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Structural
MK Parfitt
Office Building*
2/18/06

All renderings courtesy of Dreyfus Property Group and KRJDA

Thesis Proposal

Executive Summary

The design of the office building is not what needs fixed, but rather the problems presented in the design limitations need to addressed. There is a strict height limitation imposed on the site, this affects the possibility of increasing structural floor depth. The existing system utilizes post-tensioned cables to meet the design requirements. The purpose of this report is to propose a solution that meets the same design requirements. After the alternative design is created and analyzed it will be evaluated to see how well it deals with the problems that it was intended to. The solution will only then be compared to the existing system to determine overall usefulness.

Due to the ambiguous results obtained in previous investigations, one specific system was not decided upon for a redesign. Rather, a more in-depth comparison of possible solutions will be carried out. The systems chosen are a composite steel deck floor system supported by a steel moment frame, and a one-way cast in place concrete skip joist.

Three possible breadth work categories are chosen depending on the final selection of a new floor and frame system. In all cases, construction management will play a vital role in the success of the new system. Additionally and somewhat related to that is LEED impact. For the one-way pan joist system, architectural concerns will be considered due to the addition of columns to the plan.

*Building location withheld at owners request

Background

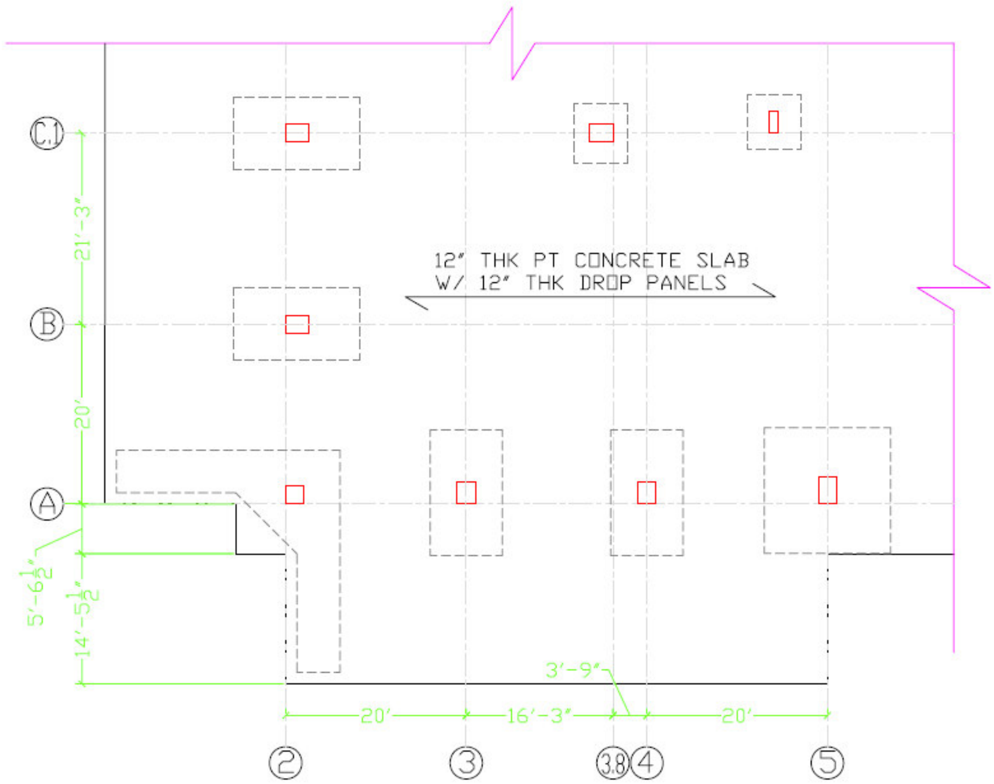
The general system used in gravity load resisting is a mixture of concrete floors systems and load bearing reinforced concrete columns. The below grade floors are flat plate concrete slabs with drop panels, and above grade post-tensioned floors slabs were utilized. Lateral wind and seismic forces are resisted primarily by the rigid moment frames created by the concrete superstructure and to a lesser extent by smaller shear walls that make up the elevator core.

The building has 3 levels of below grade parking. The bottom-most level rests on a traditional reinforced slab on grade. The load bearing concrete columns terminate into reinforced concrete spread footings.

Above the foundation and level 3 parking, but still below the finish grade, there is a flat plate concrete slab. This reinforced slab also employs a few drop panels to maintain the slab thicknesses. These drops are either 5-1/2" or 8". This slab is 8" thick 5ksi normal weight concrete. Columns in this area match columns below and are specified as 10ksi normal weight concrete.

Starting on the second floor things get very interesting. There is a 20' cantilever on the three street facing sides of the building (west, south, and east). This slab is a post-tensioned concrete system with folds and cast beams to account for the overhanging load. The slab is 12" with additional 12" drops. Column C/C distance is typically 20' and there is a 20' cantilever around 3 sides of the building. This span is doubled to approximately 40' between the outer set of columns and the core set. Design live load is a constant 100 psf for all office and corridor areas, which make up the majority of the upper floors. Floors 6 through 12 are all duplicates of one another. Floors 2 through 5 only differ from those in that they include the 5 story atrium space. All concrete is 6 ksi in the post-tensioned slabs. The roof slab is very similar to the other PT slabs.

A representative corner plan is shown below. This area was chosen for analysis and redesign because it is a representative section of the building.



SW CORNER FLOORS 6-12 (TYP.)
NTS

The building is located in downtown Washington, DC. This is an urban setting, which is reflected in several factors in lateral load determination. Its primary use is for standard office tenants, and just meets DC height restrictions at 12 stories and 128 feet. Gravity loads are resisted by a two-way flat slab with drop panels poured around the majority of columns. The slab contains post-tensioned tendons for additional stiffness and an enhanced stress profile.

