William W. Wilkins Professional Building

Columbus, Ohio

Proposal

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Structural Option

AE 481W

Senior Thesis

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Executive Summary

The William W. Wilkins Professional Building is a six story, 112,000 sq. ft. medical office building located in Columbus, Ohio. Costing approximately $7.4 Million, it is essentially an addition to the Grant Riverside hospital across the street. These buildings are connected by a pedestrian bridge from the third floor. Enclosed by brick veneer, precast concrete and spandrel glass panels the exterior is non-load bearing.

The Wilkins building is founded on caissons drilled 25′, on average, to bear on soil with an allowable bearing stress of 16,000psf. On each caisson is a pier supporting grade beams. The slab on grade is 4″ concrete reinforced with 6x6-W1.4xW1.4 welded wire fabric (WWF) over 6″ porous fill. Floors 2-6 consist of a 3 ½″ concrete slab on 2″ 18ga composite steel deck welded to the support steel. These slabs are reinforced with 6x6-W2.1xW2.1 WWF. Floor framing generally consists of a W16x31 beam connected compositely to the floor slab. Beams frame into a W24x55 girder. Columns are ASTM 992 Grade 50 rolled W12 steel shapes.

Lateral bracing is provided in the form of five braced frames. Two frames spanning North-South are located near the elevator shafts. Frames spanning East-West are split with one by the elevator shafts, one on the exterior South-East bay and one on the exterior North-East bay. The concentric framing members are steel tubes.

The floor system in the Wilkins building is typical of medical office buildings. However, the use of braced frames in two exterior bays reduces the available façade area for windows. Thus, two alternative designs will be considered. The first alternative to be investigated is concrete skip-joists with moment frames. Concretes properties make moment frames a natural occurrence. This will eliminate the braced framing creating a larger area for natural day lighting. The second alternative to be considered is a steel moment frame. This will also eliminate the exterior braced frames.

After an initial inspection, the best solution will be chosen for a more in depth design. Both strength and serviceability issues will be considered in the design process. To determine which is the more economical system, the proposed system or the existing system, a cost analysis will be executed.

Two breadth topics will also be considered. The first topic will look at integrating a photovoltaic (PV) skin façade with the buildings energy system. The analysis on the PV façade will include a calculation of energy savings, investigation into the integration of the energy obtained from the PVs to the buildings main energy system, and a look at the distribution of the energy.

During Technical Assignment #2, a one-way concrete slab and beam system was considered. It has since been noted this is not the best use of a one-way system, skip-joists are. Thus, the second breadth topic will be a cost and schedule comparison between both of these one-way systems to determine why skip-joists are used concrete beams.

Introduction

The William W. Wilkins Professional Building is a 6 story, 112,000 sq. ft. medical office building located in Columbus, Ohio. Costing approximately $7.4 million, it is an addition to the Grant Riverside hospital across the street. The two buildings are connected by a pedestrian bridge from the third floor. The façade is composed of brick veneer, precast concrete and spandrel glass panels. The structure is made up of steel beams acting compositely with a one-way slab. Loads are transferred through girders to the W12 columns that carry the load down to caissons.

Background

Foundation:

The foundation for the William W. Wilkins Professional Building consists of reinforced concrete piers and grade beams supported on reinforced concrete caissons. See Figure 1 below. Caissons are drilled an average of 25'-2" to rest on sand/gravel with an allowable bearing stress of 16,000psf. Concrete with a minimum 28 day strength of 3,000psi was used for the caissons. Ranging in diameter from 48" to 84", these caissons are reinforced with #9, 10 or 11 bars with #3 or 4 ties at 12 or 18 inches. Piers and grade beams have a minimum 28 day strength of 3,500psi. On average, piers are 1'x1' while grade beams vary from 12"x32" to 24"x32". Both are reinforced with #6, 7 or 8 bars with #3 stirrups at 12".

