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Realized Value Creation; New Construction in Constrained Urban In-fill Sites

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Abstract

The Case Study prepared by PCPA and Lift Group will identify a growing development problem in urban areas; high value project sites that are restrictive in size or "tight" are underutilized and underdeveloped. In an effort to remedy this problem, our team will evaluate a design program through the lens of both conventional construction and Core Cantilever Construction. It is also important to differentiate between Core Cantilever construction and the plagued "Lift Slab" construction method as they may be confused, due to the top down construction sequence. This article will demonstrate that constraints inherent to conventional construction techniques prohibit economically viable development of these project sites, while Core Cantilever construction methods increase the projects value by reducing construction timelines and increasing the useable floor area.

Keywords: Constrained site, Core cantilever, Column free, "Just in time" delivery, BIM LOD 400

1. Metropolitan Growth vs. Available Land Area

Metropolitan centers around the globe are increasingly faced with the dilemma of accommodating population influx and increased growth, despite a lack of developable project sites in the city center. As demand for growth increases, urban areas prove to be a mixture of densely packed buildings and collections of underutilized high value small lots that are too prohibitive and costly for new construction. Contrary to current trends of inward growth, the lack of developable sites has forced an expansion to the periphery of many metropolitan areas. This new urban sprawl however, can yield diminishing returns the farther removed it is from the urban center. With each expansion to the periphery, perceived project values decrease while development risk increases. The contemporary workforce prefers to live and work in close proximity to culture and civic life, thereby increasing the value of all projects closer to the center of city.

2. Value Creation and Potential

How to increase metropolitan density by utilizing existing collections of high value, small site real estate?

At the present time, many urban centers are comprised of large existing projects and a remainder of smaller underutilized lots with perceived high value. Many of these smaller lots consist of lower existing buildings with significant air rights and underutilized Floor Area Ratio (FAR) multipliers to take advantage of [e.g. Site Area of 9,000 square feet (836.1 square meters) with a FAR of 13, equals 117,000 square feet (10,869.7 square meters) of Allowable Area]. Due to the FAR calculation, the cost per site square area is often high in these urban in-fill locations. Therefore, the benchmark for return on investment can become too prohibitive for conventional construction, often yielding dormant development potential. The solution lies in leveraging the usable square area and project delivery time over cost and construction methodology.

This collaborative case-study developed by Pelli Clarke Pelli Architects (PCPA) and LIFT Group will evaluate a constrained urban site, or "tight" site condition, for a new construction high-rise in-fill project. The goal is to establish an increased value benchmark through a new Core Cantilever construction technique patented by Charles H. Thornton at LIFT Group.

3. Construction Method Clarification

To clarify the differences between Core Cantilever construction and Lift Slab construction ("Youtz-Slick" method), we must evaluate both construction methodologies. Lift Slab construction is a method with documented catastrophic failures resulting from oversight and negligence in the development of the column and slab Shearhead detailing, acceptable tolerances, and on-site construction. Although a viable construction method, the potential for catastrophic failure has led to its moratorium in many locations.

