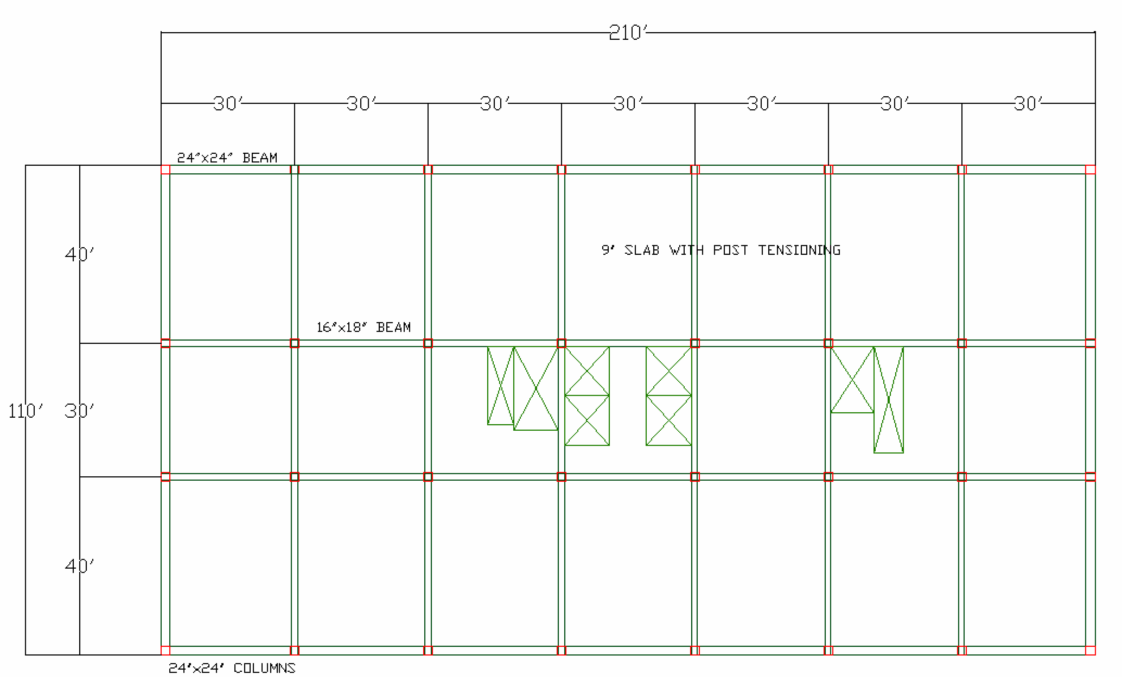
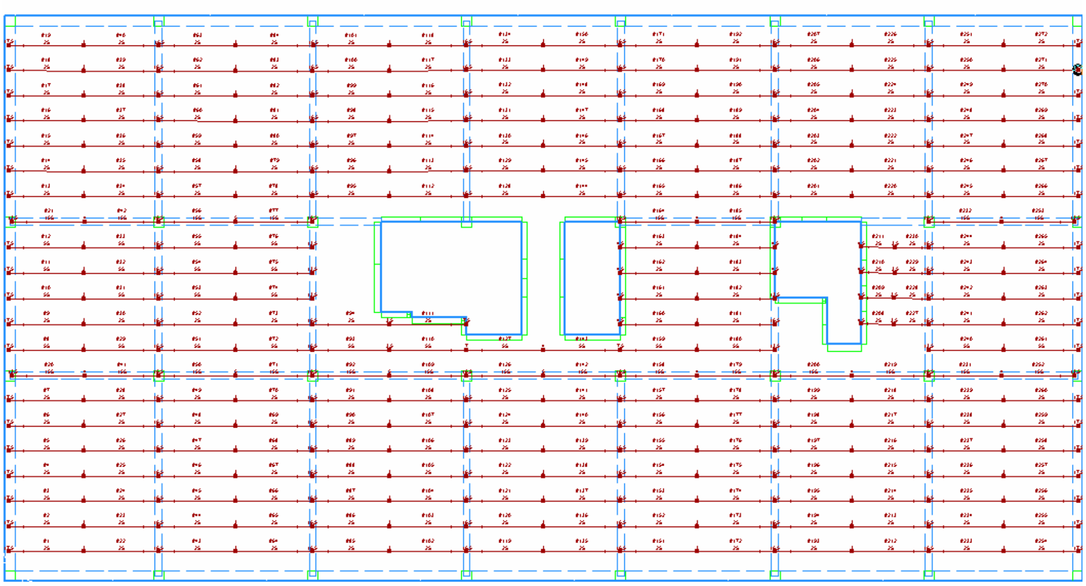
Depth Study

