WISCONSIN PLACE RESIDENTIAL

Thesis Proposal

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STRUCTURAL OPTION

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Executive Summary

Building Description

Wisconsin Place Residential consists of 15 above stories and 2 below grade stories. The building is approximately 479,000 SF, stretching from 25 feet below grade to 142 feet above grade. The building consists of 432 units spread out over the 15 floors. The 13th floor contains a 1,000 SF pool for all tenants of the building. The two levels below grade are set aside for residential parking and are integrated with the parking for the mixed use development.

Proposal

Wisconsin Place Residential is currently a post-tensioned flat plate building within a height restricted area. Although the slab thickness is only 7 ½ “, another structural system with a new column layout may be easier to construct and the cost of losing one floor of condominiums may be offset by an architectural redesign of the building and potential for more revenue may be generated.

Solution

Based on all analyses performed on Wisconsin Place Residential in Technical Report 2, the most economical floor system was found to be a precast girder-slab system. Along with a cheaper cost, the girder-slab system doesn’t require as much formwork, the hollow core planks are lighter than the post-tensioned floors, and the construction process if faster. This system is very efficient for a uniform grid-layout, which will have to be incorporated in my research next semester. The extra ½ “ of floor thickness will put the building over the allowable height limits, so by using another structural system, Wisconsin place Residential will unfortunately lose one floor of condominiums. An investigation will be made in order to see if changing the architectural layout of the building into a uniform grid with additional square footages of condominiums will offset the cost of losing a floor and potentially generate more revenue for the owner.

Breadth Topics

Along with the main study of using a precast girder-slab system and a re-design of the lateral system, two individual breadth studies will also be conducted. These include an architectural and construction management study. The architectural study will consist of generating a uniform grid layout that will accommodate the shape and size of the existing building with the exception of losing one floor. This study will also incorporate changes to individual condominium apartments as well as a redesign of the façade of Wisconsin Place Residential.

The construction management study will focus on a comparative analysis of the existing building to the re-designed Wisconsin Place Residential. This analysis will focus on the scheduling impact and cost savings involved with faster construction, condominium changes, and an overall lighter building.

Existing Structural System

Foundations

The foundation shall be supported on spread footings. Column and wall footings supported by rock shall be designed for a bearing pressure of 40,000 PSF. A 4-inch gravel base shall be provided below floor slabs as a moisture barrier. Also, under-floor sub-drainage system shall be installed. All exterior footings shall be a minimum of 2'-6" below grade. All controlled compacted fill shall be compacted to not less than 95% of the maximum dry density determined in accordance with ASTM D-698.

Floor Systems

1st Floor:
Slab on grade.

2nd - 12th Floor:

Flat plate 7 ½" thick unbounded post-tension slabs, with a two-way bottom reinforcement mat of #4@24" continuous bars each way. Hooked bars at discontinuous ends are provided along with 2 #5 top and bottom additional bars along free slab edges. Concrete for slabs shall be normal weight concrete at 5000 psi. The post-tension cables consist of uniform tendons being pulled in the S-N direction and the banded tendons are in the pulled in the W-E direction of the building. The typical uniform cables are 15.0 klf and the banded cables range from approximately 50 - 400 kips.

13th Floor:

Floors are typically post-tensioned the same as the 2nd - 12th except in the pool area. The 12" and 15" slab areas require #5@24" O.C. each way continuous on top and bottom. The 23" slab area requires #6@12" O.C. each way continuous on top and bottom.

Pool House Roof:

7" slab with normal weight concrete and 60,000 psi reinforcing steel. A top and bottom mat of #4@12" O.C. continuous each way is required. Additional top reinforcing for column and middle strips is 6#5 top bars.

14th and 15th Floors:

Floors are typically post-tensioned the same as the 2nd - 12th.