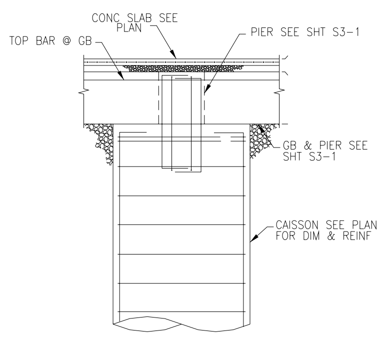

Figure 1: Typical Caisson Detail

Floor system:

The floor system in the Wilkins building is designed for composite behavior. Floor slabs consists of 3 ½" normal weight concrete on 2" 18 gage composite steel deck reinforced with W2.1xW2.1 welded wire fabric (WWF). Decking is welded to support steel. The slab on grade (SOG) varies slightly consisting of 4″ concrete on 6″ porous fill reinforced with W1.4xW1.4 WWF. Both the floor slabs and SOG are composed of concrete with a minimum 28 day compressive strength of 3500psi. A typical bay consists of W16x31 beams spanning 32′-4″ in the East-West direction framing into W24x55 girders spanning 30′-9″ in the North-South direction. ¾″ diameter by 4 ½″ long headed studs are spaced evenly across members to transfer loads. Roof framing of a typical bay utilizes the same size members designed as non-composite. On the East face there is a slight overhang supported by W12x14 beams framing into W16x26 girders. Moment connections are used where beams connect to columns and girders. A typical floor plan is shown below in Figure 2.