Concrete is the material of choice in the construction of this building. As stated, the structural system is a two-way flat-slab with drop panels and post-tensioning. The columns, drops, and slabs are all poured integrally and further joined by steel reinforcement. Typical framing details show the moment carrying ability of column-slab joints. Because the slab-column connection is properly reinforced and poured monolithically, the system can be considered a rigid moment frame. The lateral loads are transferred from the glass curtain wall to the slab edge. The slab acts as a rigid diaphragm and uniformly distributes the lateral loads to the columns along each frame section.

Problem Statement

There are no clear problems with the existing design, which is to be expected as the engineers are knowledgeable and competent. Instead, an alternate design will be investigated and then evaluated based on the inherent limitations of the site and usage, then compared with the current design. These limitations that restrict the possible designs are what can be seen as "problems."

The building must retain the overall architectural vision and theme. If this is impacted, then an explanation of the degree of the impact will be necessary. This means that ideally the building will keep the exterior cantilever and façade. The building must be able to maintain its occupancy category and all other building and site specifications.

A mixed use office must be created as an end result of the design. Regional and local zoning requirements should not be violated. Once again, any infringements will need to be discussed and weighed against the benefits of that system. A major limiting factor in the redesign is floor depths. The existing design makes use of all allowable vertical rise in the municipality. The floor depths should not be increased, because it is not very reasonable to reduce the number of occupied floors in the building.

Proposed Solutions

A common construction method used in similar instances is steel moment frame with composite steel deck. This was investigated in the 2nd technical report and seemed feasible, except for an increase in structural floor depth. Regardless this system could still be used as a solution. The concrete columns of the building will be replaced with steel columns in roughly the same locations, preserving the architecture of the space. The floor depth of this system was initially found to be roughly 35 inches deep. This is substantially deeper than the current system, but some methods can be used to create a thinner structural steel system. Heavier decking can increase the decking span, which will require fewer infill beams. Then there will be fewer point loads on the girders with less dead load applied from framing. All decking, beams and girders will employ shear studs to benefit from composite action of the floor slab. When the system depth is reduced to match the existing floor depth, there will then only be an issue of whether the cost is competitive to the existing PT concrete floor.

Solution methods

The composite steel deck system will require a complete redesign of the structural system. LRFD manual of steel construction will be used to size all typical members and proprietary steel deck catalogs will be used to determine decking sizes for gravity loads. The cantilever area will be of special concern as the members and connections must resist excessive deflection. A computer model will be created using RAM steel to determine lateral effects. The lateral resisting system will try to utilize braced frames in the building core, and moment frames where additional horizontal stiffness is needed. The braced frames are not a possibility in the exterior bays due to the open office plan. The necessary connections will be detailed depending on whether moment capacity is needed or just shear.

Tasks and tools

I. Steel Frame Redesign

- A. Grid design
  1. Check and revise column layout
  2. Determine grid sizes and critical spans
  3. Verify that new plan meets architectural needs
- B. Design of floor system
  1. Determine gravity loads per ASCE 7-02
  2. Select decking based on maximum spans/fire ratings/composite action
  3. Layout girders and joist framing
  4. Size joists and girders, check constructability
- C. Vertical load bearing
  1. Calculate tributary areas and floor loads and apply to columns
  2. Sum loads from columns above and apply to columns below
  3. Design footings and details for new columns
- D. Perform lateral frame analysis and design
  1. Recalculate lateral loads based on new structure weight and frame behavior using ASCE 7-02 and IBC 2003
  2. Create RAM model for lateral analysis
  3. Detail connections to meet frame action requirements
- E. Finalize design and details
- F. Construction Management
  1. Cost analysis
  2. Revise schedule
  3. Site layout and constructability
- G. LEED accreditation
  1. Materials and recycling
  2. Construction practices

Timetable

February 2006

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19 Layout Building Grid	20	21	22 Size decking and begin member design	23	24	25 Finish floor system design
26 Design columns for gravity	27	28				

March 2006

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			1 Redesign foundation	2	3	4 Create lateral model
5 Design lateral bracing and connections	6	7	8 Cost analysis and schedule	9	10	11 Site layout and constructability verification
12	13 LEED analysis and implication	14	15	16	17	18
19 Complete breadth work	20 Wrap up final design and details	21	22	23	24	25
26	27	28	29	30	31 Complete final design and details	

April 2006

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
						1
2 Format final report	3	4	5 FINAL REPORT DUE	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28 Classes end	29
30						

Breadth Topics

Construction Management

Any solution will require construction management issues to be addressed. First and foremost a cost analysis will be preformed to determine the amount of cost increase associated with the new system. Steel is inherently a very different material and there are very different costs associated with its use. Also a revised project schedule will be constructed which may or may not affect the project cost. Steel requires an increase in lead time, but in many cases can allow for faster construction. Then the constructability of the redesigned steel system will be investigated. No matter how much better a solution looks on paper, if it cannot be built then it is no good. This includes the actual construction, as well as site layout and delivery factors. The site is in an urban setting and there will be limited space for on-site storage.

LEED Impact

This building is to be certified with a LEED silver rating. Altering the structural system and construction practices will undoubtedly impact the LEED points acquired. The use of steel instead of concrete creates a whole new list of criteria to meet for LEED approval. There are issues with where and how the steel is produced. On-site recycling is also a very big issue. While all that is being checked, additional suggestions will be made on how to possibly increase the LEED rating of the construction.