Floor System Re-design

Currently, the floor system in place for The Helena is a flat plate slab. The slab is 12” for the ground and sub-grade floors and 8” for all residential floors. This floor system was chosen to be the best solution for the column layout which was designed by the engineers. A flat plate slab also seems to be the only viable solution for such a layout. The concept for this re-design was based off of the ability to be able to move the column placements within the building’s layout and design a new layout which would make it possible for the design of other floor systems which could be more beneficial or accommodating for the owner and residents.

In the previous section, the columns were re-designed into a grid pattern in an attempt to create typical bays and open up the ability to design for different floor systems which could be better solutions for the floor system design. In Technical Assignment #2, a structural floor system analysis was done and a flat plate slab was determined to be the best solution for the existing column layout. It was because of this lack of options for alternative floor systems that initiated this proposal for an analysis of alternative floor systems which would be possible solutions given the column placements conditions required for them to be functional.

ALTERNATIVE FLOOR SYSTEMS CONSIDERED

Since the columns were designed to be made from concrete, only concrete alternative floor systems were considered. The first of these was the one-way slab system. This system works best for rectangular shaped bays. It consists of a slab reinforced with rebar spanning in only one direction. The slab then rests on beams which will transfer the loads into girders and those girders will send the load into the columns. The rebar spans in the short direction because that is the way the load path will naturally take. It is not beneficial to place rebar in the long direction because the loads will want to transfer themselves through the shortest possible distance and the rebar will have no effect on helping the loads follow the long bay direction. A disadvantage to this system is the formwork will take more time to erect since the beams are poured integrally with the slab. One advantage to this, however, is the conduit can be placed below the slab between the beams, taking less time to pour the slab. Not as much time is needed to place the conduit in the slab, so the slab can be poured quicker because of this. Since the conduit can be placed after the pouring of the slab, the forms will not be needed

and can be used to get the next pour set up, decreasing the amount of time it takes to pour the floor system. The use of a slab plus beams and girders will make this system too deep for the parameters of this building. A flat plate slab system will be much shallower than a one-way slab system and have less of an effect on the overall building height. The use of floor-to-ceiling glass gives the building a sense of seamlessness and the look would not be expressed as well if the floor system was deeper.

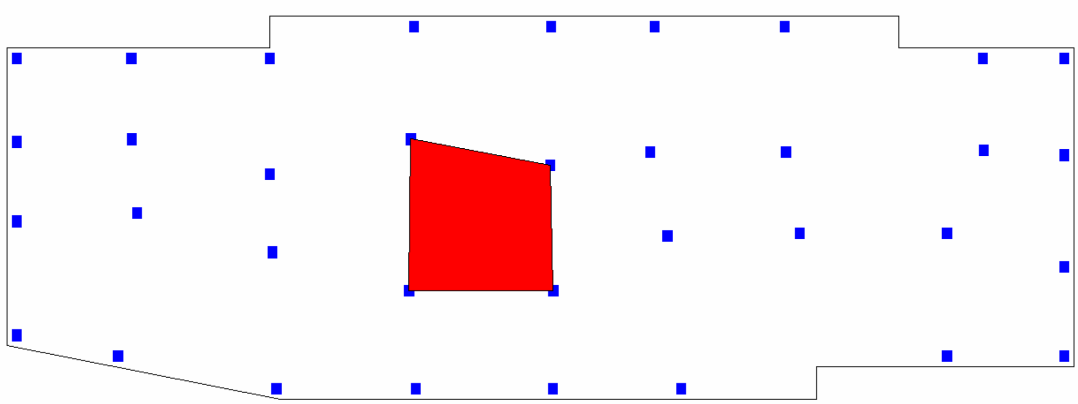
A post-tensioned slab was another floor system which was considered. Post-tensioning is accomplished by adding tendons inside of the concrete slab which are then tightened to give the slab added support. The tendons will span across the slab and the force from the tendons will be great enough to cause the slab to act as a one-way system. This system is not a bad alternative considering the length of the building is 2.5 times the depth which could make it easy for the system to be made into a one-way slab. Keeping the system in the form of a slab will help to minimize the depth of the system as well as the overall building height and also maximize plenum space. There are disadvantages to using a post-tensioned slab however. The cost and time for the project will be greater. It will take more time to have to add the tension into the slab after it has been poured than to just have a slab that needs to be poured and move to the next one. It is also more involved to make any alterations to the slab. If any holes need to be cut into the slab for mechanical ductwork or conduit to pass through, the locations of the tendons must be carefully documented to ensure they are not ruptured.

