

## **Commissioning Repetitive Floors in a High-Rise Office Building**

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### **Synopsis**

Zapata Engineering provided commissioning services to support the Leadership in Energy and Environmental Design – Commercial Interiors (LEED-CI) requirements for Fundamental and Enhanced Commissioning for the 23-floor renovation of the 60-floor Bank of America Corporate Center in Charlotte, NC. This paper describes the challenges and opportunities, and how the actions and decisions of team members contributed to project success. Challenges encountered during the project that provided opportunities for the commissioning authority included: the commissioning agent joined the team late in the design development phase; a compressed design and construction schedule required simultaneous activity on multiple floors; the complexity of paperwork tracking for simultaneous, multi-floor recordkeeping; and, limited input to the construction schedule. Efficiencies planned into the project from inception that furthered project success included: Owner selected team members who had worked together previously; architect’s “chassis design” provided a common mechanical, electrical and plumbing foundation for each floor; the chassis design resulted in the grouping of floors for efficiency of effort; and, the commissioning agent used the grouping of floors and common chassis design to reduce the complexity for all parties involved in managing the documentation. Contributors to success were: using LEED Accredited Professionals from the beginning so that early decisions considered the commissioning process; organizing the project into logical groups to reduce complexity; selecting team members with previous experience working together; and using standard commissioning specifications, forms and documents throughout the project.

### **About the Authors**

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## Introduction

In 2006, Zapata Engineering was retained to provide commissioning services to support the LEED-CI requirements for Fundamental and Enhanced Commissioning for the 23-floor renovation of the 60-floor Bank of America Corporate Center in Charlotte, North Carolina. This large multi-floor project presented the design, construction, and commissioning team with both challenges in execution and opportunities for efficiencies. This paper will describe those challenges and opportunities, and how the actions and decisions of team members contributed to the project's success.

### **The Building**

The Bank of America Corporate Center, located in Charlotte, North Carolina is a 60-story office building designed by the architectural firm of Cesar Pelli and Associates and built in 1992, see Figure A. The level of construction is landmark-grade, and the interior finish and material selections are above average. All the office space is Class A. This was meant to be a signature building, and it is. The overall design of the building floorplate is a circle superimposed on a square. At 871 feet, it is the tallest building in the Charlotte, North Carolina skyline and the tallest building between Atlanta and Philadelphia. The Corporate Center is a prestigious office building location, housing the headquarters of one of the largest banks in the United States -- the Bank of America. Additional tenants include multiple law firms. Bank of America occupies about one-third of the building for a variety of different work processes. This is the first major renovation of the Corporate Center involving the 23-floors wholly occupied by Bank of America. Each floor encompasses approximately 23,300 square feet. This is part of the bank's effort to upgrade its corporate infrastructure, provide first class facilities for its employees and is part of the bank's commitment to Higher Standards and its effort to become the most admired company in the United States. This renovation was developed to obtain a Gold level certification according to Leadership in Energy and Environmental Design – Commercial Interiors (LEED-CI) Version 2.0 administered by the United States Green Building Council (USGBC). Credit points involve both Fundamental and Enhanced Commissioning.



**Figure A: Bank of America Corporate Center, Charlotte, NC**

### **The Project**

The project was broken into multiple phases. The Pilot Phase included the 6<sup>th</sup>, 19<sup>th</sup>, and 21<sup>st</sup> floors. The 19<sup>th</sup> and 21<sup>st</sup> floors were to be LEED-GOLD, and the 6<sup>th</sup> floor (as a unique layout) was to be LEED-Certified. The Phase 1 floors included 14, 20, and 23 -- all to be LEED-GOLD. The first floor to undergo renovation was floor 19.