Proposed for my in depth study of Building B is a check of two alternate structures, both consisting of cast-in-place concrete. The first uses the same column layout as the existing steel structure, using 40’ x 30’ and 30’ x 30’ bays, while the second adds a row of columns in the east/west direction, cutting down the bay size to 30’ x 27.5’. Also, due to both alternate structures being concrete, shear walls will be investigated and compared to the existing braced frame lateral support. RAM Concept was used for the design of both concrete floor systems, with the use of excel spreadsheets and PCACOL for the design of the columns.

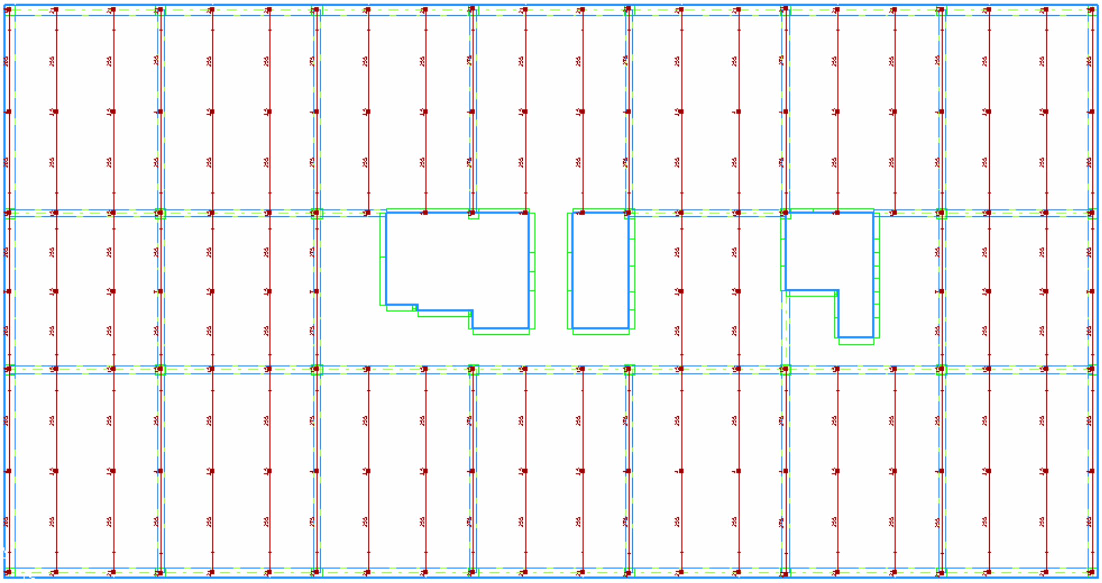
The first alternate structure being looked at has the same column layout as the original building. A post tensioned flat slab with drop panels was my original design for the floors, but throughout the design process this was changed to a flat slab with beams spanning from column to column. The structural plan of the floor system is shown below.



