Executive Summary

Parkridge 6 is a 7 story 226,000 sq.ft. Commercial office building located in Reston, VA. The building is designed to a maximum height of 115'. The south face of the building is made up of sloping columns that slope outward from the ground level to the roof. The north face of the building contains an arcade created by stepped portions of additional floor area on the second floor through the fifth floor.

The foundation for Parkridge 6 is a shallow foundation system made up primarily of spread footings. The typical floor is a composite system with 3 ¼" of lightweight concrete on a 2"-20 gauge steel deck. The building grid consists of 3 bays in the N-S direction spaced at 37'-2", 35'-0", and 37'-2" respectively. In the E-W direction there are 10 bays with the first bay on both ends being 25'-8" and all others 25'-0".

The lateral system for Parkridge 6 is a series of braced frames. In the N-S direction there are 2 frames and in the E-W direction there are 3 frames. The bracing elements of these frames are made up of HSS sections ranging from 8x8 to 12x12.

The proposed alternative system to be studied in the next semester will be a post-tensioned slab and beam system. This system still allows for the framing dimensions of the original system while keeping within floor to floor height restrictions. A goal that I will try and accomplish with the post-tensioned system will be to use the cables to distribute the lateral load of the sloping columns into the slab and force the slab to act as a deep beam. Along with a study of this alternative system, two breadth studies shall be done in the construction management and mechanical options. The breadth in construction management will be an investigation of the scheduling and cost impact of switching to a post-tensioned system. I will also investigate how to phase the construction process to allow tenants to move in as soon as possible. The Mechanical breadth work will look at the impact of the slab openings required by the current mechanical system on the structure, and suggest possible alterations resulting from the change in structural system.

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Introduction

The proposed Parkridge Center – Phase VI building is a 226,000 Sq. Ft., seven story commercial office building located in Reston, VA. The building is designed to a maximum height of 115'. The south face of the building slopes outward from the ground level to the roof, while on the north face of the building there are stepped portions from the second floor to the 5th floor creating an arcade at ground level. All of the occupied space is above grade.

Existing Gravity System

Foundations

Parkridge 6 rests on a shallow foundation system consisting of spread footings ranging in size from 5' x 5' to 20' x 20' with depths ranging from 12" to 42". The lateral resisting elements of the building rest on mat foundations. The allowable bearing pressure is 3000 psf. The slab on grade is 4" thick and is reinforced with a 6x6-10/10 welded wire mesh.

Floor System

Each floor contains the same three by ten bay core. The south most exterior bay on each floor varies based on the slope of the columns on the south face creating larger floor area on higher level floors. Floors 2 thru 5 contain extra floor area on the north side of the building above the arcade. The North-South (N-S) spans of the core three bays are 37'-2" for the exterior bays and 35'-0" for the interior bay. The East-West (E-W) spans of the core bays are 25'-8" for the first interior bay and then 25'-0" for the remaining bays. Intermediate beams are spaced at the third points of each bay and span in the N-S direction. Typical beam sizes for the core bays are W21's for the interior girders, W18's for the exterior girders, and W16's for the intermediate beams. Each beam is cambered to 1-1/4" this was done to account for serviceability issues arising from the members chosen. Each floor above grade uses a composite deck made up of 3 ¼" Lightweight concrete on 2"-20 gage steel deck. The total floor thickness is 5 1/4". The slab itself is to be reinforced with 6x6-10/10 WWM.

Columns

Each column extends 3 floors and is spliced above the slab. The columns along the south face of the building, column line A.1, are sloped outward from the ground to the roof. Typical sizes for the sloped columns begin at a W12x65 at the roof to the 7th floor, W12x96 from the 7th floor to the 4th floor, and W12x152 from the 4th floor to the foundation. Typical sizes for the interior columns range from a W12x53 at the upper floor to a W14x233 at the base of the building.