## Challenges in Execution

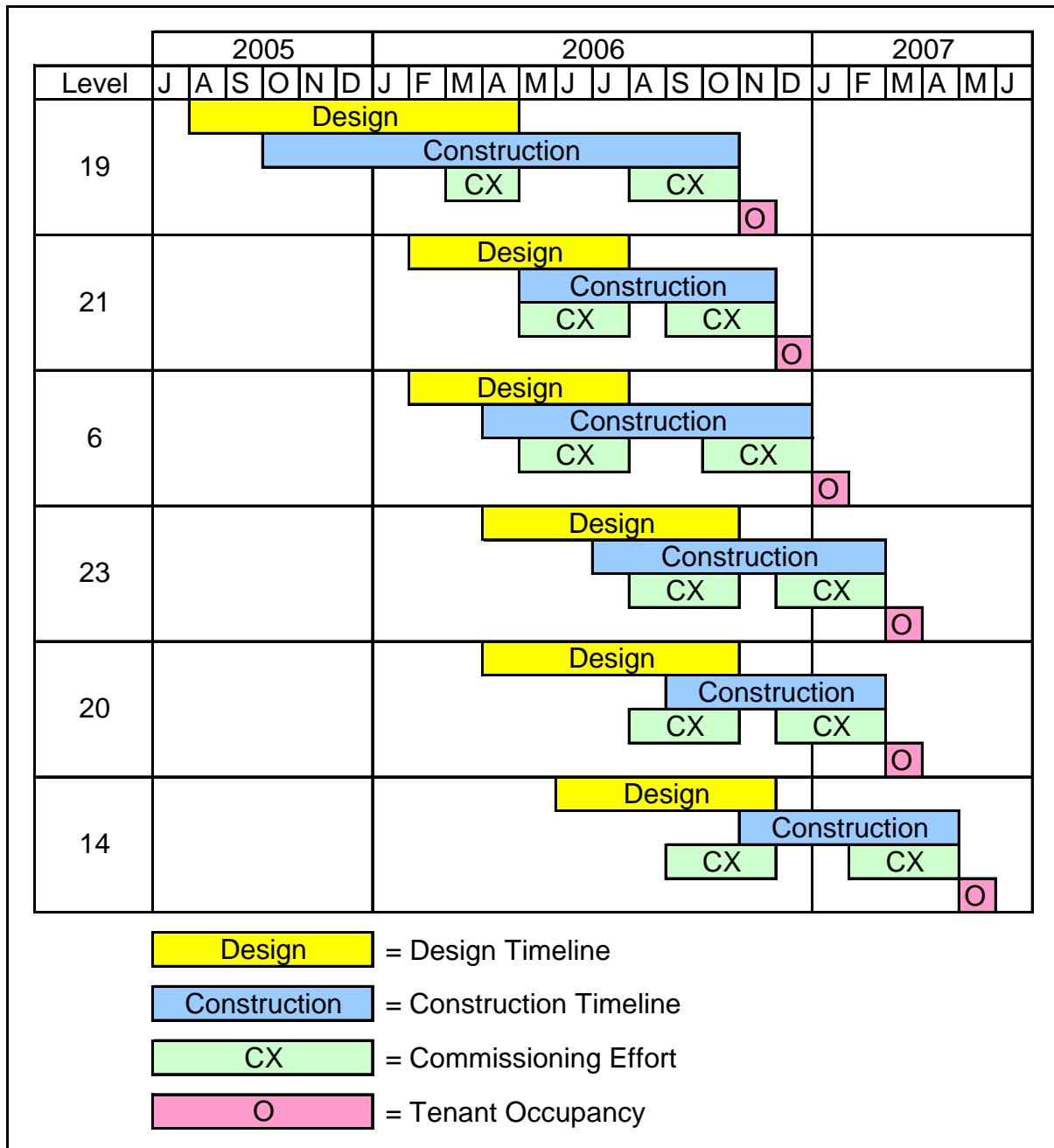
The project team encountered many challenges in the early stages of the project. Challenges encountered during the execution of the project that provided opportunities for the commissioning authority were:

- The commissioning agent joined the team late in the design development phase and had to overcome lack of formal owner requirements and basis of design
- A compressed design and construction timeframe required simultaneous activity on multiple floors and presented both scheduling and record keeping challenges
- The complexity of paperwork tracking for simultaneous, multi-floor record keeping
- Limited input to the construction schedule
- Re-use of existing air handlers on each floor
- Enforcing standards for contractor-provided documentation
- Training and operations and maintenance manuals
- Tenant familiarity with building operations

The commissioning agent joined the team late in the design development (DD) phase and had to overcome lack of formal owner requirements and basis of design. The owner's representative hired the commissioning authority at the end of the DD stage for floor 19. This left little time for the design reviews required for enhanced commissioning credit. The commissioning team pulled together and completed the design review in one week and provided comments back to the design team. During the review, formal documents for the owner's requirements and basis of design were not available. In some ways, this had a positive effect, in that during the design review, it forced verbal discussions with the design team to communicate and articulate their understanding of the owner's requirements and how they incorporated them into the design. This resolved itself after the review of the 19<sup>th</sup> floor design, as the follow-on floors had the same requirements. Likewise, immediately on the heels of the 19<sup>th</sup> floor review, the schematic design (SD) and DD reviews came for the 23<sup>rd</sup> and 6<sup>th</sup> floors. The timing made for a hectic few weeks, but one that resulted in great learning about the project and a clear vision of the end-state for the occupied space.

A compressed design and construction timeframe required simultaneous activity on multiple floors and presented both scheduling and recordkeeping challenges. In an effort to be as efficient as possible, the design and construction team kept work crews always busy through a staggered schedule. Figure B represents some of the critical dates showing the overlapping and simultaneous actions being conducted on multiple floors of the building.

The overlapping nature of the floor requirements allowed lessons-learned to be immediately applied to the next floor. It also allowed for immediate feedback and inclusion in the design, review and/or construction processes.



**Figure B: Gantt Chart Depicting Similtaneous Scheduling**

As anyone involved with commissioning knows, the ability to document all actions is key to providing quality service that can withstand a USGBC audit. The complexity of paperwork tracking for simultaneous, multi-floor recordkeeping has been and still is a challenge. As shown in Figure B, it is entirely possible to be conducting a DD review of one floor, a prior-to-construction document (CD) review on another, writing a commissioning plan for upcoming floors, conducting pre-functional testing on one floor and functional testing on another. During one site visit, the commissioning agent must be conversant on issues on multiple floors and in

various stages of design or construction. None of it will ever be remembered unless it is documented and tracked in the commissioning record book. We had to take meeting minutes, provide regular updates to the owner, and constantly feed all documents into both the hardcopy record books and the electronic filing system.

As commissioning agent, we have had limited input to the construction schedule. There were several reasons for this. First, the construction team and owner were both new to the LEED process. Initially, neither appreciated the value that the commissioning process, in particular, the pre-functional and functional testing, would bring to the team. The value to support the quality goals were much appreciated after the completion of the first floor (Level 19). Next, the construction schedule rarely gains time during the project. Almost always the project is crashed at the end to meet schedule requirements. The first floor is always more difficult as discovery learning is usually the norm. Add to that, the commissioning functional testing is one of the last things to happen before occupancy. Combined, it means that as the first floor came to completion, the occupancy date “ribbon cutting” was set; construction was not complete; and functional testing had not started on all four systems (HVAC, Hot Water, Electrical and Automated Shade Controls). This created a crashed construction and commissioning schedule and an after-hours commitment from all to meet the ribbon cutting celebration timeline. These issues worked themselves out as the team moved to subsequent floors. For follow-on floors, both the owner and construction team valued the extra set of eyes provided by the commissioning team. The commissioning team and the construction team developed a good working relationship. Lessons-learned on the first floor were incorporated into both the design and construction processes for the next floors. As floors progressed, corrective action lists from the commissioning representatives got smaller; with the result being more time allowed for tests, discussion, solutions and follow-up.

