the building is designed with a two-way flat plate slab system. Slabs consist of 6000 psi concrete that are typically 8" thick except for the roof, the 2nd floor, and the lobby where they are 10", 12", and 10" thick respectively. While the 60,000 psi reinforcing varies size throughout the building, the most common reinforcing is #5 bars at 12" o/c at the top and bottom of the slab going both directions. The bottom of the slab is left exposed over the living rooms and bedrooms of the condominium units. The typical floor plan can be seen on the left.



Columns

The columns in this building do not follow a consistent grid in order to accommodate the floor plans. They are mostly rectangular columns located around the perimeter of the building with a few of them on the interior to break up the large bays. Almost all of the interior columns are hidden behind walls with additional room around them. Columns consist of 8000 psi concrete with usually 8 rebars along their edge varying in size from #7-#11. The bars are held in place with ties. Typical floor to floor height is 9'-9".

Lateral System



Lateral forces are carried in this building by the central core. It consists of concrete shear walls surrounding the elevator shaft and stairwell and all four sides. The walls are 1 ½ foot thick in the North-South direction and 2 feet thick in the East-West direction, and they extend from the foundation to the top of the building. The concrete strength is 8000 psi until the 14th level where it decreases to 6000 psi. The reinforcing is typically #5-#7 at 12 in. o/c. on both faces of the walls.

The walls in the East-West direction contain penetrations at every level to accommodate for doorways. The wall is still continuous due to a 2 feet deep link beam reinforced with #9 and #10 bars at the top and bottom.

There is one additional shear wall in the East-West direction that extends off of the building core. It starts at the foundation of the building and goes all the way to the 25th floor.

There are some other smaller penetrations in the shear walls on various floors. The shear wall can be seen on the right.

Mechanical Risers

The largest openings in the slab are due to mechanical risers which are used for air supplies and exhausts. Some of the openings are provided for the use of multiple risers. The largest opening size is about 3'x3'. A summary of the risers is shown below.

Major Mechanical Risers Summary

	Number	CFM (each)	Size Range (in. x in.)
Toilet Exhausts	11	1200	14x14 - 14x18
Trash Room Exhaust	1	2800	10x6 - 14x26
Dryer Exhuast	7	3000	14x12 - 28x16
Kitchen Exhaust	1	1200	8x6 - 20x10
AHU	1	7000	20x14 - 42x18
Total		45200	

Gravity Loads

Applicable loads were taken from the New York City Code as well as from manufacturers.

Gravity Loads Summary		
	Live Load*	Superimposed Dead Load
Equipment Rooms (Pumps, Boilers, Tanks, etc)	150 psf	15 psf
Light Storage Areas	100 psf	50 psf
Lobby/Public Spaces	100 psf	40 psf
Offices	50 psf	30 psf
1st Floor Elevator Lobbies	100 psf	40 psf
Multifamily Dwellings	40 psf	30 psf
EMR/Bulkhead	100 psf	5 psf
Mechanical Roof	150 psf	40 psf
Balconies (150% of serviced area)	60 psf	15 psf
*Live Loads May Be Reduced		
	Dead Load	
Concrete	150 pcf	
Glass Cladding	8 psf	
Roof Cooling Towers	16 kip each	
Roof AHU1	2.8 kip	
Roof AHU2	1.1 kip	
	Snow Load	
	30 psf	

Problem Statement

A floor system must be designed for the building to resist the dead loads and live loads listed above.

Several serviceability criteria must be met by the floor system. The depth of the floor must be less than or equal to 8" in order to prevent a decrease in the ceiling height, which would upset tenants, or an increase in the overall building height, which would come with additional costs. It must also meet other requirements including maximum deflections, vibrations, fire protection, and architectural effect.

The floor must ultimately be economical. In order to understand the cost of the system, the complete effect of the floor system must be considered. The most obvious cost is that of the materials and construction of the floor itself. In addition to this, the construction time and the interest accrued must be considered. Finally, a decrease in floor weight will result in a decrease in cost for the columns, shear walls, and foundations.

Proposed Solution

The type of alternative floor system that will be studied is a post-tensioned concrete slab. This system will be able to meet the depth requirements set above, and will most likely result in a thinner, lighter floor system. With lower dead loads from the floor, the shear walls, columns, and foundations can be reduced in size as well.

Several different configurations of the post-tensioned system will be considered. Factors studied will include slab thickness, load balancing percentages and directions, concrete strength, and tendon strength. Also, the column grid may need to change in order to accommodate this new system.

Punching shear will most likely be the controlling factor in the thickness of the slab. The columns where punching shear is critical can be dealt with in a number of different ways.

1. Column size can be increased
2. Drop panels can be used
3. Additional columns can be added
4. Shear reinforcement can be used

All of the above factors will be considered in the creation of a few different possible layouts for the post-tensioned floor system.