Existing Lateral System

Five braced frames make up the lateral system for the building. There are two frames in the N-S direction and three frames in the E-W direction. The diagonal members of the frames are HSS 10x10x1/2 for the N-S frames and HSS 8x8x1/2 for the E-W frames. Frames two and three are connected by two intermediate frames at the roof. The diagonal members of the two intermediate frames are HSS 8x8x1/4. Frame three is an eccentric braced frame while all the other frames are concentrically braced.

Typical Floor Plans – With Lateral Frames Highlighted

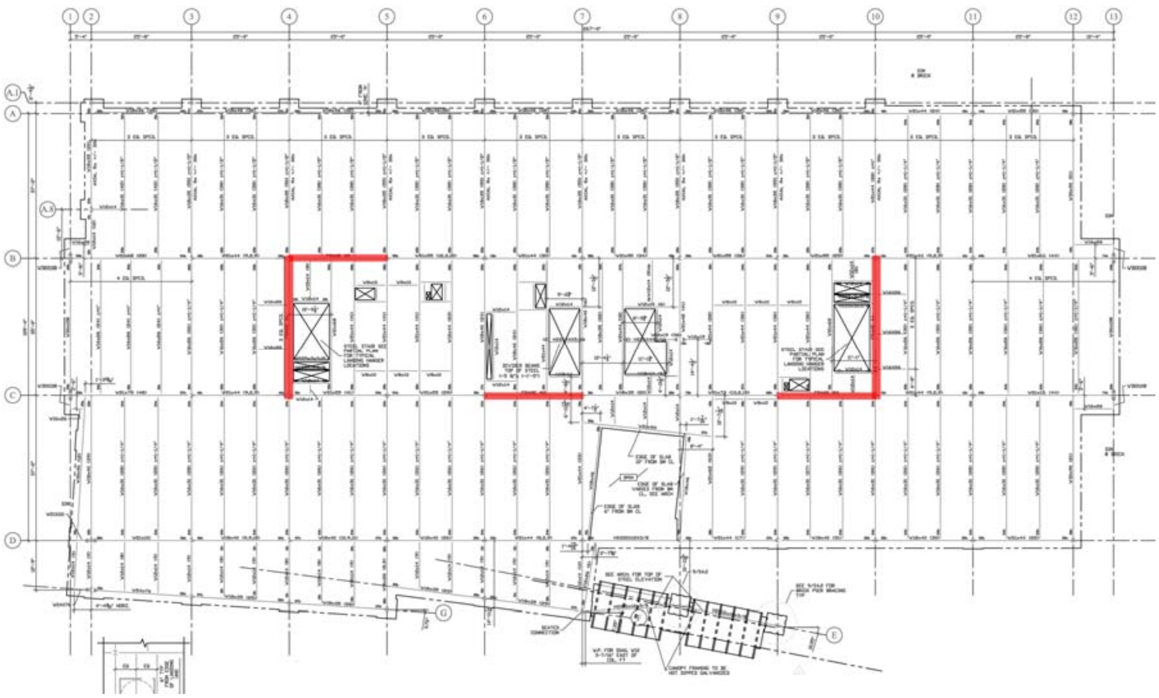

Fig 3.1 – 2nd Floor plan with highlighted frames

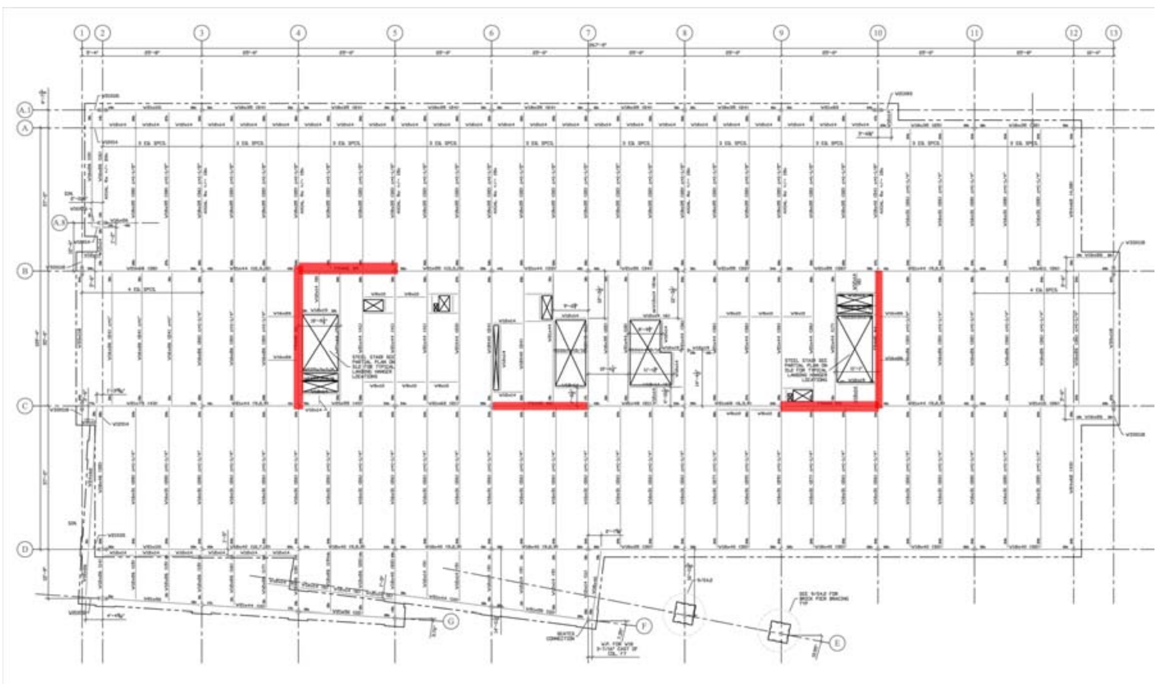