Many LEED initiatives were incorporated into the renovation design, however, the renovated mechanical system re-used the existing air handlers in the design. During functional testing, the commissioning authority determined that there was inadequate air flow when all terminal units were at a full, open position. The contractor and designer brought a team together consisting of the testing and balancing (TAB) contractor, mechanical contractor, and the design engineer to investigate and develop both design and operational solutions. These solutions and alternatives were then elevated to the appropriate decisionmaking authority.

Although contract specifications, the Commissioning Plan, and the commissioning scoping meeting were provided to the contractor team, it was readily apparent that the team was not familiar with LEED processes and documentation requirements. Most subcontractors were used to providing industry-wide submittals such as cut sheets, order logs, and shop drawings. However, it required extra effort to ingrain the LEED specific documentation requirements among the team members. An early challenge was discovered during pre-functional testing. Although the commissioning authority was present during initial pre-functional testing and the subcontractors performed the tests, continued documentation of test results by the subcontractors was not consistent. Since the LEED record keeping requirements had not previously been the subcontractors’ “standard,” consistency suffered. Since this project included repetitive floors and

these recordkeeping anomalies were recognized early, we were able to establish good documentation for subsequent floors with a moderate amount of coaching for the subcontractors.

Similar to the recordkeeping challenges referenced above, other LEED-specific requirements, such as training and O&M manuals, were initially difficult to properly document. Initially, subcontractor efforts accomplished the training and produced O&M Manuals, but they did not meet the commissioning authority's standards. Corrective actions on subsequent floors included planned videotaping of training; and completeness of written O&M Manuals.

Lastly, after occupancy, some tenant expectations did not synchronize with the functional aspects of the installed building systems. This renovation design had automatic shade controls that were linked to a light dimming system within the outermost 25-feet of the building. During both pre-functional and functional testing the lighting/shade/energy systems functioned automatically as designed and installed. The shades lowered and rose in response to outside light; and the lights zoned at the outermost edges of the building dimmed and brightened in response to the ambient conditions. Together they maintained a relatively constant level of available light throughout the floor plate. However, some occupants were annoyed with the frequency of shade adjustments. One response was for the occupants to manually override automatic adjustments. This resulted in a second problem in that once a manual command is given, the system must cycle through a complete cycle of dark and light before it returns to automatic activity. As a result, periods of excessive light or shade required further manual activity by the occupants. This issue was addressed in two ways. First, the shade subcontractor reset the shade controls to their longest setting before they automatically adjusted. Dimming sensitivity was likewise adjusted to lessen fluctuation and increase cycle time. Second, the occupants were re-briefed on the system design and operation, and the recent adjustments made to increase their comfort in the renovated space.

Bottomline, the process had its bumps at the start, but through a cooperative effort from all members of the team, those challenges were overcome. This resulted in a team that is more efficient and is producing the same or better quality product in less time.