The lateral system must also be redesigned looking for any potential for optimization.

Solution Method

The first step will be to determine where additional columns can be added in the architectural plans without interfering.

The design of the post-tensioned slab will be based on the requirements made in Chapter 18 of ACI 318-05 *Building Code Requirements for Structural Concrete*. The analysis and design of the possible slabs will be carried out using RAM Concept, and will be verified by hand calculations. Various combinations of slab thicknesses, prestressing, and column locations will be considered in order to find a few potential floor designs. These floor designs will then be compared in order to determine the most effective slab design.

With the new slab design, the effect on other systems must be considered. They will be designed using ACI 318-05 provisions as well. The columns will be adjusted for the new gravity loads using hand calculations. Seismic loads will be recalculated based on ASCE7-05 due to the new weight of the building. The shear walls will be redesigned for the new loads using a model in ETABS to check strength and serviceability, while looking at alternate configurations in order to make it more efficient. Finally, the redesign of the foundation will be considered based on the new loads taken from ETABS and the geotechnical report.

Breadth Studies

Construction Schedule and Costs

Switching the floor systems from conventional reinforcing to post-tensioning will create major changes in the construction schedule and overall cost of the building. These changes must be studied in order to fully understand the effects of the alternate system. This study will involve creating a construction schedule for the original system as well as the new post-tensioned system and then comparing the two. In addition, a cost analysis of the two systems will be performed taking into account any reduction of building materials due to a reduced overall building height.

Mechanical Risers

The sizes of mechanical ducts are often constrained by the structure and the architecture's allowances for openings. This is why it is important to have an understanding of how much duct size relates to the overall efficiency and cost of the mechanical system. In this study, the size of the major risers of the building will be increased in order to see how much the size of the fan exhaust system will decrease. If the change is significant, it may be a more efficient to modify the architecture in order to accommodate the larger riser size.

Tasks & Tools

Design of Post-Tensioned Slab

1. Determine possible column locations
2. Research post-tension design
    a. View Chapter 13 of ACI 318-05 Requirements
    b. Look at plans of post-tensioned buildings from other student's drawings.
    c. Read post-tension design chapter of *Design of Concrete Structures*.
3. Design possible slabs using RAM Concept
4. Verify answers with hand calculations
5. Decide on most efficient system

Redesign of Columns, Shear Walls, and Foundation

1. Recalculate seismic loads using ASCE7-05
2. Design columns
    a. Obtain gravity load distribution from RAM Concept
    b. Design columns by hand calculations
3. Design shear walls
    a. Build model of shear walls using ETABS
    b. Redesign shear walls by hand based on results
    c. Remodel and analyze the new shear walls
4. Design Foundation
    a. Obtain base reactions from ETABS model
    b. Decrease the required number of piles based on new loads

Construction Schedule and Costs Breadth

1. Create detailed estimate based on values from RS Means
    a. Include all the units of the original and new structure
    b. Include decrease in cladding, piping, wiring, and ducts due to change in building height
2. Create schedule using primavera based on times estimated from RS Means

Mechanical Risers Breadth

1. Determine allowing openings in floor slab based on ACI 318-05
2. Research pump design and pressure loss through ducts from Chapter 10 of the book *Heating, Ventilating, and Air Conditioning*
3. Resize fans based on possible duct sizes

Timetable

Spring 2008 Thesis Schedule	Week 1 Jan. 14	Week 2 Jan. 21	Week 3 Jan. 28	Week 4 Feb. 4	Week 5 Feb. 11	Week 6 Feb. 18	Week 7 Feb. 25
Design Post-tensioned Slab							
Determine possible column locations							
Research post-tension design							
Design possible slabs							
Verify designs with hand calculations							
Redesign Columns, Shear Walls, Foundations							
Recalculate Seismic Loads							
Design Columns							
Design Shear Walls							
Design Foundation							
Construction Schedule and Cost Breadth							
Create detailed estimate							
Create schedule							
Mechanical Risers Breadth							
Determine allowable openings in slab							
Research pump design and pressure loss							
Resize fans for alternate sized ducts							
General							
Catch Up							
Work on Report and Presentation							

	Week 8 Mar. 3	Week 9 Mar. 10	Week 10 Mar. 17	Week 11 Mar. 24	Week 12 Apr. 7	Week 13 Apr. 14
Design Post-tensioned Slab						
Determine possible column locations						
Research post-tension design						
Design possible slabs						
Verify designs with hand calculations						
Redesign Columns, Shear Walls, Foundations						
Recalculate Seismic Loads						
Design Columns						
Design Shear Walls						
Design Foundation						
Construction Schedule and Cost Breadth						
Create detailed estimate						
Create schedule						
Mechanical Risers Breadth						
Determine allowable openings in slab						
Research pump design and pressure loss						
Resize fans for alternate sized ducts						
General						
Catch Up						
Work on Report and Presentation						