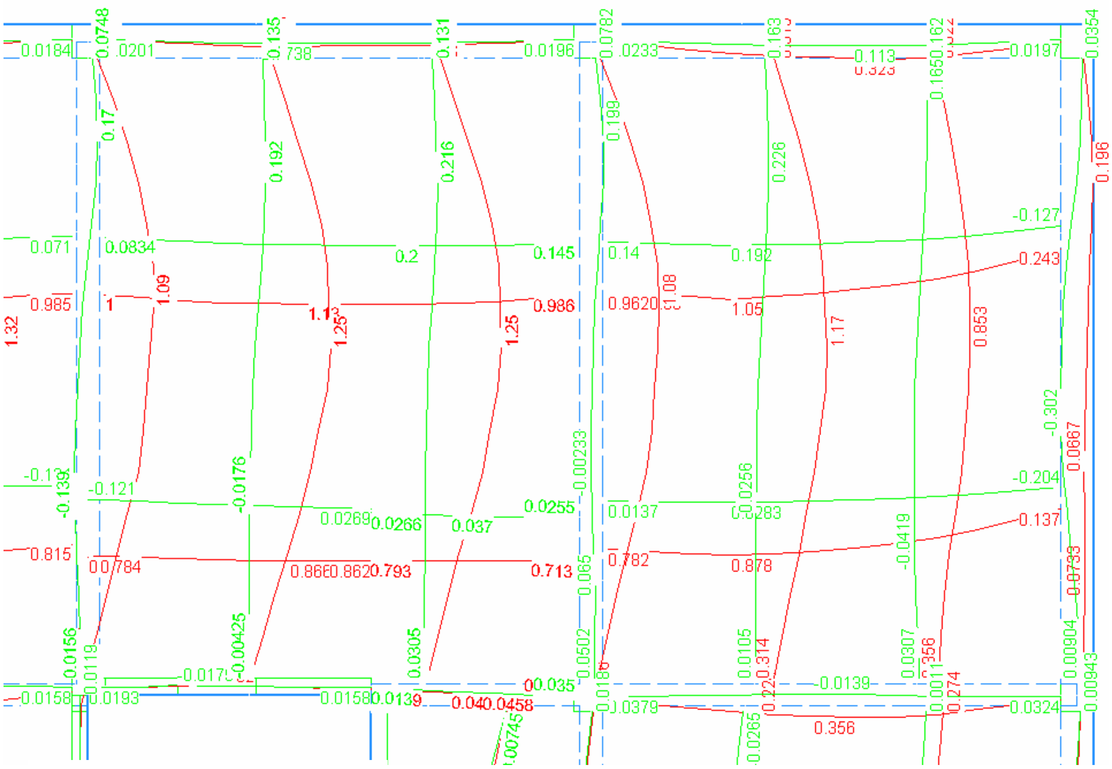
The floor system of Building B is made up of a 9 inch flat slab, 16” x 18” interior beams, 24” x 24” exterior beams, and post tensioning in both directions. When working through the design of the floor, a 9” slab was necessary due to the amount of deflection occurring in the larger span. The use of any shallower slab would cause deflections greater than 2”, which is the limit when considering L/240 for the maximum allowable deflection. All of the beams were designed to aid in the strength of the system, as well as counteract punching shear at the columns. The exterior beams are larger than the interior beams due to the amount of moment being transferred to them by the interior beams and slab. Post tensioning was needed to help limit the deflection in the slab. The area needing the most post tensioning was located along the beam in the 40’ span direction. A maximum of 27 strands of ½” unbonded tendons were needed in order to create an allowable span. 25 strands were used for the rest of the tendons in the north/south directions. In the east west direction, 5 and 15 strands were used, the greater being used along the beams. Post tensioning plans in both directions, as well as a deflection plan of a section of the building are shown below.



Lateral Tendons



Longitudinal Tendons



Deflection Plan – Northeast section of Building

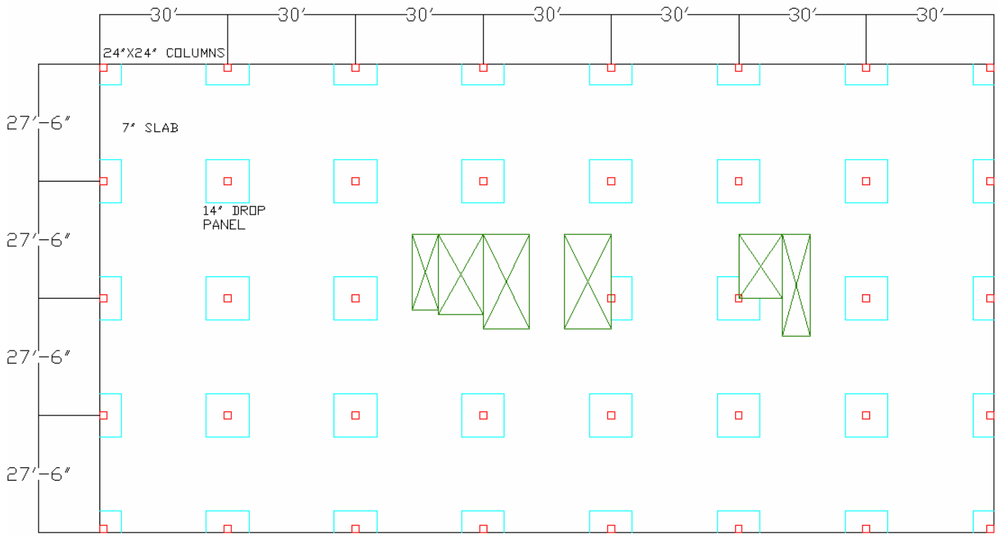
Final Presentation

The design of the columns for this system include 24" square columns for the 4th through 9th floors, 28" square columns for the 2nd and 3rd floors, and 32" square columns for the 1st floor. The columns were sized through the use of PCACOL, assuming biaxial loading. Axial loads were calculated using tributary area method. Also, moments on each column were taken from RAM Concept calculations. For the design of each floors column sizes, only the worst case scenario was considered and used for every column on that floor in order to maintain uniformity and create an easier build. Detailed Calculations through excel and a summary of Calculations from PCACOL can be found in Appendix A.2. Also, a summary of the column sizes and reinforcement is shown below.