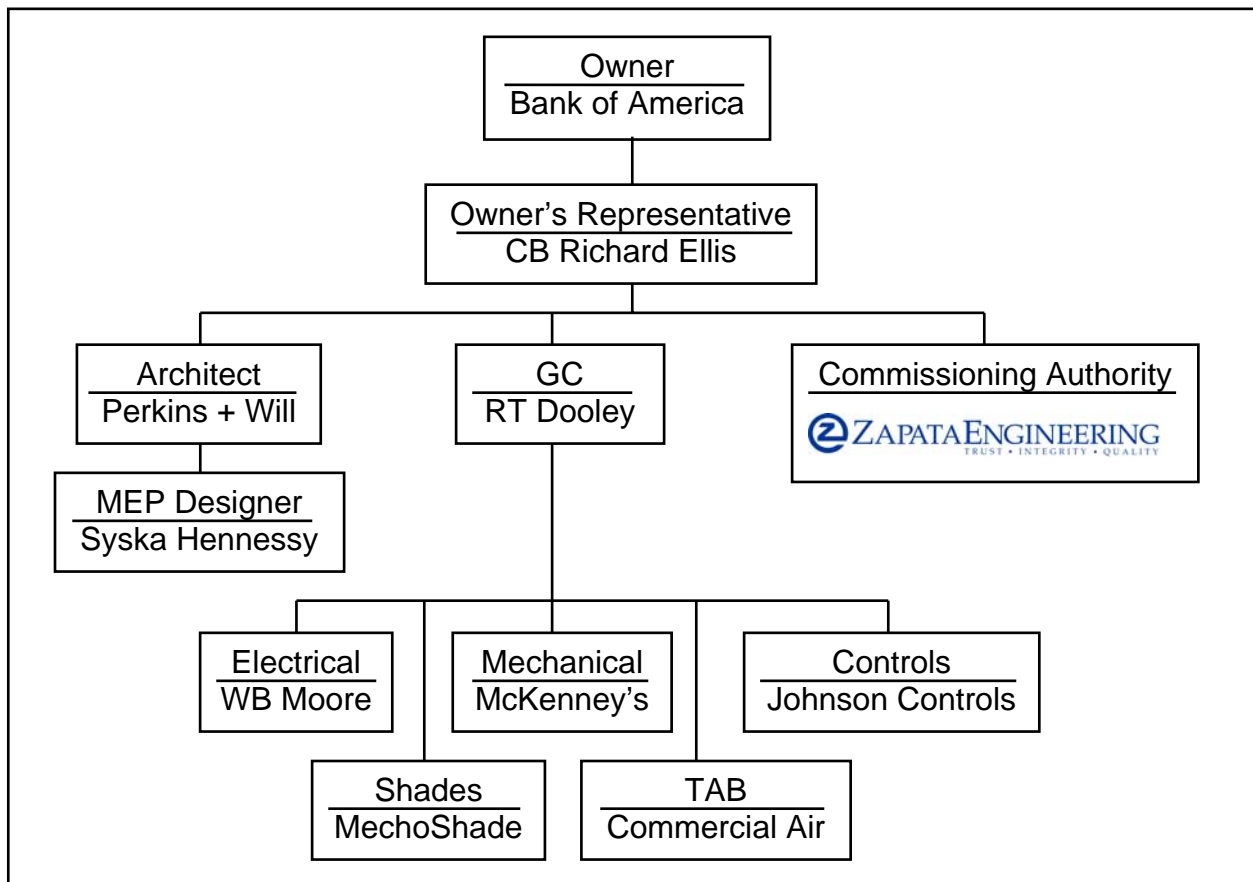
## **Opportunities for Efficiencies**

Efficiencies planned into the project from inception, design, and construction that furthered project success included:

- Teamwork and communication were enhanced by the owner's decision to select team members who had worked together previously on other projects for the owner.
- Chassis Design - Efficiencies were facilitated by the architect's "chassis design" that provided a common mechanical, electrical and plumbing foundation for each floor's renovation.
- Grouping of Floors - This chassis design resulted in the grouping of floors for effort; facilitated sequencing of work; and simplified review of submittals and conduct of pre-functional and functional testing.

- The commissioning agent utilized the grouping of floors and the common chassis design to reduce the number of commissioning plans and minimizing the number of different reporting and tracking forms, thus reducing the complexity for all parties involved in managing the documentation.
- Corrective actions on repetitive floors allowed for lessons learned to be immediately applied.
- Pre-commissioning walk-through of all above-ceiling work prior to the closing of the ceiling with special-ordered 4' x 4' fragile ceiling tiles.

A major factor contributing to the success of this project, was that teamwork and communication were enhanced by the owner's decision to select team members who had worked together previously on other projects for the owner. Figure C depicts the members of the project team that were involved in the commissioning process. Almost all members of the team had worked together before this project developed. This included the owner, owner's representative, architect, MEP designer, general contractor (GC) and the commissioning authority. All of the subcontractors had worked for the GC before.