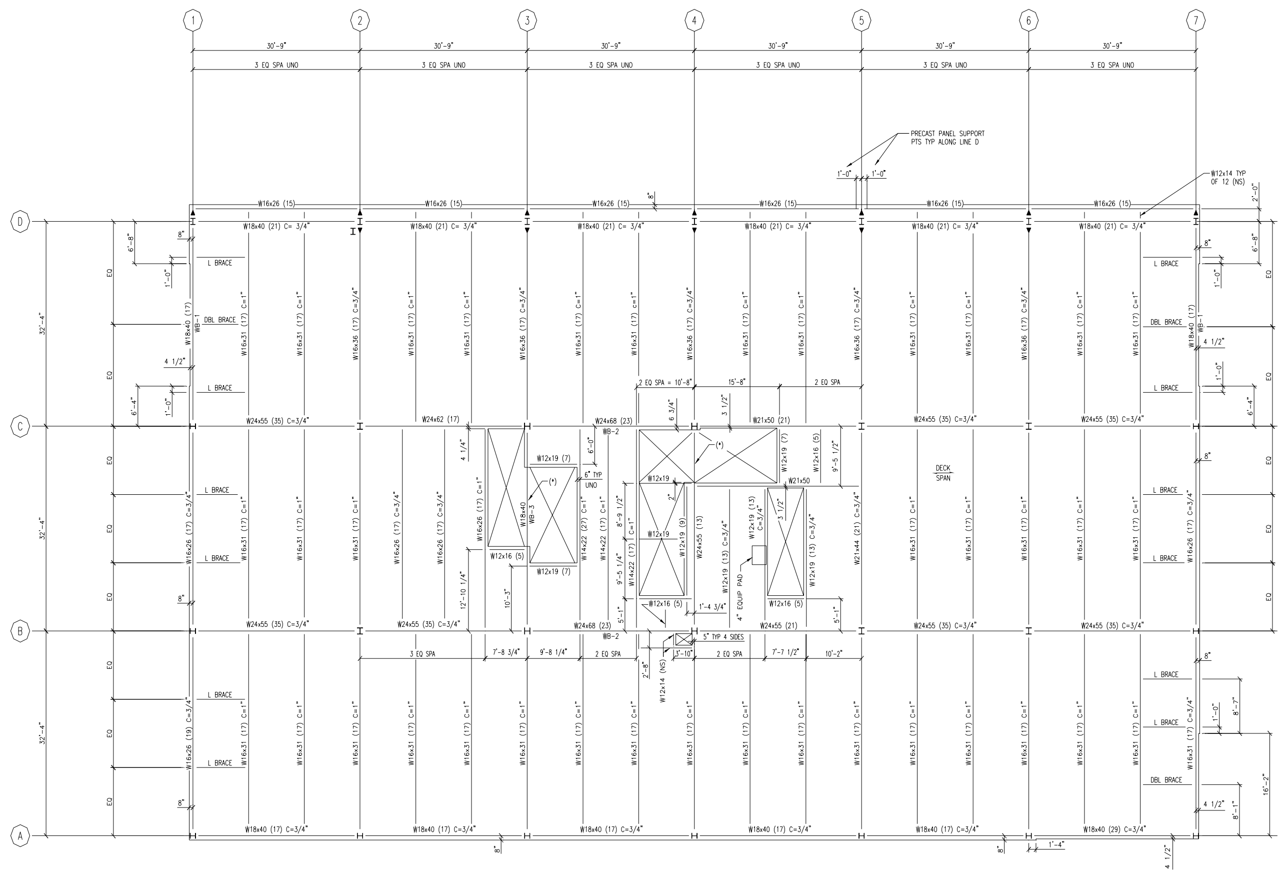

Figure 2: Typical Floor Plan

<u>Columns:</u>

Columns are ASTM 992 Grade 50 rolled W12 steel shapes with splices on the third and fifth floors. Splice connections use welds and ¾″ diameter A325 bolts. Web bolts are slip critical, to connect plates. See Figure 3 below. The largest columns are W12x136 and are part of the lateral system. Gravity columns range from W12x40s at the roof level to a max of W12x106 at ground level. Base plates are either 18x18 or 20x20 with thicknesses ranging from 1 ¾" to 2 ½". Connections consist of (4) anchor bolts of varying sizes.

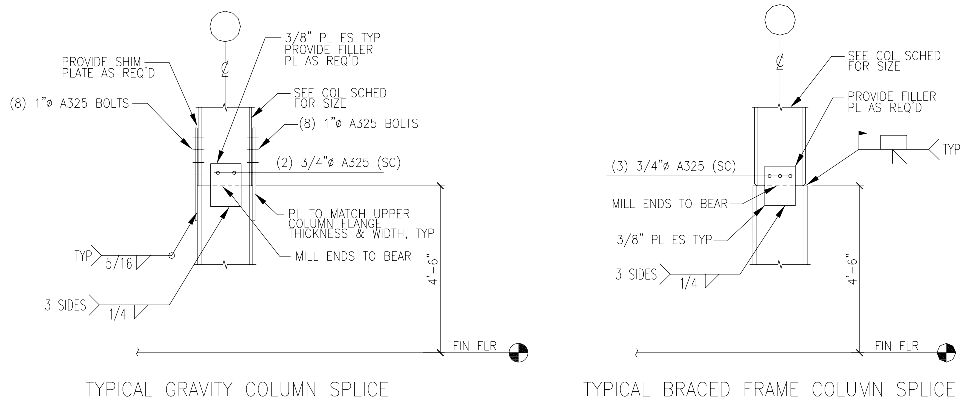

Figure 3: Typical Column Splice Details

<u>Lateral System:</u>

Lateral loads are resisted in the Wilkins building using braced frames. Two frames spanning North-South are located near the elevator shafts. Frames spanning East-West are split with one by the elevator shafts, one on the exterior South-East bay and one on the exterior North-East bay. Lateral bracing in these frames are ASTM A500 Grade B tubes ranging in size from TS5x5x.1875 to TS8x8x.25. A typical braced frame is shown in Figure 4 below. The tube steel is welded to gusset plates that connect to main framing members.

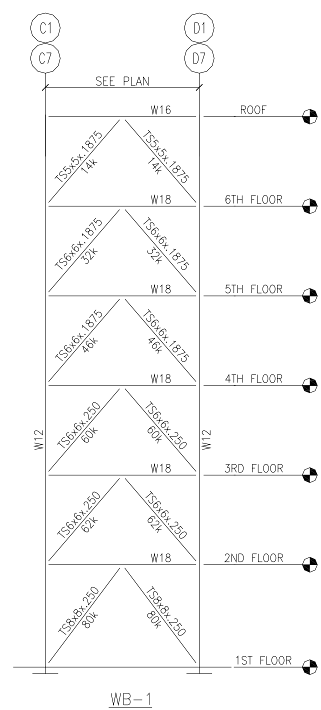

Figure 4: Typical Braced Frame

Problem Statement

Buildings must be designed to resist all applied forces according to the International Building Code (IBC) or the accepted code for the state it will be built in. This includes gravity and lateral loads. Gravity loads consist of dead, live and snow loads as determined from ASCE 7-05. While lateral loads consist of wind and seismic loads which will be determined from ASCE 7-05 as well. All load cases set forth in the IBC will be evaluated.

The floor system used in the Wilkins building may or may not be the most efficient and cost effective system. Two different systems will be investigated for their integration into the Wilkins building. Both the integration into the floor framing and the effects the systems have on the lateral system will be looked at.

The current lateral system used in the Wilkins building consists of concentric braced frames. For the most part this works well. However, as noted above, there are braced frames located in two exterior bays. This significantly reduces the amount of window space on the North and South faces. It was also determined in Technical Assignment #3 that in the East-West direction wind controls, where as, in the North-South direction seismic controls. Changing the structural system may well alter the seismic forces applied to the Wilkins building. As a result, a new lateral system will be investigated.