40'x30' Layout

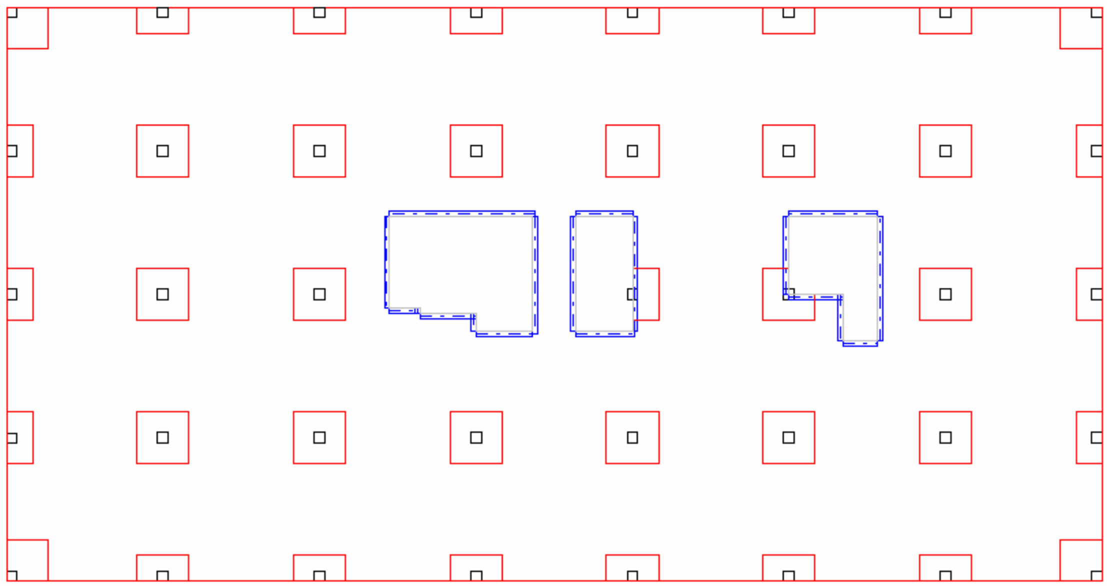
Floor	Column Size	Reinforcement	Area of Steel (sq in)	Applied Loads			Allowable Loads		
				P (k)	Mx(ft k)	My(ft k)	P (k)	Mx(ft k)	My(ft k)
9	24"x24"	8 - #8	6.32	205	-158	37	568	-449	105
8	24"x24"	8 - #8	6.32	486	229	28	897	429	53
7	24"x24"	8 - #8	6.32	754	229	28	1111	353	44
6	24"x24"	8 - #8	6.32	1021	229	28	1246	283	35
5	24"x24"	8 - #8	6.32	1289	229	28	1297	240	30
4	24"x24"	12 - #10	15.24	1556	229	28	1580	234	29
3	28"x28"	12 - #9	12.00	1824	229	28	1873	235	29
2	28"x28"	20 - #9	20.00	2091	229	28	2127	224	28
1	32"x32"	12 - #10	15.24	2360	229	28	2433	226	28