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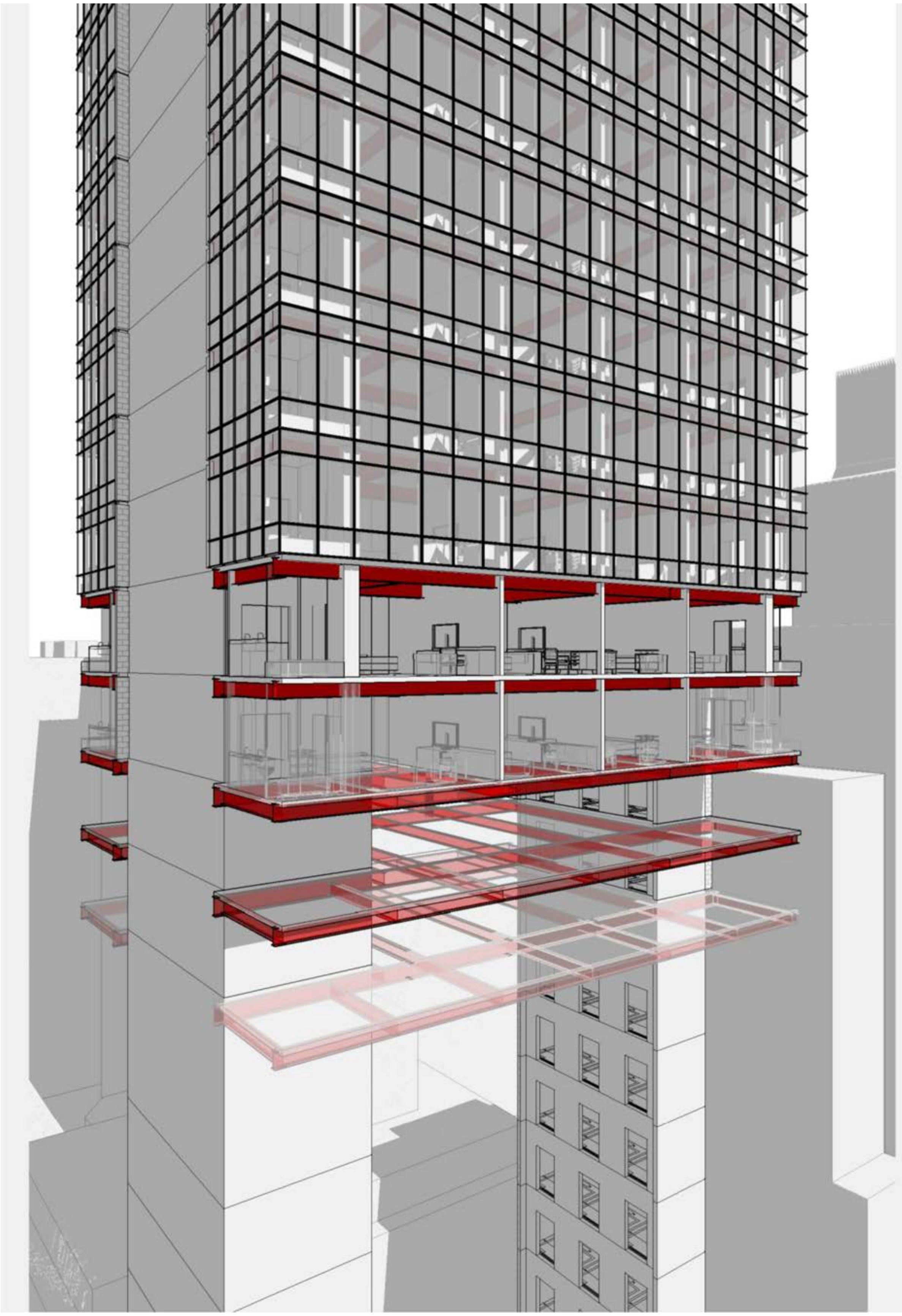


Figure 1. Diagram of Core Cantilever Construction.