Fig 3.2 – 3rd Floor plan with highlighted frames

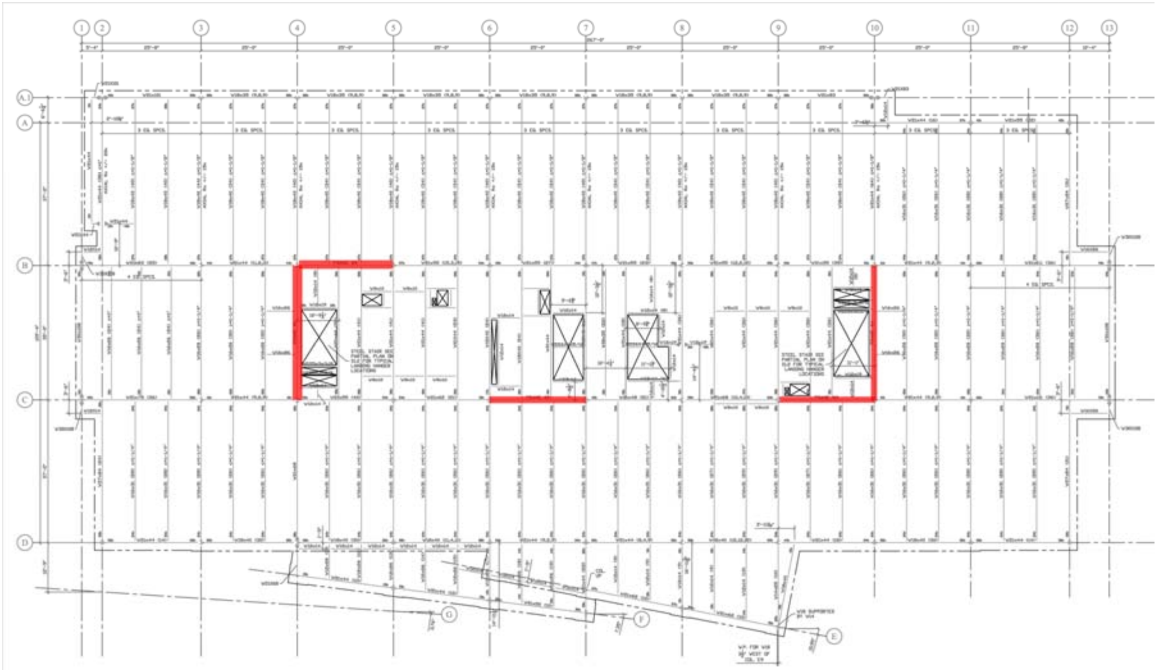

Fig 3.3 – 4th floor plan with highlighted frames

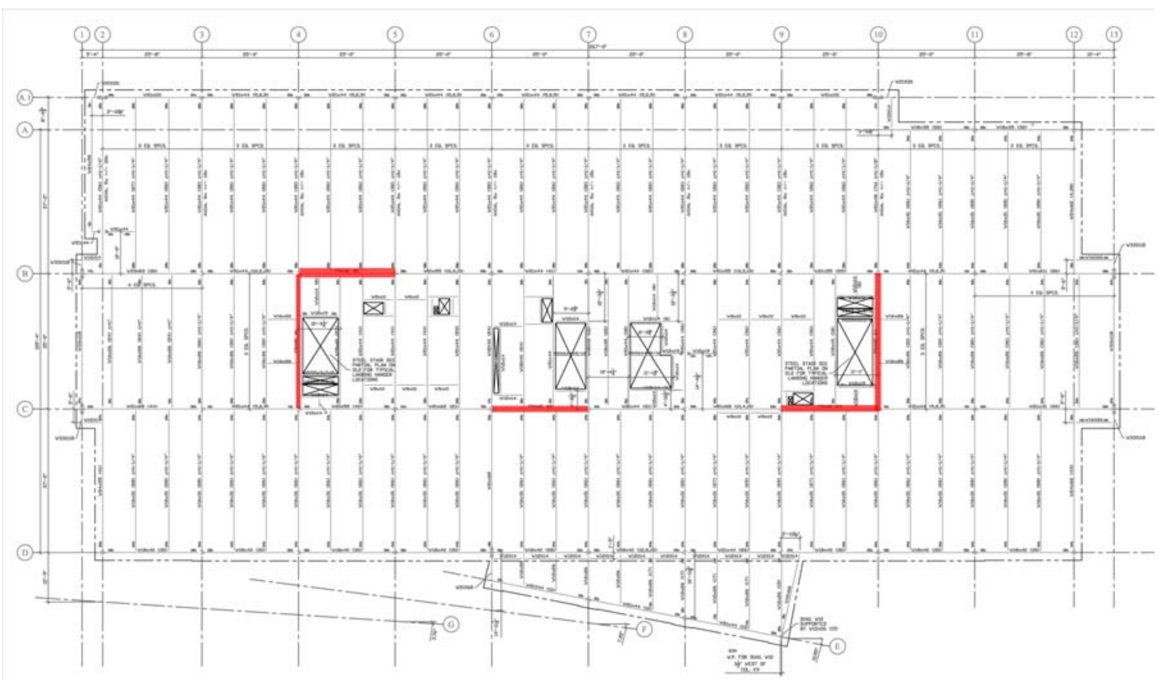

Fig 3.4 – 5th Floor plan with highlighted frames

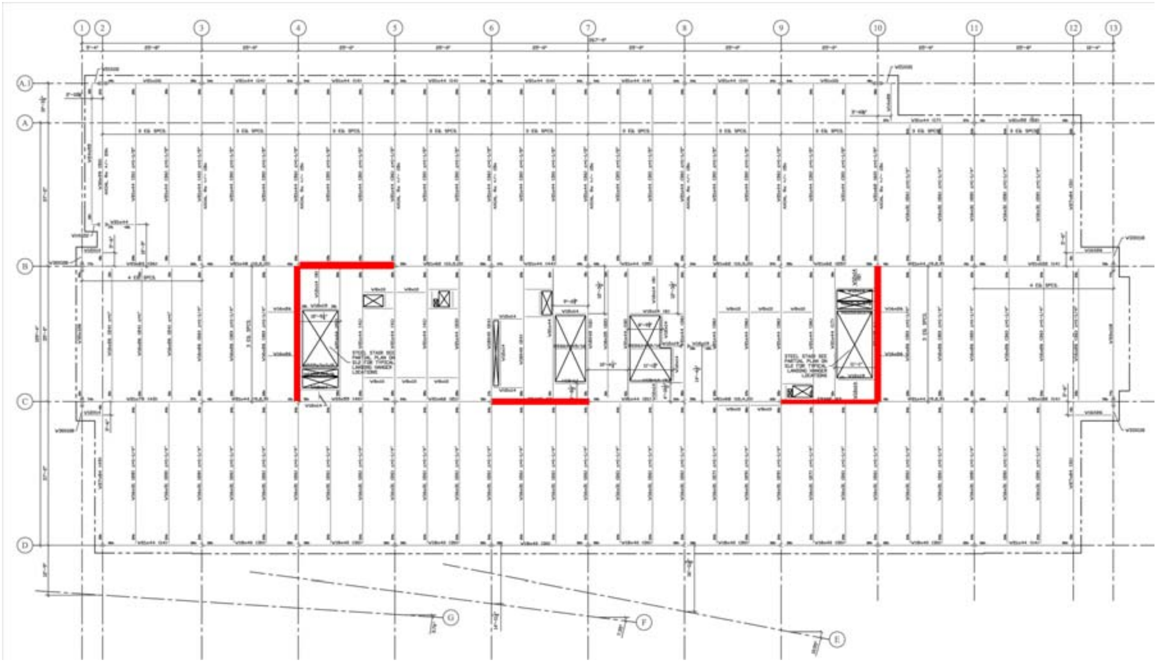

Fig 3.5 – 6th Floor plan with highlighted frames

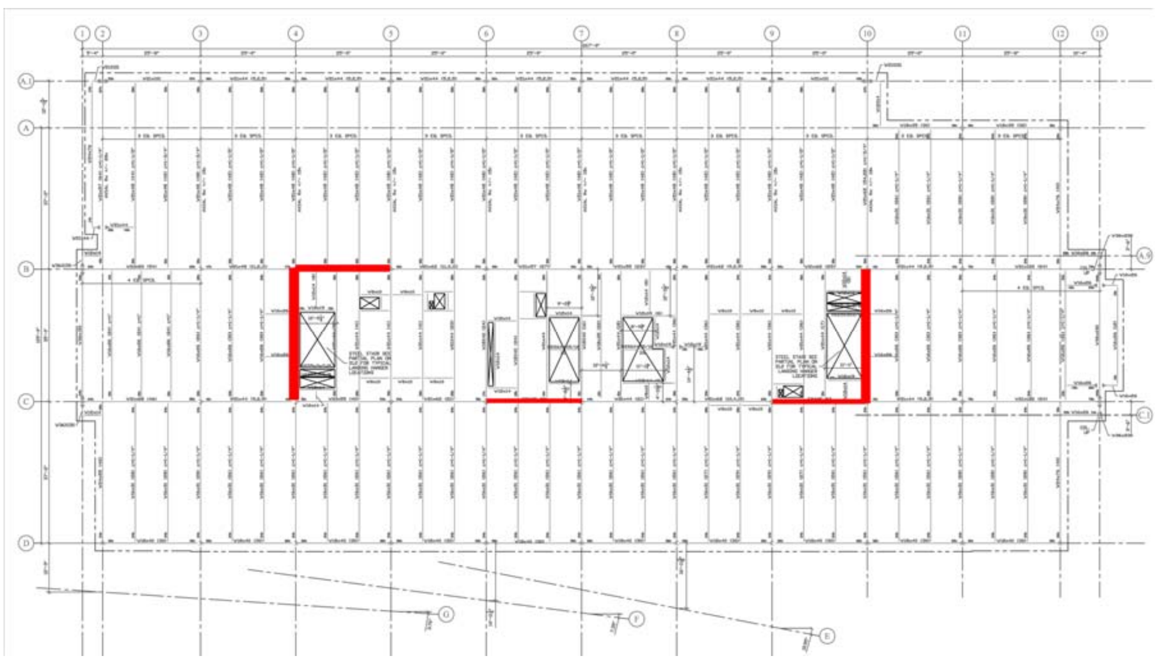

Fig 3.6 – 7th floor plan with highlighted frames

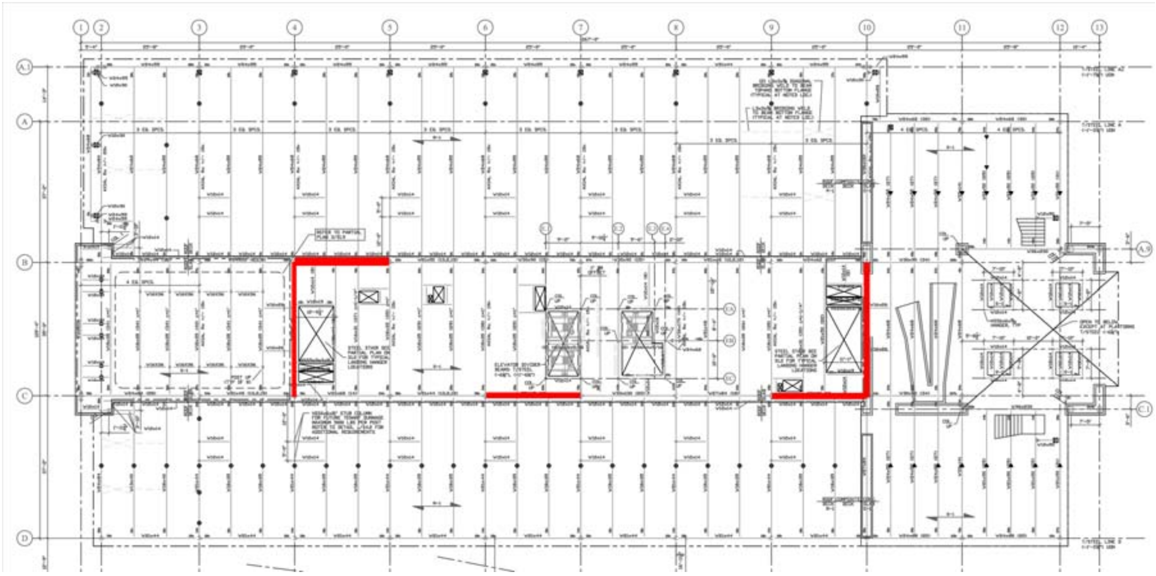

Fig 3.7 – Roof plan with highlighted frames

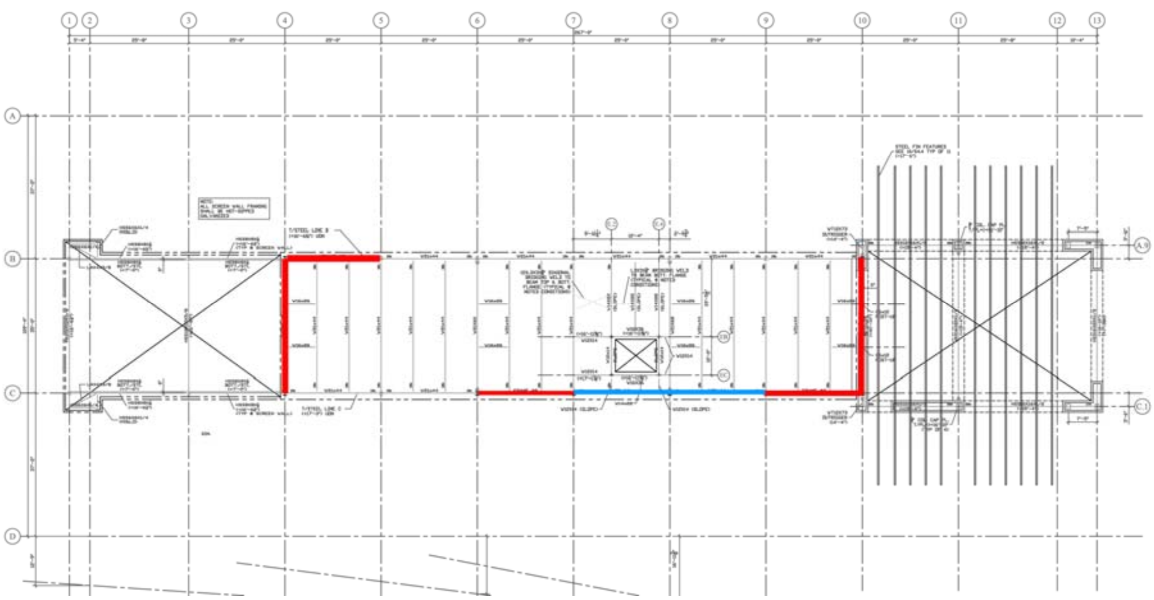

Fig 3.8 – Penthouse Roof plan with highlighted frames

Gravity Loads

Live Loads – IBC Table 1607.1	
Roof Garden	100 PSF
Offices	70 PSF
Corridors	80 PSF
Stair and Exits	100 PSF