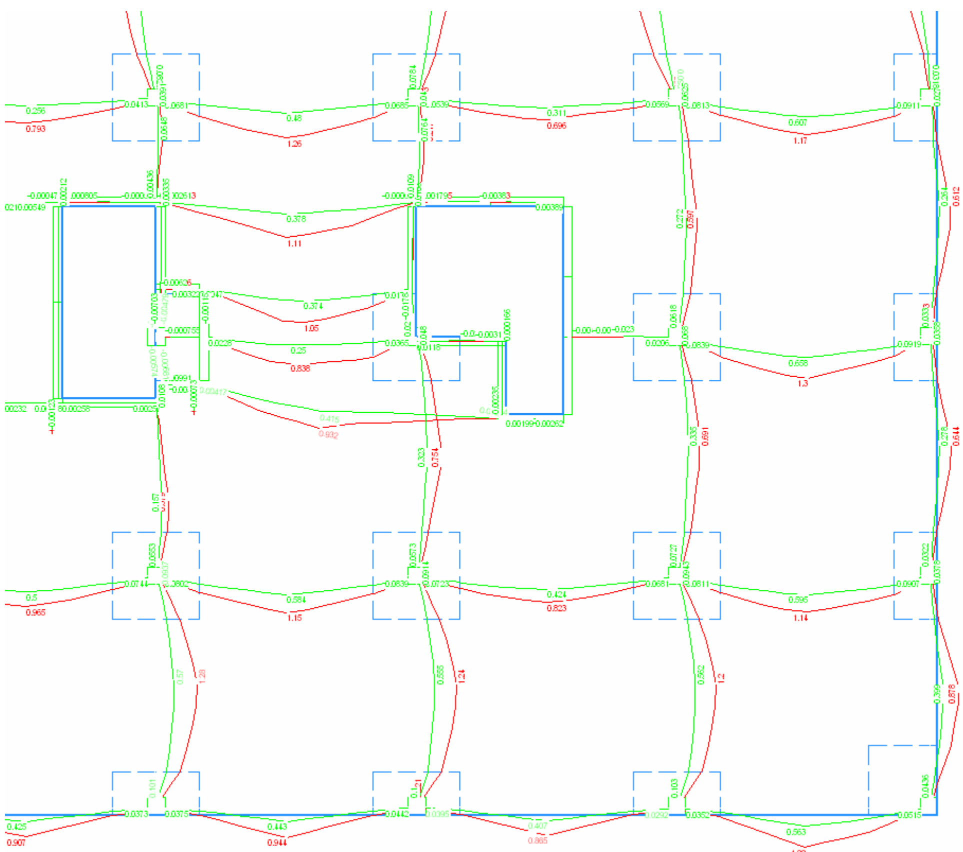
The second alternate structure investigated added a row of columns creating 1 uniform bay of 30' x 27.5'. The floor system for this design is a flat slab with drop panels. The structural plan is shown below.



The floor system of this design uses a 7" flat slab with 14" drop panels, sized at 10' x 10'. The drop panels increase in size around the corner columns in order to accommodate for punching shear. These panels are the same depth as the others, with an 8' span in both directions. Due to the decrease in bay size, post tensioning was not needed for the design to work. Reinforcement in the slab ranged from as little as 5 # 4 bars along the edge beams to as much as 30 #8 bars starting at the middle of the slab. This seems like a large number, but being spaced out over 15', it isn't quite as congested as assumed at first glance. Considering L/240 for maximum deflection, or a maximum deflection of 1.5", every span was acceptable. The worst deflection, which occurred on the southeast section of the building, was 1.3". A plan of the floor system, along with a deflection plan of the southeast corner of the building can be found on the next page.

Final Presentation





The design of the columns for this system includes 24” square columns for the 2nd through 9th floors and 28” columns for the first floor. As with the first alternate design, the columns were designed using PCACOL, assuming biaxial loading. Axial loads were calculated in excel using the tributary area method. Moments were found in RAM Concept. Detailed Calculations through excel and a summary of Calculations from PCACOL can be found in Appendix A.2. Also, a summary of the column sizes and reinforcement is shown below.

30'x27.5' Layout

Floor	Column Size	Reinforcement	Area of Steel (sq in)	Applied Loads			Allowable Loads		
				P (k)	Mx(ft k)	My(ft k)	P (k)	Mx(ft k)	My(ft k)
9	24"x24"	8 - #8	6.32	142	155	-149	283	233	-301
8	24"x24"	8 - #8	6.32	341	115	-149	736	259	-336
7	24"x24"	8 - #8	6.32	530	115	-149	1010	229	-297
6	24"x24"	8 - #8	6.32	714	115	-149	1175	193	-250
5	24"x24"	8 - #8	6.32	898	115	-149	1267	165	-213
4	24"x24"	8 - #8	6.32	1082	115	-149	1297	138	-179
3	24"x24"	8 - #8	6.32	1266	115	-149	1297	120	-155
2	24"x24"	12 - #9	12.00	1450	115	-149	1477	120	-155
1	28"x28"	8 - #9	8.00	1634	115	-149	1746	127	-164

Due to the change from steel to concrete, shear walls were designed to replace the steel braced frames in order to resist lateral loads. The walls are 12” thick and are located exclusively around the openings on the interior of the building. The design was checked through the use of ETABS. A total drift of 0.79 inches was found when designing for the worst case loads, seismic. Compared to the steel braced frame of the existing design, this dropped the total drift by nearly 50%. Even with the decrease in drift, both designs were well below the allowable drift of 3.68”.