**Figure C: Project Team Relationships**

Chassis Design - Efficiencies were facilitated by the architect's "chassis design" that provided a common mechanical, electrical and plumbing foundation for each floor's renovation. This factor significantly assisted in speeding the process along after completion of the first floor. Since each floor had a similar basic design, for subsequent floors, we knew what worked and what did not work. This sped the design reviews, allowed for increasing capability through the learning curve; and allowed improvements and incorporation of design changes and construction processes. Each floor has common systems for electrical, HVAC and plumbing.

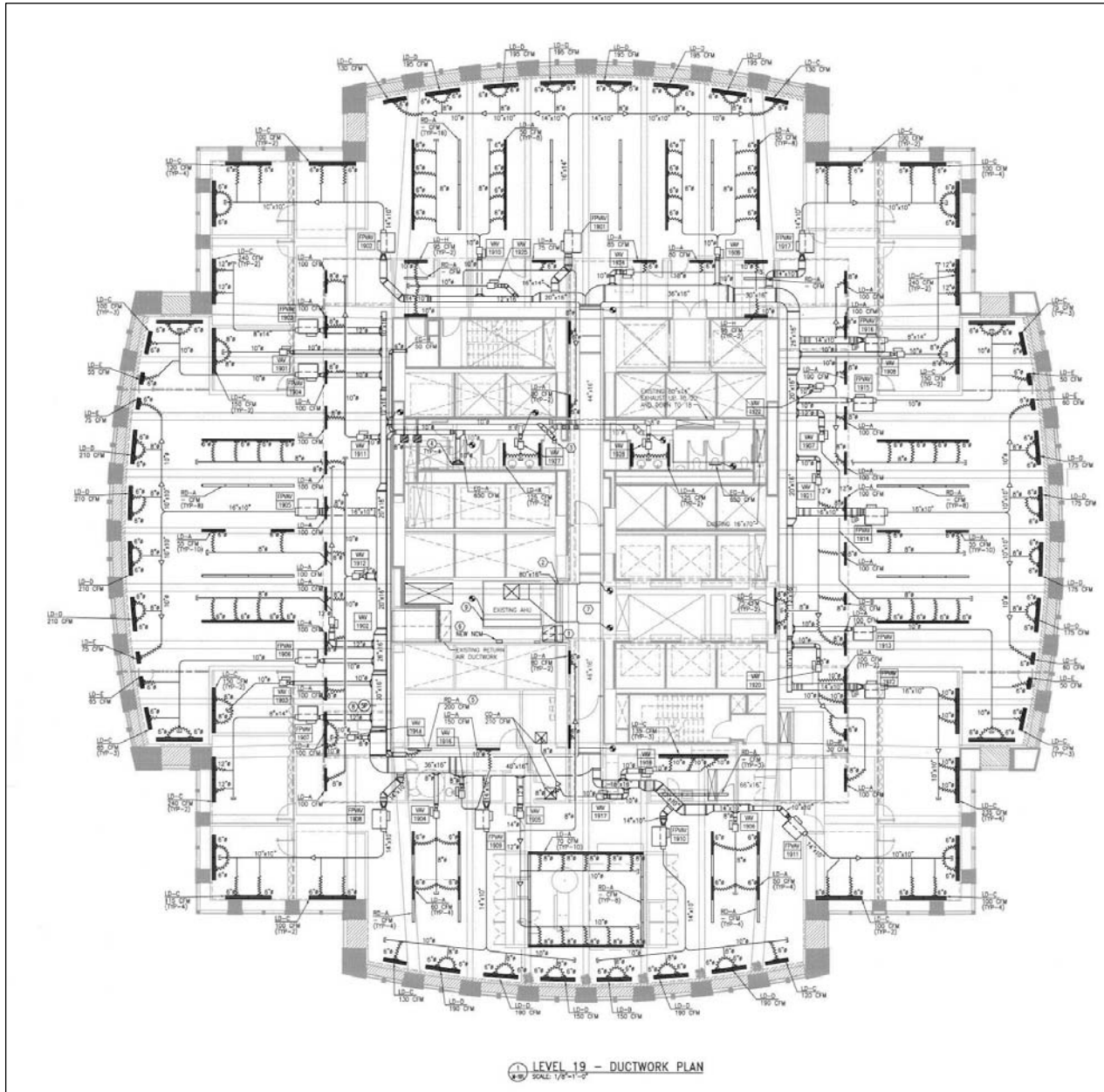


Figure D: Example of the Chassis Design from Level 19 - Mechanical

Grouping of Floors - This chassis design resulted in the grouping of floors for efficiency of effort; facilitated sequencing of work; and simplified review of submittals and conduct of pre-functional and functional testing. This allowed for demolition to significantly proceed the renovation start to eliminate delays. The grouping allowed for the entire team to focus on the immediate issue at hand and then share the solutions to those issues immediately on the next floor. This allows for common O&M Manuals, common training, and common recordkeeping documents.

The commissioning agent used the grouping of floors and the common chassis design to reduce the number of Commissioning Plans and minimize the number of different reporting and tracking forms, thus reducing the complexity for all parties involved in managing the documentation. For the six floors renovated so far, we have produced three sets of documentation as follows: floors 19 and 21; 6; and, 14, 20 and 23. Grouping of similar floors not only reduces the volume of books, but add quality and consistency to the commissioning process.

The repetitive floors and the standardized chassis design allowed for corrective actions and lessons-learned on an early floor to be immediately applied to the following floor renovations. An example involved the temperature sensors. As happens during construction, there were variations and deviations from the plans and the actual installation of various components. On the initial floor (19), it was discovered that some temperature sensors were improperly placed. For example, sensors were mounted on exterior walls, directly under air supply boxes, or near a known heat source such as