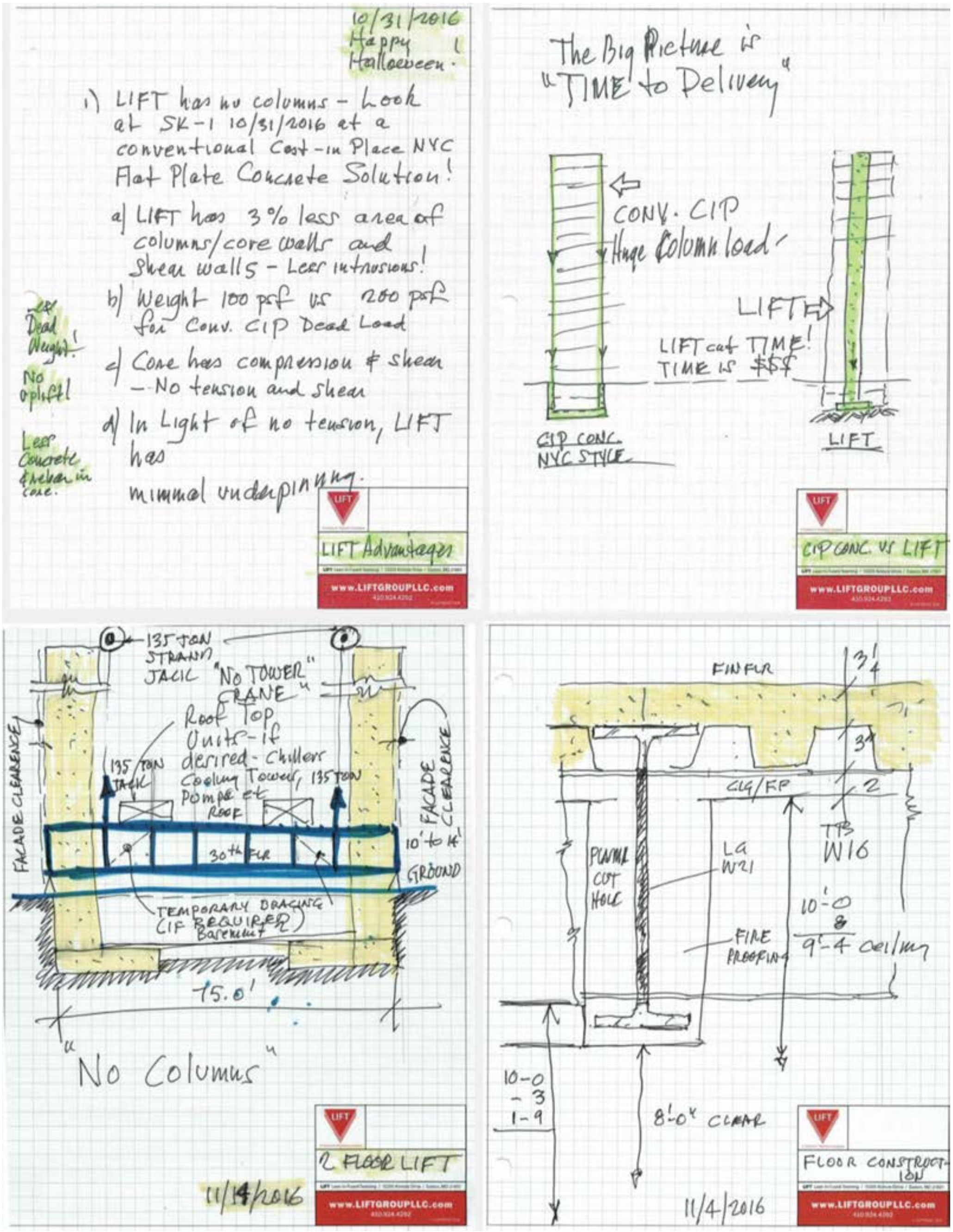


Figure 2. Diagram of Core Cantilever Planning.

3.1. Lift Slab Construction

The Lift Slab construction technique relies on columns with intermittent vertical fixing points that support hoisted floor slabs with Shearhead embeds at each column location. The primary steel columns are erected in vertical stages prior to floor plate construction. Multiple post tension floor plates are then poured in packages of two or three at the base of each stage, floors are stacked however separated by a bond breaker. Packages are then hoisted to the desired floor elevation, the sequence beginning with hoisting the upper floors of each stage first. The floor's Shearheads are supported on two steel wedges that are field welded into position on opposing sides of the column below the floor. The building structure is constructed in vertical stages, and from the top of each stage moving downward.

In investigating the L'Ambiance Plaza Building Collapse, Thornton-Tomasetti Engineers (T-T) were secured by the City of Bridgeport to perform a building forensics report. The L'Ambiance Plaza project was a two tower Lift-Slab

