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Structural
MK Parfitt
Office Building*
12/11/05

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.

Proposed are three systems. A waffle slab or Filigree slab concrete system. Then a composite steel deck system, and lastly a one-way concrete pan joist system. Each solution will require a unique application method. A sample method of deployment is broken down and then quantified on a timetable.

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

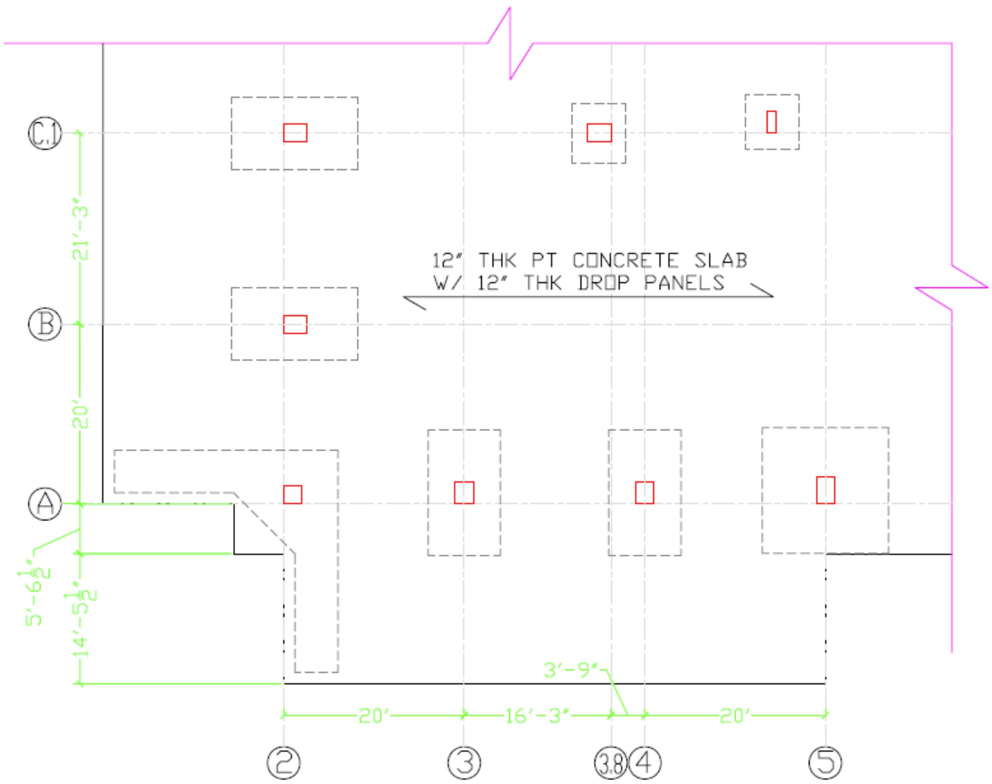
The general system used in gravity load resisting is a mixture of concrete floors systems and load bearing reinforced concrete columns. The below grade floors are flat plate concrete slabs with drop panels, and above grade Post-tensioned floors slabs were utilized. Lateral wind and seismic forces are 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 pier 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". The slab here 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). The slab is now 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 the most regular 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 are reproduced below to prove 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

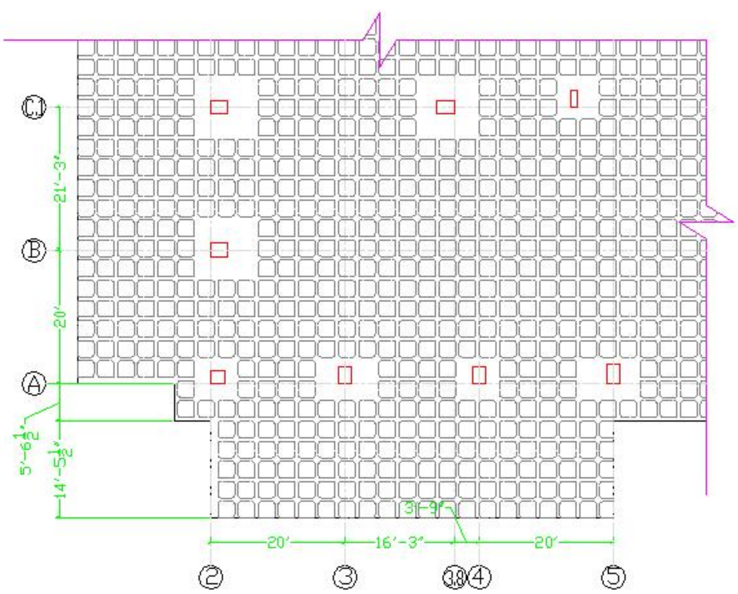
There are no clear problems with the existing design, which is to be expected as the engineers are knowledgeable and competent. Instead, an alternate design will be investigated and then evaluated based on the inherent limitations of the site and usage, then compared with the current design. These limitations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