a copier. These locations resulted in erratic operation and false readings. These issues were brought to the attention of the design team which indicated that aesthetic considerations had been and would continue to be a critical consideration. As a result, the design and construction team, in order to meet both the aesthetic and the functional requirements of the project, is investigating alternative locations and technical solutions such as insulated enclosures to reduce the effect of heat transmission from walls on sensor readings.

Due to the compressed nature of the initial floor (Level 19) Commissioning Schedule and routine construction activities that were not synchronized due to any number of hiccups, the ceiling was closed up prior to all above-ceiling work being completed. This resulted in almost every subcontractor removing ceiling panels on multiple occasions to access and complete work. Unfortunately, the ceiling tiles were an expensive, special-ordered, 4' x 4', fragile, architectural panels, and several were damaged. The solution to this was to conduct a pre-commissioning walk-through of all above-ceiling work prior to the closing of the ceiling with the special-ordered 4' x 4' ceiling tiles. This applied to all subcontractors whether they were involved in traditional LEED (MEP) disciplines or not. This was a huge success in preventing damage on future floors as well as motivating and coordinating all the subcontractor work that was above the ceiling. An additional benefit was that on the subsequent floors the lessons learned allowed the renovation to progress faster than planned, and the schedule was not as tight prior to the above-ceiling walk-through.

## **Conclusion**

This project serves as an excellent case study of the challenges and opportunities presented to the commissioning team for a high-rise office building. Challenges were overcome and opportunities seized to ensure success.

The major contributors to success were use of LEED Accredited Professionals from the beginning so that early decisions considered the commissioning process; organizing the project into logical groups to reduce complexity; selecting team members with previous experience working together; and using standard commissioning specifications, forms and documents throughout the project.

As of March 2007, three floors are complete, three more are in construction, and five more are in design, as the project team moves toward finishing the 23-floor project.