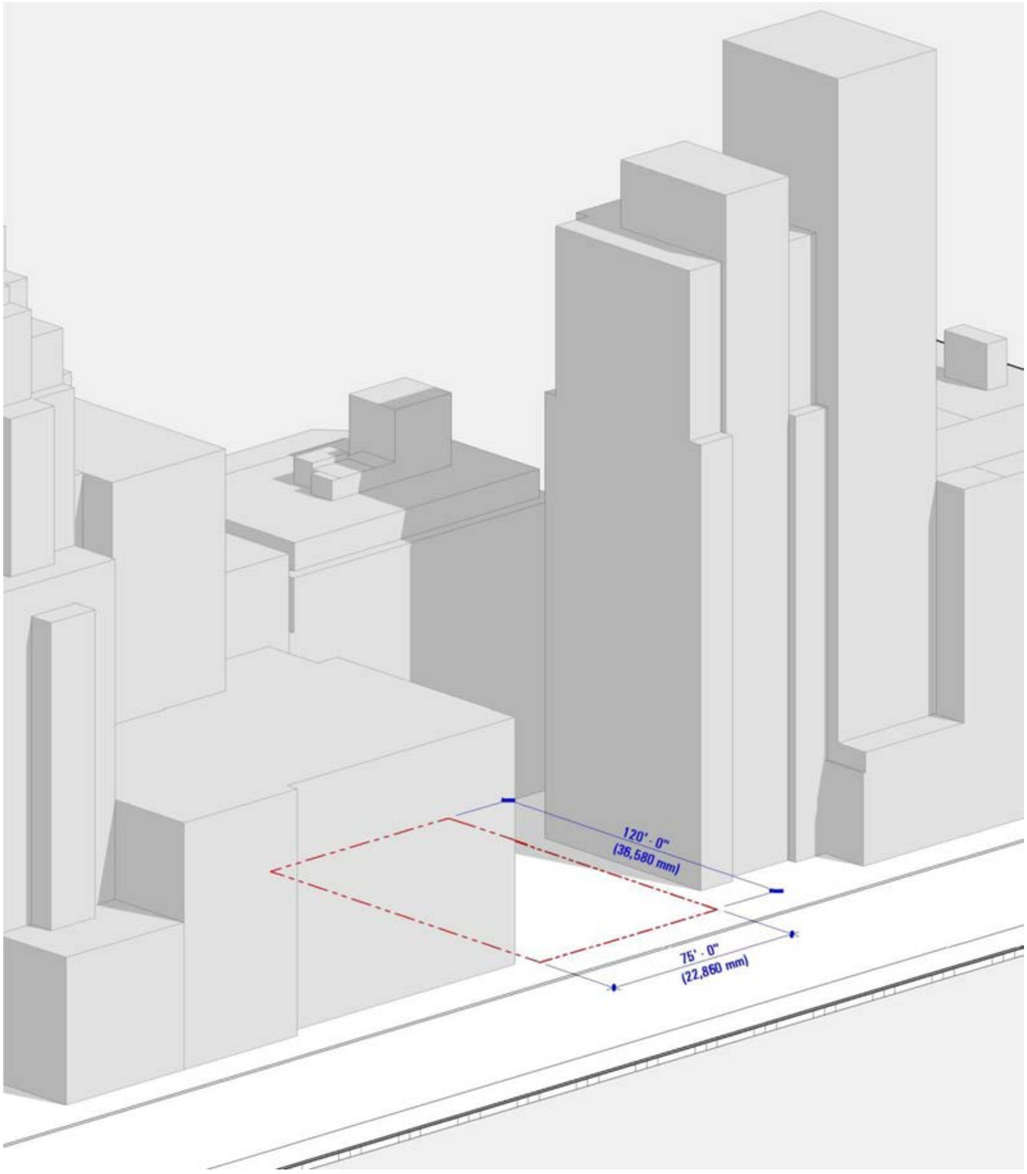


Figure 3. Hudson Yards Retail Interior.

project with cast in place connections between the East and West Towers. In the T-T investigation a failure was pinpointed at the intersection of a Shearhead and an out of plumb building column; the gap between the column and Shearhead was large enough to cause a steel wedge to roll out of position, thereby overstressing the opposing steel wedge to the point of failure. The floor slab package collapsed and caused a sudden full building collapse.

3.2. Core Cantilever Construction

Core cantilever construction differs from Lift Slab construction because it requires the building cores to be built to their full height before the floor construction is started. After the cores are completed, the tower is essentially constructed in reverse order, with the roof and top floor being first in the sequence. Assembly of the floor structure, slab, and facade occur at ground level, thereby increasing worker safety, ease of assembly, and speed.