Changing the floor and lateral systems will alter the weight of the structure. All concrete floor systems investigated in Technical Assignment #2 induced a greater weight than the existing composite structure. As a result, the foundation will potentially need to be redesigned as well.

Problem Solution

The first alternative system that will be investigated is skip-joists. During the investigation, different spans will be considered which will give different joist sizes. To determine the most appropriate span for the existing bay size a cost and serviceability analysis will be conducted. To do this, loads and code requirements will be determined from the IBC, ASCE 7-05, American Concrete Institute (ACI) and other codes as needed. Due to concretes material properties the logical lateral system to be considered is moment connections.

The second alternative system will be a steel moment frame. This will allow for an increase in windows on the North and South faces of the building by eliminating the braced frames. After an initial inspection, the best system will be chosen to continue the design. A cost analysis will be performed to determine if the new system is more economical than the existing system.

Solution Method

Floor Systems:
To design the floor systems gravity loads will need to be determined. This will be done according to IBC with reference to ASCE 7-05.

For the skip-joists initial pan sizes will be taken from CRSI Handbook. After determining initial sizes further analysis will be performed through hand calculations to adopt the spans taken from CRSI Handbook to fit the bay sizes in the Wilkins building. Strength and serviceability issues such as deflection will be analyzed. The skip-joists will be designed according to ACI 318.

For the steel frame, initial member sizes will be determined through RISAFloor. From here a more in depth analysis will be performed to determine whether to maintain the existing composite structure or to use a non-composite structure. From here, the columns will be designed.

Lateral System:
Lateral loads will be determined from chapters 6, 11 and 12 in ASCE 7-05. A new check will be performed to determine whether wind or seismic controls and the moment connections will be designed to meet the worst case loading situation.

Breadth Options

Two breadth topics will be considered as part of this thesis. The first topic will look at integrating a photovoltaic (PV) skin façade with the buildings energy system. To do this research will be conducted on currently available PV façades. The analysis on the chosen system will include a calculation of energy savings, investigation into the integration of the energy obtained from the PVs to the buildings main energy system to include wiring and transfer switches, and a look at the distribution of the energy.

During Technical Assignment #2, a one-way slab with concrete beams was analyzed. It has since been noted that this is not the best use of a one-way slab. Common practice consists of the use of skip-joists. Therefore, my second topic will be a cost and schedule analysis of both one-way systems to determine why skip-joists are used over concrete beams.

Tasks and Tools

Task 1: Determine Loads

A. Determine gravity loads from ASCE 7-05 and drawings
B. Determine wind loads from chapter 6 in ASCE 7-05
C. Determine seismic loads from chapters 11 and 12 in ASCE 7-05

Task 2: Establish Trial Member Sizes for Skip-Joists

A. Establish minimum slab thickness from ACI 318
B. From CRSI Handbook select pan sizes

Task 3: Establish Trial Member Sizes for Steel Frame

A. Input frames into RISAFloor and solve
B. Determine initial column sizes

Task 4: Refine Chosen Floor System

A. If skip-joists, adapt pan sizes obtained from CRSI Handbook for actual bay size
    1. Determine which pan size will be most efficient
    2. Look at foundation
    3. Design columns
B. If steel, determine whether to design as composite or non-composite and fully design columns

Task 5: Design Moment Connections

Task 6: Breadth Topic 1

A. Research available PV skin systems
B. Select best system
C. Perform energy analysis
D. Design transfer switch and wiring configuration
E. Determine distribution of energy

Task 7: Breadth Topic 2

A. Perform cost analysis using RS Means

B. Create construction schedule using Primavera

Task 8: Final Report

A. Compile final report
B. Create final presentation
C. Practice
D. Present to faculty

Timetable

	January			February			
	1/15-1/19	1/22-1/26	1/29-2/2	2/5-2/9	2/12-2/16	2/19-2/23	2/26-3/2
Task 1							
Task 2							
Task 3							
Task 4							
Task 5							
Task 6							
Task 7							
Task 8							

	March				April		
	3/5-3/9	3/12-3/16	3/19-3/23	3/26-3/30	4/2-4/6	4/9-4/13	4/16-4/20
Task 1		B					
Task 2		R					
Task 3		E					
Task 4		A					
Task 5		K					
Task 6		!					
Task 7		!					
Task 8							