Main Roof:

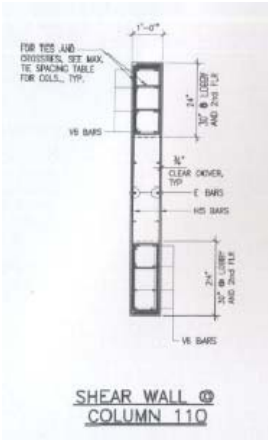
Slab is 8" thick unbounded post tensioned with a two-way bottom reinforcement of #4@24" continuous each way. For the 10" and 12" thick areas, #5@24" continuous mats are required as well as 2 #6 top and bottom additional bars along free slab edges.

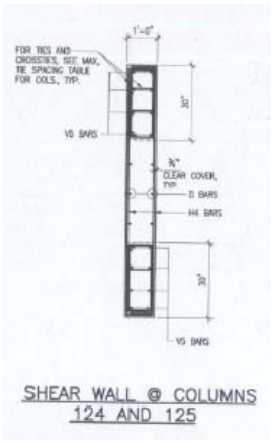
Columns

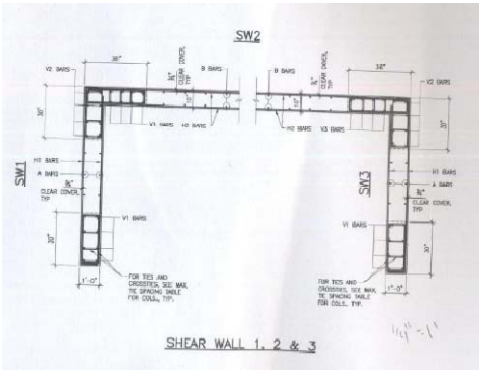
The columns in Wisconsin Place Residential are primarily standard reinforced concrete with varying sizes, shape, and reinforcement depending on their location and loads that are applied throughout the building. The most typical shapes are 16”x28” and 16”x32”. The reinforcement for the columns varies from floor to floor. The typical reinforcement is 8#7 or 8#8 bars, but varies throughout typical levels. The 12^{th} – 13^{th} floor reinforcement is typically #10 or #11 bars, due to the fact that they are supporting the pool. The loads vary greatly from column to column and are as large as 1380k and as small as 122k for dead loads and 293k to 17k for live loads at the top of the pad.

Lateral System

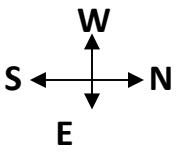
Concrete shear walls make up the buildings lateral load resisting system. Two elevator cores serve as the main components of these elements and are connected from the 1^{st} Floor to the roof. There are also three other shear walls spread out on the west side of the building. Typically the shear wall reinforcement is #4@12” for horizontal reinforcement and #6 or #7 bars for vertical reinforcement. The typical reinforcement for ties and crossties cooresponds to the maximum spacing for columns.