Opposed to 'Lift Slab' construction that relies on a shearhead imbeds and bearing plates at the columns, the 'Core Cantilever' system hoists the composite steel and concrete floor deck to the desired elevation and engages the fully cured concrete core with a proprietary push or pull shear detail with a male / female imbed; thus allowing the floor to work as a conventional cantilever. All mechanical, electrical, plumbing, and façade elements are loaded and installed before the floor hoist occurs. This construction technique does not require a tower crane; therefore, all on-floor fit-out items must be supplied prior to its ascension. To maintain the schedule, "just in time delivery" is

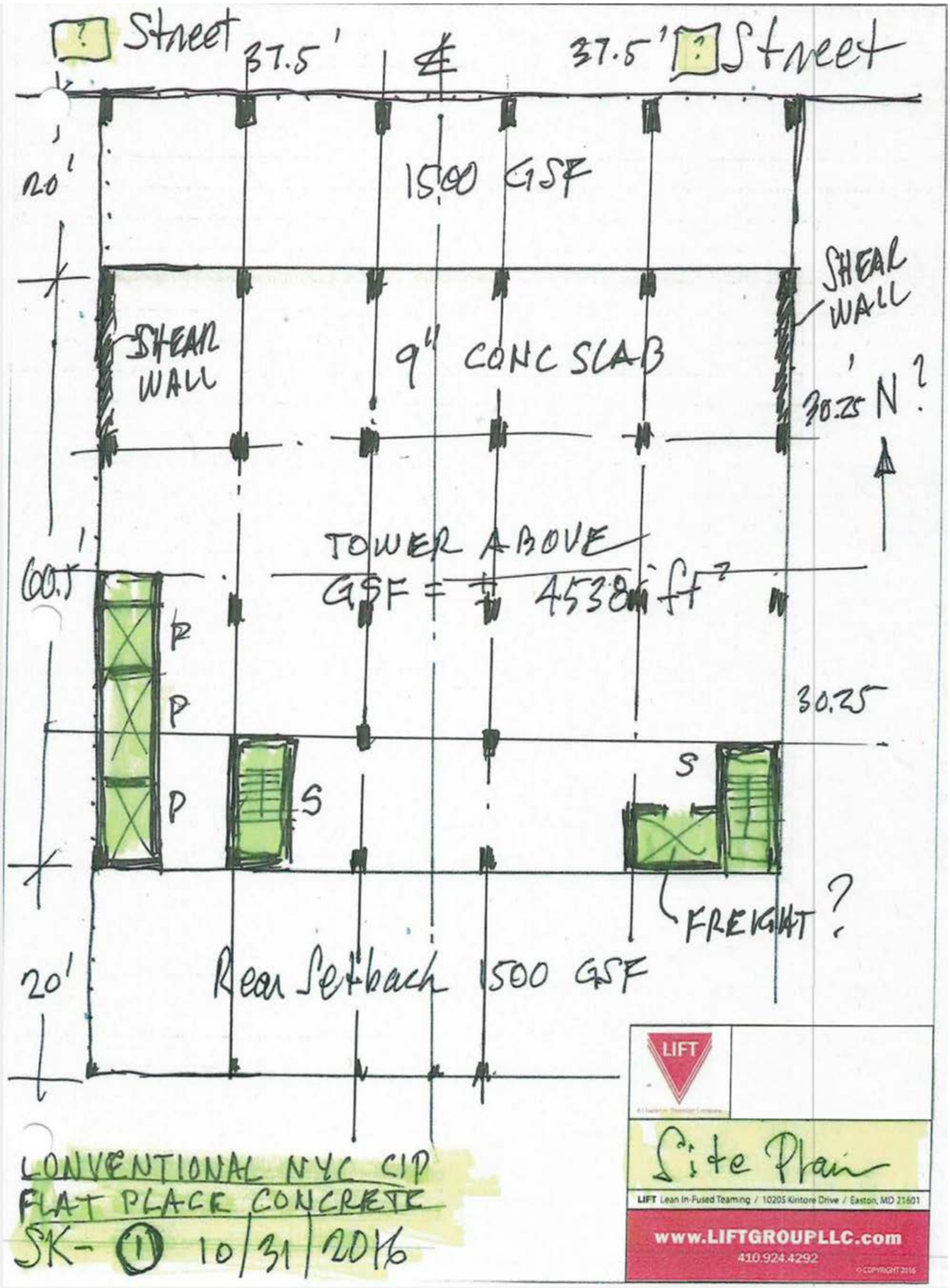


Figure 4. Diagram of Conventional Construction.