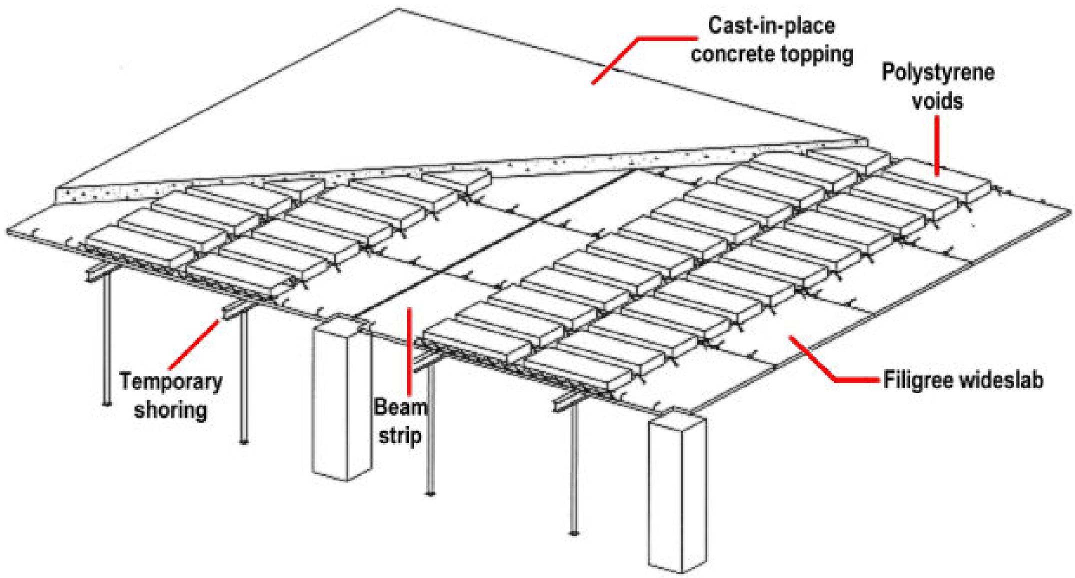
Proposed Solutions

A – The first possible alternative is a waffle slab or Filigree slab system. These systems will use concrete, consistent with the original design. This will assure that variance in material cost does not prove to be a major drawback to the alternative system. A waffle slab system consisting of 30" domes was considered as part of a previous technical assignment. The bay size did not have to be changed, and the overall slab depth decreased slightly from 24" to 23". The representative bay layout is shown below.