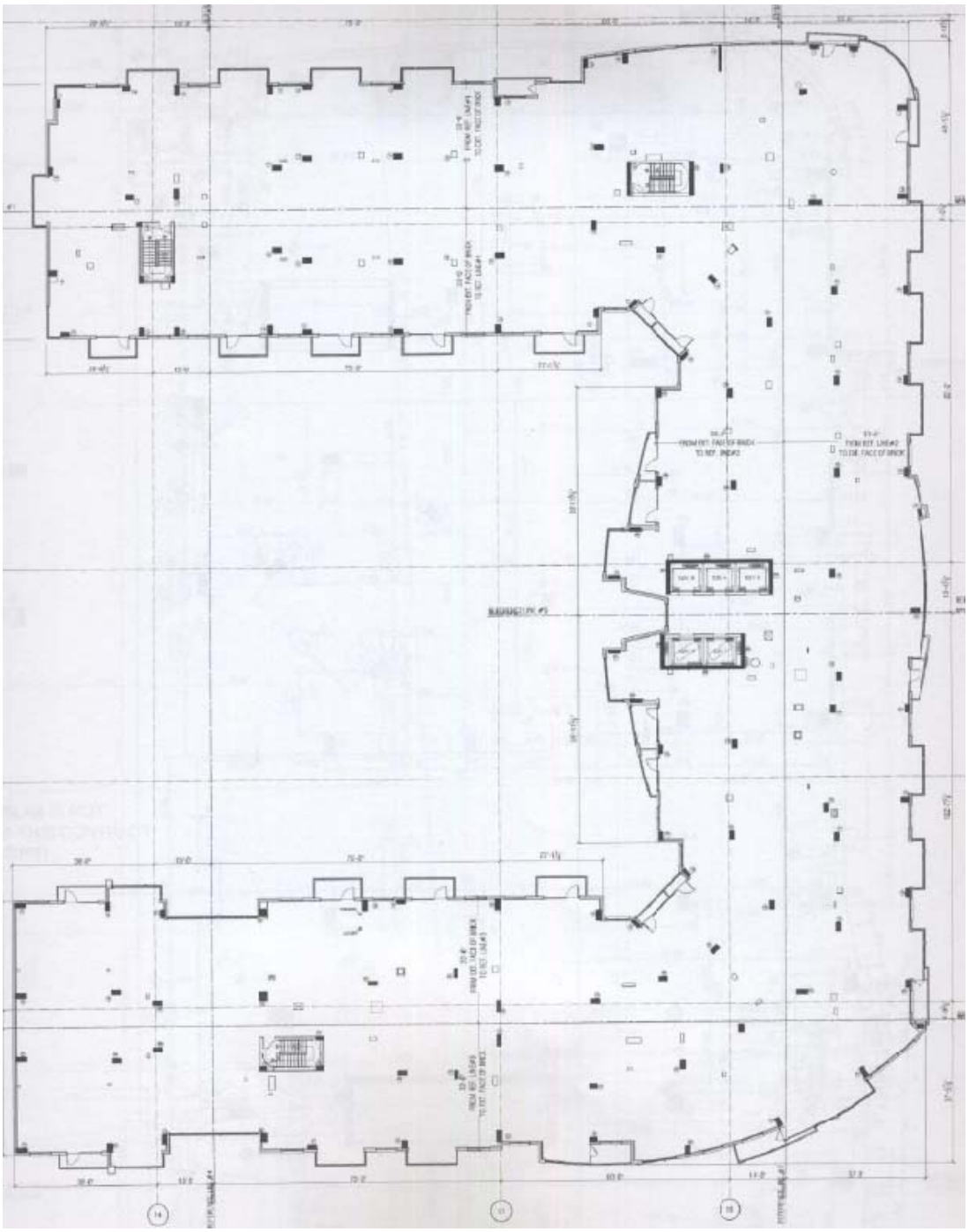






Typical Floor Plan





Problem Statement

Wisconsin Place Residential is currently a post-tensioned flat plate building within a height restricted area. Although the slab thickness is only 7 ½ “, another structural system with a new column layout may be easier to construct and the cost of losing one floor of condominiums may be offset by an architectural redesign of the building and potential for more revenue may be generated.

Problem Solution

In Technical Report 2 it was found that the slab depth was the most critical part of the structural design due to the height restrictions of the building. The provided height of the building is 142’ 11- ½” and the allowable height is 143’. Based on all analyses performed on Wisconsin Place Residential in Technical Report 2, the most economical floor system was found to be a precast girder-slab system. This system was not used in the actual building most likely because of the irregular column grid layout proposed by the architect. A precast girder-slab system was investigated in Technical Report 2 and it was found to be approximately $5.00/sqft cheaper in cost. Along with a cheaper cost, the girder-slab system doesn’t require as much formwork, the hollow core planks are lighter than the post-tensioned floors, and the construction process if faster. The downsides of using the girder-slab system are the requirements of additional fire proofing, the limitability of DB beam shapes, and an increase in slab thickness of approximately ½ “. This system is very efficient for a uniform grid-layout, which will have to be incorporated in my research next semester. The extra ½ “ of floor thickness will put the building over the allowable height limits, so by using another structural system, Wisconsin place Residential will unfortunately lose one floor of condominiums. An investigation will be made in order to see if changing the architectural layout of the building into a uniform grid with additional square footages of condominiums will offset the cost of losing a floor and potentially generate more revenue for the owner. The additional square footages may be achieved by simply adding a few extra square feet to all of the condominiums,

which will make the price range of living in the building higher or an additional section of the building will be added to so that the condominiums will stay the same size, but there will be more on each floor. Regardless of the architectural changes, the building will maintain all functional services that it produces now.