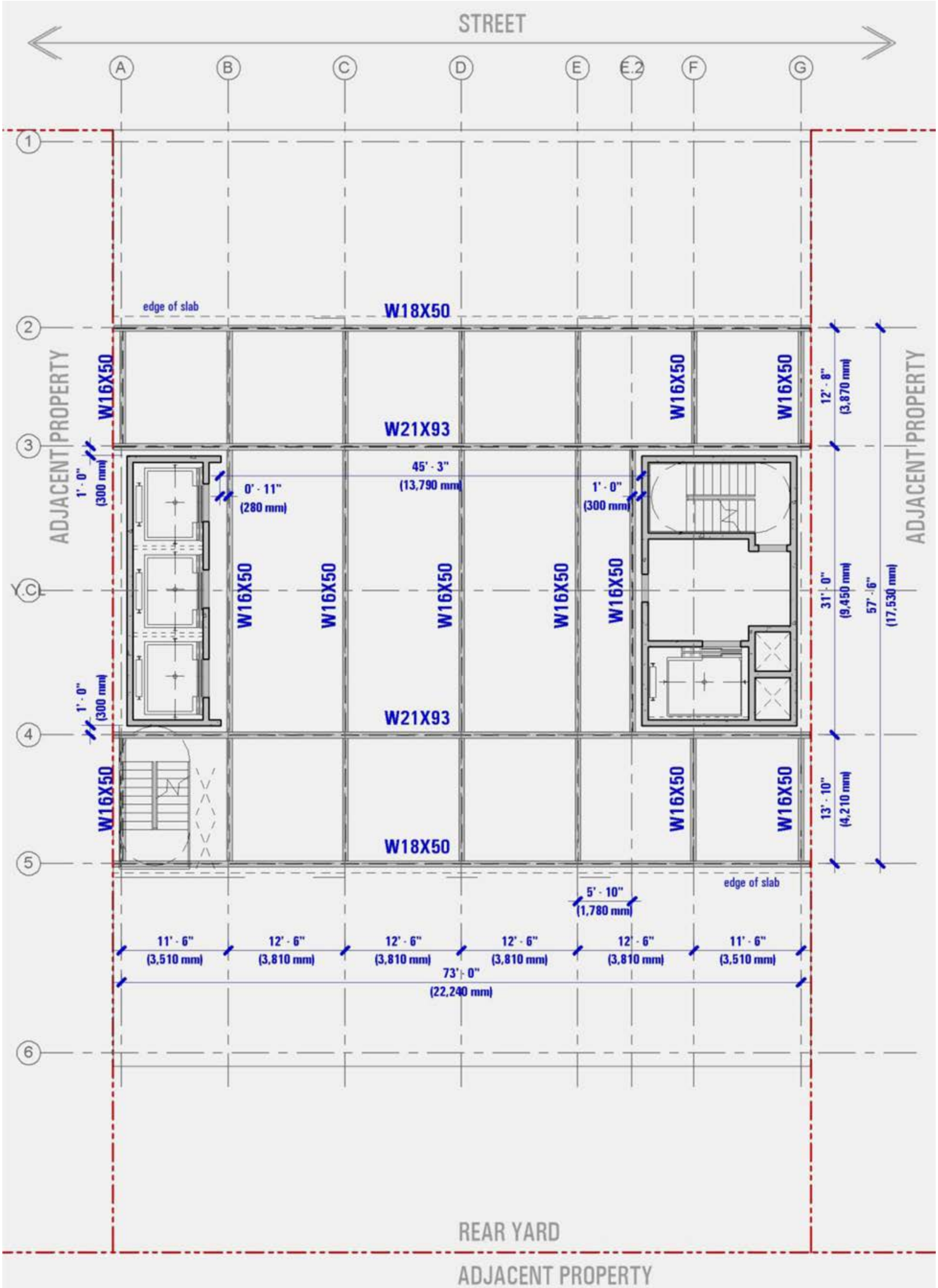


Figure 5. Core Cantilever Framing Plan.

Figure 6. Elevated Sky Lobby View, Confidential Design Scheme.