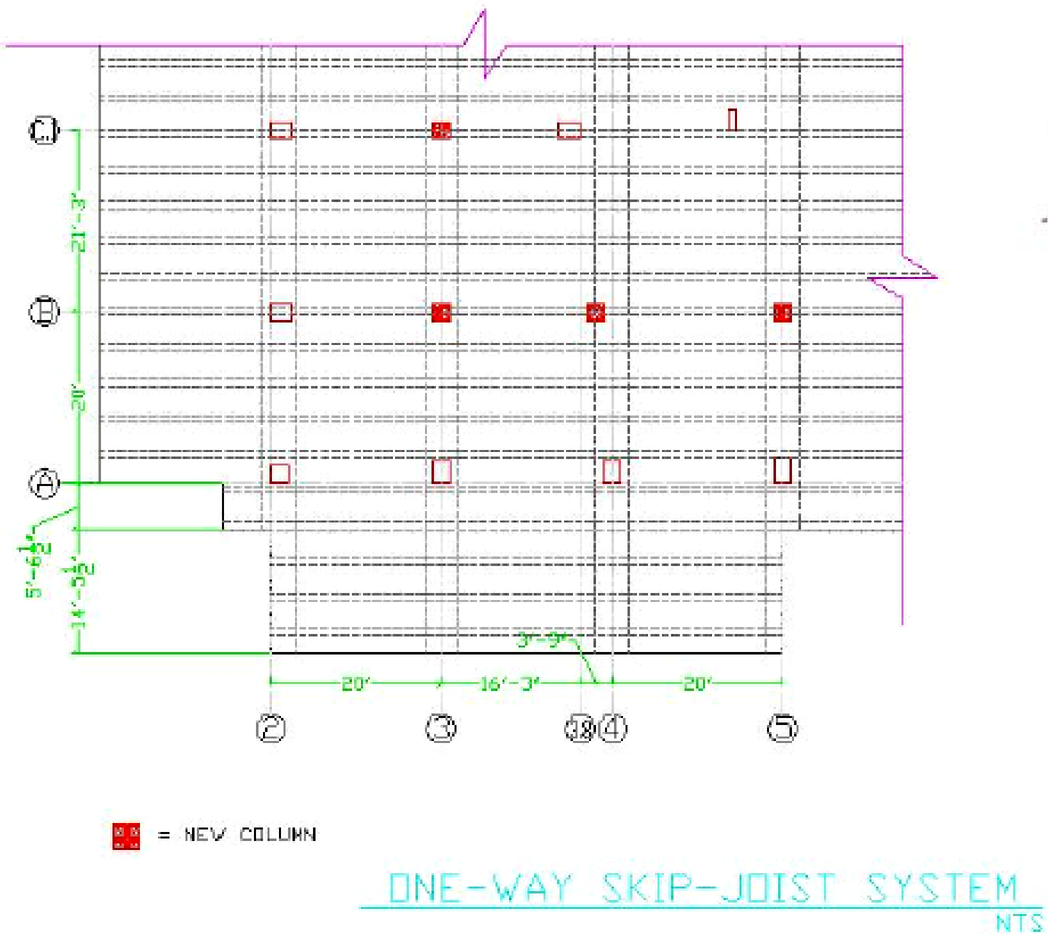
30" DOME TWO-WAY WAFFLE SLAB
NTS

A Filigree slab was not chosen as one of the alternatives in the previous technical report because it was unknown the author at the time. Upon initial research it seems to be a viable alternative and warrants further study. A system thickness is unknown at this time for the filigree construction. An isometric of the filigree flat plate method is shown below. It incorporates both precast and CIP concrete slab to increase construction rate and strengthen the floor system.



B – A common construction method used in similar instances is 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 floor depth can be reduced from the 35" found previously. This is because the composite deck adds strength to the system which will allow for a thinner floor slab. The reduced slab weight will require shallower joists and then shallower girders. If the system can be reduced to match the existing floor depth, it will then only be an issue of whether or not there is a noticeable cost increase with the material change.

C – The last solution that was determined to be of value was a one-way pan joist system. The pan joist system was found to have a much shallower floor system depth, from 24" down to 16.5". The ribs and girders ended up being very sizable, with girders being 4 feet wide. Despite this, there is a huge consequence in that more columns are needed to force the layout into a one-way system. The resulting plan is shown below.



Solution methods

A – The waffle slab and filigree slab system will follow similar methods. Waffle slabs will be designed using CRSI handbook guidelines. Hand calculations and computer models with be used where the CRSI tables do not apply. ADOSS is easy and quick for designing concrete structures. An ETABS model will be employed to check lateral loading. The change in slab will alter the structure weight, and therefore impact equivalent seismic loads. Gravity loads will not be changed and will still be determined from ASCE 7-02. The filigree slab will be designed with proprietary design aids available from a filigree systems designer. Lateral analysis will again be checked using a computer model, likely in ETABS.

B – 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 members and proprietary steel deck catalogs will be used to determine decking sizes for gravity loads. A computer model will be created using RAM steel to determine lateral effects. The necessary connections will be detailed with moment capacity or braces to allow moment or braced frame action.

C – The one-way joist system will not require a complete redesign, but will need to determine the impact of additional columns being added to the space. The foundation will include more footings to dissipate the column forces into the soil. The pan joists will be sized using CRSI handbook and checked by hand at critical areas such as the cantilever. Lateral resistance will be determined via an ETABS model and the altered structure weight will be taken into account.

Tasks and tools

* a detailed task list and schedule will only be created for one solution, because only one solution will ultimately be chosen.

I. One-way skip-joist system

- A. Investigate impact on architecture
  - 1. Determine column placements
  - 2. Identify critical sections
  - 3. Note negative compromises
- B. Preliminary sizing of pan joist system
  - 1. Determine gravity loads per ASCE 7-02
  - 2. Size joist members and slab using CRSI 2002 tables
  - 3. Size girders to coincide with pan depth using CRSI tables
  - 4. Verify gravity design with ADOSS or SAP2000
- C. Size columns
  - 1. Based on redistribution of floor weight, size columns using ACI interaction diagrams and PCA-COL
  - 2. Size footings for new columns
  - 3. Check existing columns for new loading and resize if necessary
- D. Perform 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 ETABS or SAP2000 model for lateral load analysis
  - 3. Detail connections to meet frame action requirements
- E. Finalize design and details

Timetable

January 2006

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	2	3	4	5	6	7
8	9 Spring semester begins	10 Begin choosing solution	11	12	13	14
15 Revise proposal for solution	16 Investigate architectural impact	17	18	19	20	21
22	23 Begin floor system sizing	24	25	26	27	28
29	30	31				

February 2006

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			1	2	3	4
5	6	7	8	9	10	11 Finish floor system design
12 Begin column and foundation designs	13	14	15	16	17	18 Finish column and foundation designs
19 Begin frame design and computer modeling	20	21	22	23	24	25
26	27	28				

March 2006

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			1	2	3	4 Finish frame analysis
5 Start breadth work	6	7	8	9	10	11
12	13	14	15	16	17	18
19 Complete breadth work	20 Start final design and detailing	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, if any, of cost increase associated with the new system. Also a revised project schedule will be constructed which may or may not affect the project cost. Then the constructability of the alternative system will be investigated. No matter how much better a solution looks on paper, if it cannot be built then it is no good.

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. While that is being checked, additional suggestions will be made on how to possibly increase the LEED rating of the construction.

Architecture

Certain solutions will have an effect on the architecture of the building. The one-way pan joist system added columns to the office plan space. The space usage will be evaluated to determine whether this is a reasonable sacrifice. The floor plans will be modified for the new layout.