## Structural Analysis

5.1 - Existing Conditions

The CSUF is comprised of a concrete frame, with concrete slab floors. On the third floor there are two type of columns used to support the roof. As illustrated in Figure 1, the columns along the west wall are square, with a side length of 24" and the rest of the columns are circular with a diameter of 30". For the third floor, the beams are 44 by 26 inches. An 8 inch slab rests on top of the beams and the floor to floor height for the 3rd floor is 19 feet. The circular columns were reinforced with 6#10 rebar, and the square columns were reinforced with 8#11 rebar. Columns A1 and A2 are designed around the stairwell, and were not considered in the analysis.

The column with the largest bay area and load was used to size the existing columns. For the circular columns, the largest bay area, located on column B8 is 646 sq. ft. Column C8 is the square column with the largest bay area equaling 366 sq. ft. The roof design dead load was 62.22 lb/sf. The snow load was 0.02 lb/sf. The live load was 0.15 lb/sf. These were the loads I used in my redesign calculations.

The original green roof can be seen in Figure 2. The gap between columns B4 through B7 and C4 through C7 is due to a mechanical pad that supports an air handling unit and relief fan. These columns were not downsized because even though the green roof around them was removed, they still need to support the mechanical pad. The other gaps in the green roof are due to skylights and exhaust fans.

All the circular and square columns are the same size. This helps ease the construction process because the contractor can use the same formwork for different columns, and will not need to worry about placing the wrong size column in the wrong place.

Figure 1 – Typical Framing Plan (North Wing)

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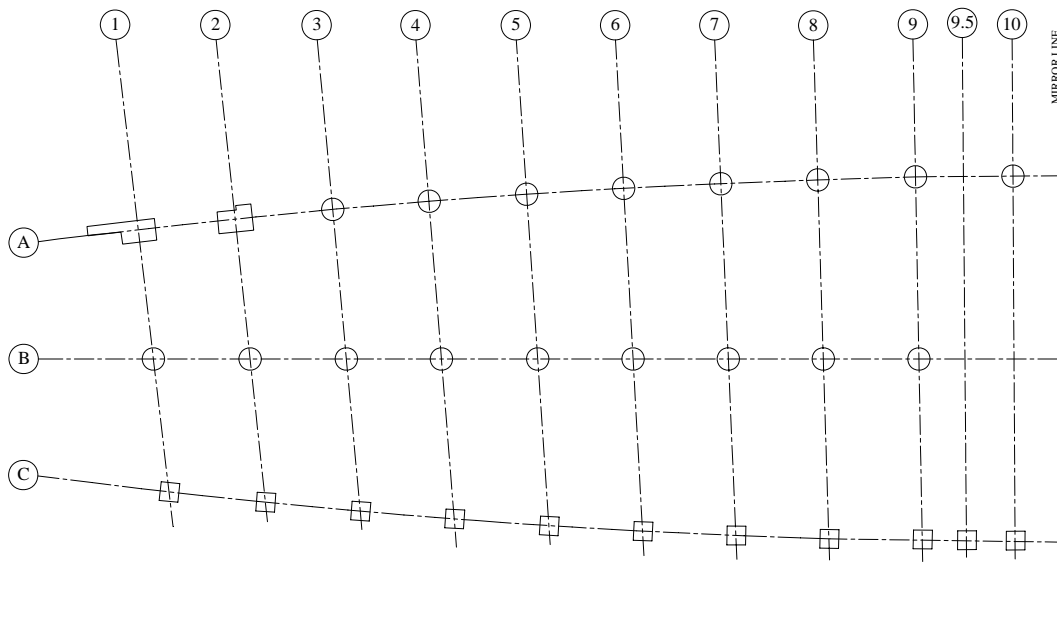
Figure 2 – Original Green Roof Coverage Area (North Wing)
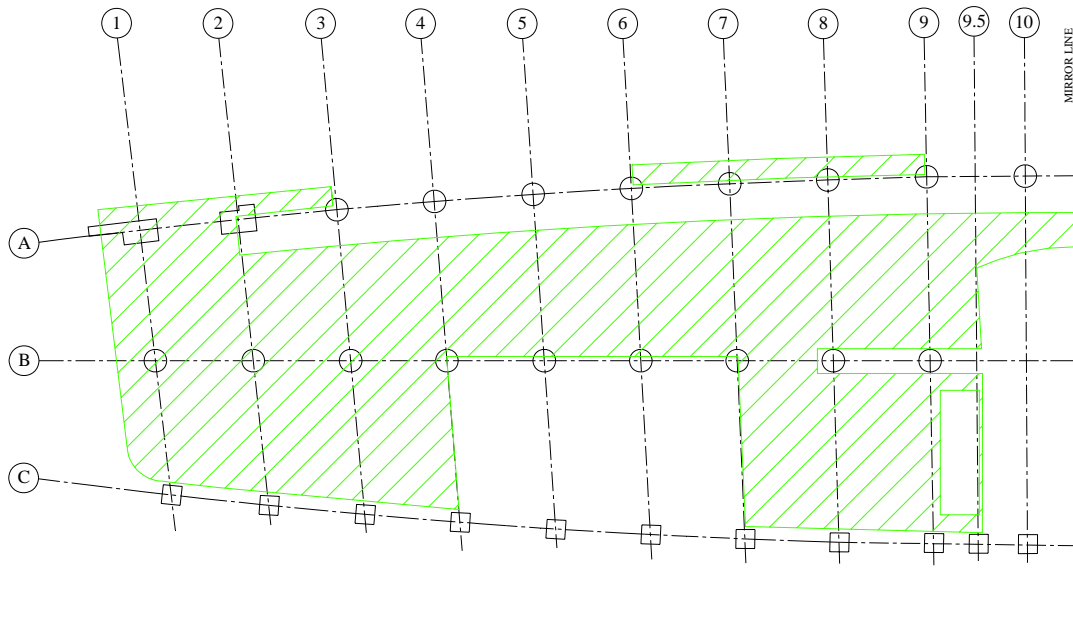
5.2 - Redesign Procedure