Lobbies and First Floor Corridors	100 PSF

Table P.1 – Live Loads

The value of live load for offices includes a 20 PSF addition for partitions. To be consistent with the original design a value of 100 PSF will be used as the live load on a typical floor.

Snow Load Chapter 7 ASCE7-05	
Pg	30 PSF
C_e	0.9
C_t	1.0
I	1.0
$P_{f,\ min}$	20 PSF
$P_{f,\ Calculated}$	18.9 PSF
P_f	20 PSF

Table P.2 – Roof Snow Load

The roof live load will be taken to be equal to the calculated snow load of 20 psf.

Dead Loads		
Typical Floor		
Composite Floor System	41 PSF	Estimated Using United Steel Deck Catalog
Misc. (Self wt., finishes, etc.)	10 PSF	Estimated Using AISC Manual of Steel Constr.
Ponding of Concrete	10 PSF	
Roof		
Deck	2 PSF	Estimated Using United Steel Deck Catalog
Insulation	3 PSF	Estimated using AISC Manual of Steel Constr.
Roofing	20 PSF	
Curtain Wall		
Glass Curtain Wall	.215 KLF	From Building Specifications
Pre-cast Assembly	.55 KLF	From Building Specifications
Roof Garden		
	160 PSF	From Materials in Specifications

Table P.3 – Dead Loads

Lateral Loads

Wind

(See Appendix for complete spreadsheet of wind calculation)

Total Worst Case Wind Load Each Direction	
z (ft)	P (psf)
0-15	12.503
20	13.140
25	13.650
30	14.160
40	14.924
50	15.562
60	16.071
70	16.581
80	17.091
90	17.473
100	17.728
115.17	18.212

Table P.4 – Wind Load

Seismic

(See Appendix for complete spreadsheet of seismic calculation)

Seismic Force Distribution						