Finally, a pre-cast concrete plank floor system was analyzed and, along with the re-location of columns, considered to be the best viable solution for an alternative floor system. The planks are not very deep members and they will rest upon members which will rest on the columns, making for less transfer of loads and a shorter load path than the one-way slab system. There are many benefits to using a pre-cast concrete plank system. It is well suited to carry large loads across long spans because of the pre-stressed reinforcement designed into the member. The members are made from the same ultimate strength concrete as other systems are molded in. The material is strong, durable and does not require much maintenance. It is created off-site in factories where optimal conditions are created and the pieces can be precision made to adjust to the sizes and special details required. Once brought on-site, it only needs to be put into place and connected. This means much faster construction and also helps to make it more favorable to any weather conditions as opposed to having to cover a building to heat it or using admixtures in concrete to help it cure faster.

The planks also meet the required fire resistance rating and do not require any additional fireproofing saving time and money. This pre-cast system is also recognized by the Leadership in Energy and Environmental Design (LEED) rating system. With the building trying to achieve a gold LEED rating, this system just seems to fit the overall theme of the building very well.

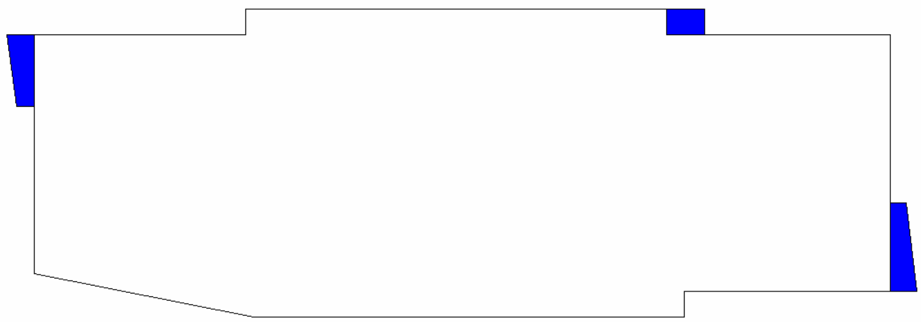
PRE-CAST CONCRETE PLANK DESIGN

The largest bay within the floor plan was selected to designate the design of the floor plank size. Even if the design would allow for smaller plank sizes at a different bay of the floor, it would not be worth designating a different plank size because of the care that would need to be taken during the construction process. The planks are designed with two different depths, 8 and 12 inch. It would not be hard to tell these different planks apart, however, it would be extremely hard to differentiate between the planks which have 4 bars of reinforcement as opposed to those having 6 bars. Trying to keep track of which plank to place at which area would be tedious on-site and would slow down construction. It is much easier to take the planks to the site in one stack in the order they need to be placed in and just let the workers be able to put them in place without having to worry about which is the correct plank for the position.



Design bay used for plank sizing for 12th through 38th floor

The planks were designed to run in the East-West direction to cover the balconies which are found on the Northwest corner, Southeast corner, and north façade of the building. A diagram is provided below to illustrate the balcony locations.



Balcony locations for residential floors

This diagram shows the layout of the 32nd through 38th floor plan which contains all three balcony areas. The balcony on the Northwest corner starts at the 14th floor and continues to the top floor, the Southeast balcony begins at the 30th floor to the top floor and the North façade balcony is in place for floors 30 through 38. Spanning the planks in the East-West direction allows for a much easier design of the balcony area; the planks will simply extend across the member and be cantilevered to the edge.

The loads used for the design of the floor system were taken from Technical Assignment #1 and are as follows:

Dead Loads

<u>Residential Floors:</u>

MEP/Light	5 psf
Sprinklers	5 psf
Finishes	15 psf
Partitions	20 psf

<u>Ground Floor:</u>

Partitions	20 psf
MEP/Light	5 psf
Sprinklers	5 psf
Finishes	15 psf

<u>Parking Floors:</u>

MEP/Light	5 psf
Sprinklers	5 psf

<u>Roof:</u>

MEP/Light	5 psf
Sprinklers	5 psf
Finishes	15 psf

Live Loads – As designated by the New York City Building Code

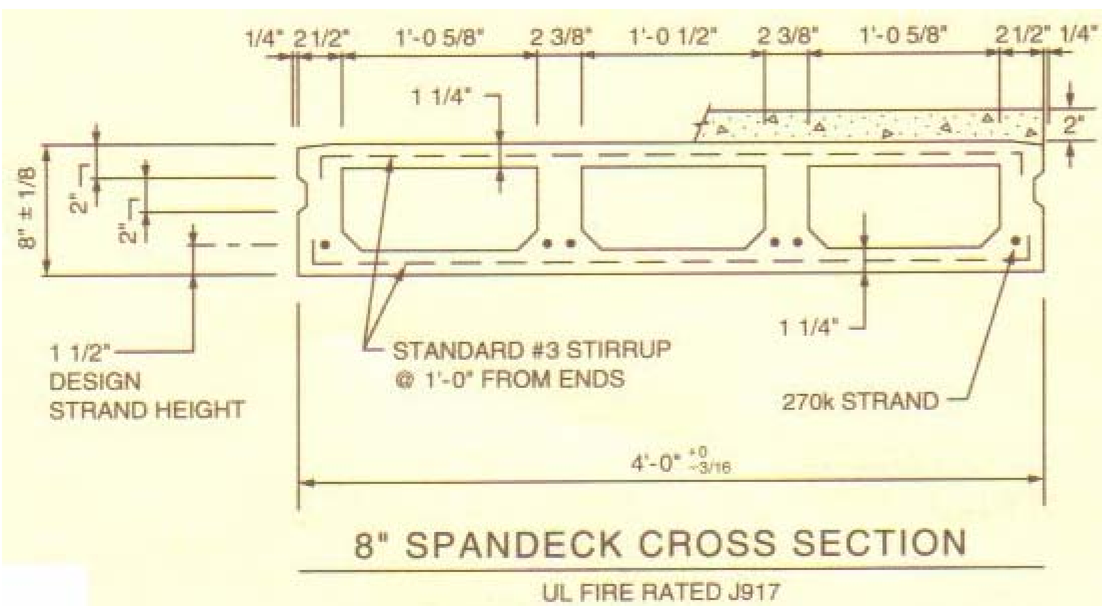
Residential Areas	40 psf
Offices	50 psf
Lobbies	100 psf
Corridors	100 psf
Mechanical Equipment Rooms	75 psf
Stairs	100 psf
Assembly Spaces	100 psf
Parking Areas	50 psf
Retail	100 psf

The plank was designed using materials from Nitterhouse Concrete Products, Inc. The typical bay size measures approximately 25'-8" x 25'-8". Using the loads given by the New York City Building Code and the plank span, a plank depth size and reinforcement strand pattern can be established. A diagram of the load table is shown below.

8" SPANDECK W/2" TOPPING				ALLOWABLE SUPERIMPOSED LOAD (PSF)																						
STRAND PATTERN				SPAN (FEET)																						
				10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Flexure	4	–	1/2"ø	795	718	650	590	500	426	366	317	275	240	210	184	162	142	125	110	96	84	73	60	49	39	
Shear	4	–	1/2"ø	571	509	458	415	378	347	320	296	275	257	240	222	199	178	160	145	133	126	115	103	93	84	
Flexure	6	–	1/2"ø	1155	1040	945	859	732	629	544	474	416	366	324	287	256	228	204	183	164	147	132	118	103	90	77
Shear	6	–	1/2"ø	589	525	472	428	391	360	331	308	286	266	249	235	220	207	195	184	175	160	145	132	120	110	100

Allowable superimposed load table for 8” plank with 2” topping

The 6 strand pattern was chosen with an allowable superimposed load, at 26’, of 133 psf. Each strand is a 270K, one-half inch in diameter and sets 1.25 inches above the bottom of the plank. Additional dead load from the self-weight of the system will be 330 plf. All other information for the plank can be found in the Appendix. The following diagram shows a cross-section of the plank that is to be used for the residential floors.



Cross-section of 8” plank used for residential floors

Once the floor system was designed, the steel members which would support the planks were designed. The 3rd edition Load and Resistance Factor Design (LRFD) steel manual was used for the design. Using the beam tables in the steel manual, it was determined that a W10x49 member is the optimal member and would be sufficient to carry up to 150'K at an un-braced length of up to 30 feet. Because this was found to be among the largest bay in the floor plan and with the support of up to 30 feet of un-braced length, a W10x49 will be the largest member needed to support the pre-cast planks. This will mean that the overall building height will not be affected very much if at all. It is possible to rest the beams on the columns at a little lower height and simply frame around the beam as an interior finish. This would allow for the new floor system to have no impact on a building height change thus making it a more than suitable alternative floor system.