As the green roof is reduced in size, some of the columns' dead loads were also reduced. Even though the green roof was reduced by small increments, every reduction was done to the same area, so that columns were able to be downsized faster. This can be seen in the Structural Appendix Section, Figures 1 to 7. To keep the ease of the construction process the same, the columns were only reduced in size to their minimum, meaning that only after the green roof was removed from the columns' entire bay area, was it reduced in size. This means that there are now two differently sized circular columns, and 2 differently sized square columns. The smaller columns will be placed starting on the north wing, while the large columns will be placed on the south wing. Even though there are 4 different types of columns, the ease of construction should still be the same.

To calculate the reduced load, the weight of the green roof was subtracted from the design dead load listed above. The weight of the green roof was calculated using data supplied by the manufacturer (Table B.1). The following equation was used to calculate the reduced force on each column.

Total Load = (1.6)Live Load + (1.2)Dead Load + (0.5)Snow Load   Eq. (2)

ENERCALC, a program used to size columns was used to calculate the size for a column with the reduced force. An example of the calculations can be found in Appendix B.

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5.3 - Redesign Results

The results are shown in Table 8. Table 8 also shows the difference between the large and small columns.

Table 8 – Designed and Redesigned Column Information

	Large Circular Column	Small Circular Column	Large Rectangular Column	Small Rectangular Column
Size	30" Diameter	14" Diameter	24"x 24"	12"x 12"
Reinforcement	6 #10	8 #8	8 #11	8 #6
CY of Concrete	3.45	0.75	2.81	0.71
Lbs of Steel	491	406	808	286

Figures B.1 to B.7 (Located in Appendix B) illustrate the columns that can be reduced in size to the small column after the green roof was removed. Table 9 shows the number of columns used in each design.

Table 9 – Number of Columns Used in Design and Redesign

Green Roof (%)	Large Circular Columns	Small Circular Columns	Large Rectangular Columns	Small Rectangular Columns
66 - Designed	34	0	20	0
60	34	0	20	0
55.	33	1	19	1
50.	32	2	18	2
45	29	5	17	3
40	29	5	15	5
35	27	7	15	5
30	21	13	15	5