Floor	w_x	h_x	k	$w_xh_x^k$	$\Sigma w_ih_i^k$	C_{vx}
Base	--	--	--	--	--	--
2	2561.24	15.00	1.00	38418.56	1030201.93	0.037
3	2692.77	28.33	1.00	76295.25	1030201.93	0.074
4	2563.19	41.67	1.00	106799.39	1030201.93	0.104
5	2570.64	55.00	1.00	141385.17	1030201.93	0.137
6	2536.08	68.33	1.00	173298.77	1030201.93	0.168
7	2645.26	81.67	1.00	216029.31	1030201.93	0.210
Roof	2638.54	96.67	1.00	255058.81	1030201.93	0.248
Penthouse Roof	198.98	115.17	1.00	22916.67	1030201.93	0.022
						1.000

Floor	F_x (Kips)
Base	770.19
2	28.72
3	57.04
4	79.84
5	105.70
6	129.56
7	161.50
Roof	190.68
Penthouse Roof	17.13
	770.19

Table P.5 – Seismic Floor Shear

Statement of Problem

A structural system must be designed to resist both the applied gravity and lateral loads described in tables P.1 through P.5 of the preceding section. This system must also maintain a maximum amount of rentable space on each floor. The structural system must also be able to be constructed in a short amount of time to allow for tenants to begin moving into the building. The total depth of the system must allow for a floor to floor height of at least 15' on the ground and 7th floors and 13.33' on all other floors. This must also allow for a floor to ceiling height of at least 9' on all floors. The structural system must also be able to accommodate the significant architectural features of the building such as its sloping columns and roof garden.