Solution Method

The first step in the redesign of Wisconsin Place Residential will be finding a typical bay size that will accommodate all gravity loads and serviceability requirements for a precast girder-slab system. The floor system will be designed in accordance with ACI-318-05, referencing all applicable sections. Once the bay size is determined I will then look into the local building codes for setbacks and other limitations that may apply to the architectural changes. AutoCAD 2008 will be used to create the uniform floor plan that will accommodate all the functions that the existing building possesses. This new floor plan will reflect similar square footages of the current condominiums, but they might be increased due to a loss of one floor because of the height restrictions and thicker slab when designed using a precast girder-slab system. After the building is completely redesigned for gravitational loads and maintains full functionality, I will then re-design the lateral system based upon ASCE7-05 using an ETABS model and checking the computer model by hand calculations. A comparative analysis of the construction cost and total time of construction will be evaluated using RS means, cost works, Microsoft Project and industry contacts. Along with this analysis Revit Architecture 2008 will be used to demonstrate architectural changes of the building as well as show detail amongst the changes in the condominiums.

Breadth Options

Along with the main study of using a precast girder-slab system and a re-design of the lateral system, two individual breadth studies will also be conducted. These include an architectural and construction management study. The architectural study will consist of generating a uniform grid layout that will accommodate the shape and size of the existing building with the exception of losing one floor. This study will also incorporate changes to individual condominium apartments as well as a redesign of the façade of Wisconsin Place Residential.

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Tasks and Tools

I. Precast Girder-Slab System with Uniform Bays

Task 1: Establish Floor Loads

a) Find self weight based on member sizes
b) Find superimposed dead loads based on building plans
c) Find live loads on the basis of the IBC 2003
d) Use Nitterhouse tables for hollow core planks
e) Complete design using DB Beams and hollow-core planks

Task 2: Calculate Loss of Square Footage and New Layout of the Building

a) Reference the existing architectural plans for square footages
b) Determine a new location for the pool
c) Maintain the shape of the building, but make changes to adhere to the square footage requirements.

II. Design Lateral System and Columns

Task 3: Determine Lateral Loads and Design Steel Columns

a) Determine Wind Loads using section 6 of ASCE 7-05
b) Determine Seismic loads using Equivalent lateral force procedure from ASCE7-05
c) Determine typical column sizes using AISC Steel Manual

Task 4: Create an ETABS Model

a) Input loads
b) Determine loads from each loading scheme and find worst combination
c) Determine the sizes of the required braced frames

III. Breadth Studies

Task 5: Cost Analysis

a) Call the Realtor for the building and find out the cost per square foot of the apartments
b) Determine possible critical path changes due to new design
c) Compare cost savings of construction with the new analysis based on a detailed take-off estimate of the re-designed building

Task 6: Architectural Modifications to the Building

a) Re-design a typical Condominium
b) Design Luxury Penthouses with roof top access
c) Re-design the façade of the building

Task 7: Create a Revit Model

a) Create a model of the new building showing exterior façade and the inside and outside view of the luxury penthouses.
b) Create a movie showing the Revit model in detail

IV. Final Presentation

Task 8: Print and Prepare Presentation

a) Create a Power Point Presentation and update CPEP


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Week 17
Task 1: Establish Floor Loads
Task 2: Calculate Loss of Square Footage and New Layout of the Building
Task 3: Determine Lateral Loads and Design Steel Columns
Task 4: Create an ETABS Model
Task 5: Cost Analysis
Task 6: Architectural Modifications to the Building
Task 7: Create a Revit Mode
Task 8: Print & Prepare Presentation
SPRING BREAK
PRESENT
FINALS