Proposed Solution

The proposed alternative shall be a post-tensioned slab and beam system. It was determined through technical report 2 that the post-tensioned system is the next best alternative to the existing composite steel system. The post-tensioned system will allow for the desired span lengths in the original design while also providing the minimum required floor to ceiling heights. I plan to place post-tensioned beams along each N-S column line which will support a post-tensioned slab spanning the E-W direction. I will also investigate the possibility of using the post tensioning to distribute the lateral load caused by the sloping columns into the slab, forcing the slab to act as a deep beam.

The potential for the post-tensioned system to increase the overall weight of the building will also require that I redesign the lateral system. I plan to look at the moment frames created by the beam-column bents. If needed shear walls located at the emergency stair wells and elevator shafts within the central core of the building will also be considered.

Solution Method

To accomplish the redesign I will follow the guidelines outlined in ACI-318 for concrete post-tensioned systems. Ram Concept and RISA3d will be used to aid in the design and will be backed up by excel spreadsheets. The first step will be to determine a minimum slab depth from ACI-318. Once the slab depth is determined then the design for the post-tensioning for the slab itself can be accomplished. The next step will then be to design the post-tensioned beams.

After the slab and beams have been designed the effects of the lateral load of the sloping columns can be investigated for each floor. This step may conclude that the slab thickness needs to be increased to provide resistance to the induced lateral load of the sloping columns. If the slab depth increases significantly then the slab and beam designs will be redone to accommodate the additional self weight of concrete.

Gravity columns will then be designed, both composite steel and concrete columns will be considered for the columns in the alternative design. The composite columns may result in smaller dimension columns at each floor level adding to the rentable space.

The lateral system will be the next portion of the building designed. To accomplish this, the lateral loads will be recalculated based on revisions made to procedures done in technical assignment 3. The loads will then be applied to the moment frames using 2d models in RISA3D to determine relative stiffness and deflection. The RISA models will then be backed-up by hand calculations and spreadsheets. If necessary shear walls will also be designed using RISA3D.

Task and Tools

Loading

- Recalculate dead and live loading using IBC 2003 and ASCE7-05
- Determine preliminary slab thickness using ACI-318
- Determine additional dead load from initial slab thickness

Post-Tensioned Floor System Design

- Design PT Slab
- Using loads determined find a preliminary beam size
- Check self weight
- Check slab depth to resist lateral load from sloped columns
- Create RAM Concept model to check designs

Gravity Columns

- Determine Axial Load in columns
  - Determine concrete column size
  - Determine composite steel column size

Design Lateral System

- Determine Controlling lateral load
  - Recalculate seismic load for new system
  - Check wind loading for any changes
- Create RISA Shear Wall Models
  - Check drift and stiffness
- Create Back-up calculation spreadsheets
- Check members and adjust as needed

CM Breadth Study

Mechanical Breadth Study

Prepare Final Presentation and Report

Time Table

(See scheduling table on next page.)

Breadth Study

Construction Management

Parkridge Center – Phase 6 is a commercial office building meaning most if not all the space in the building will be rented out. The switch from a composite system to a post-tensioned system for Parkridge 6 poses several scheduling issues that will need to be looked at; the need for tensioning of the cables to be done after concrete meets strength could cause delays. The tensioning will be phased in a way to get the base of building occupied as soon as possible. A detailed cost analysis will also be performed.

Mechanical

Parkridge Center – Phase 6 currently uses a variable air volume system with central air handling units. The switch to a post-tensioned system will potentially cause problems with the large openings required for the supply and return ductwork. The floor slabs will be checked for strength at these openings. Also the floor to floor clearance will be coordinated with the current duct sizes. An alternative water-air system may also be investigated which would include the use of a ground source heat pump.