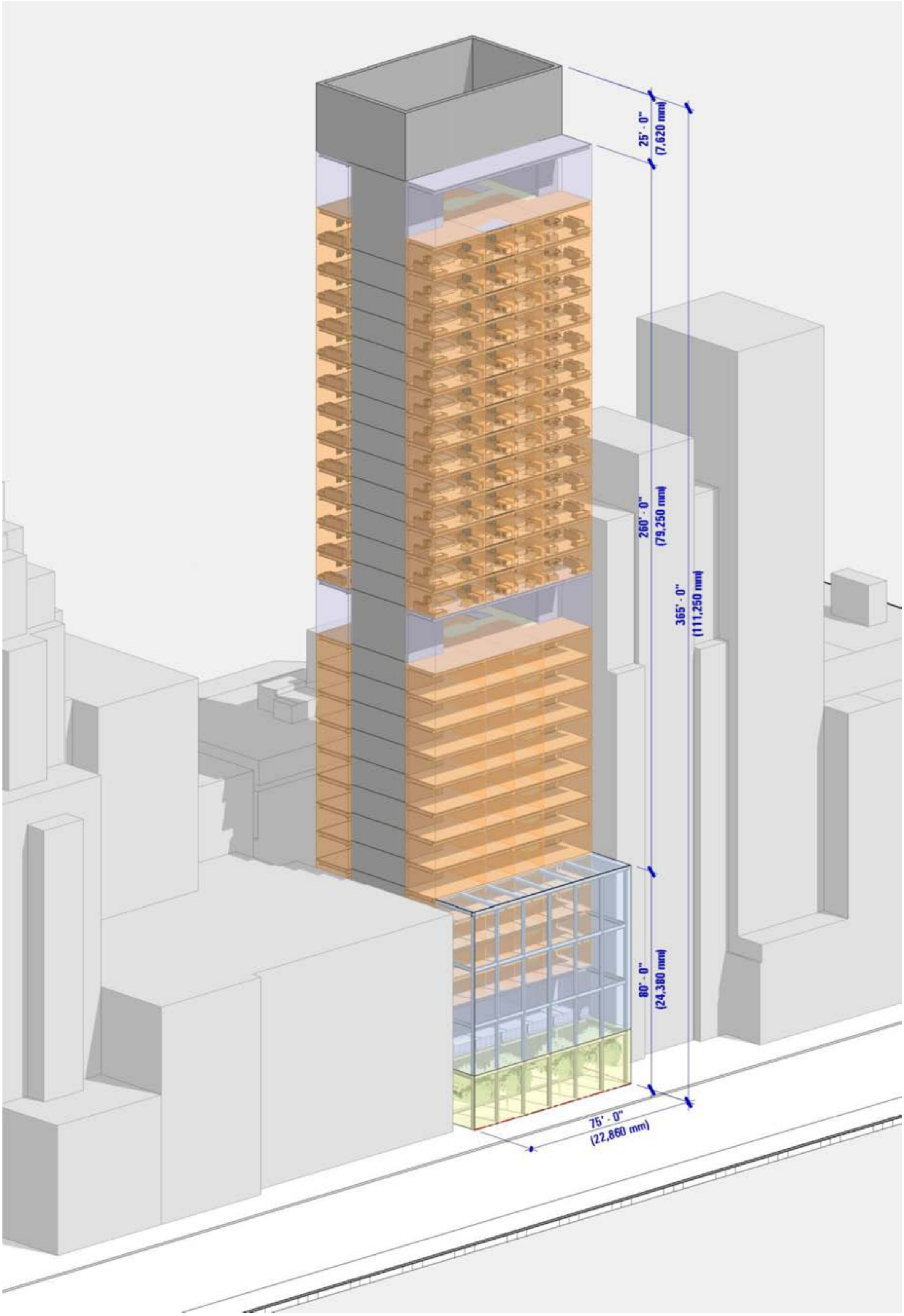
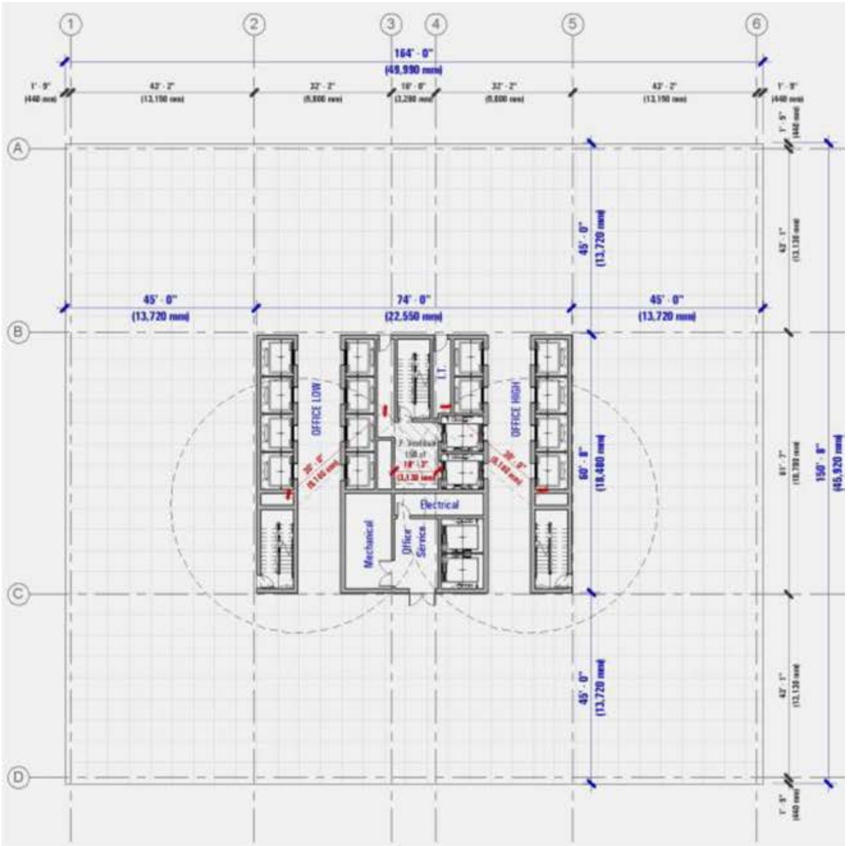
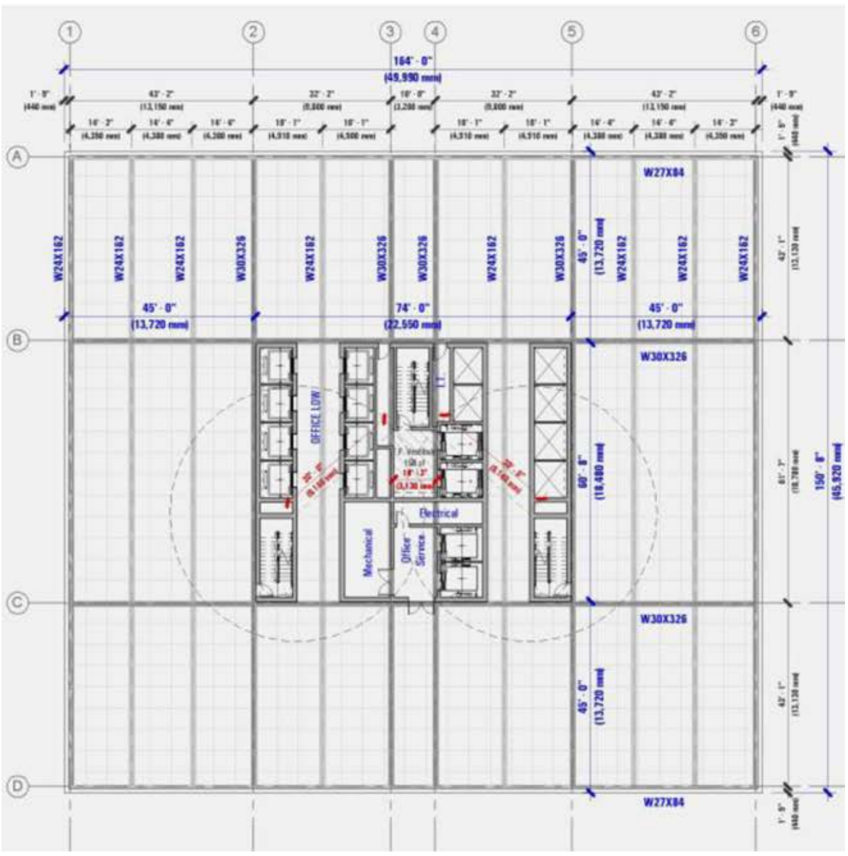


Figure 7. Diagram of Core Cantilever project in Site.





Figures 8 and 9. Central Core Office Plans using Core Cantilever Construction.

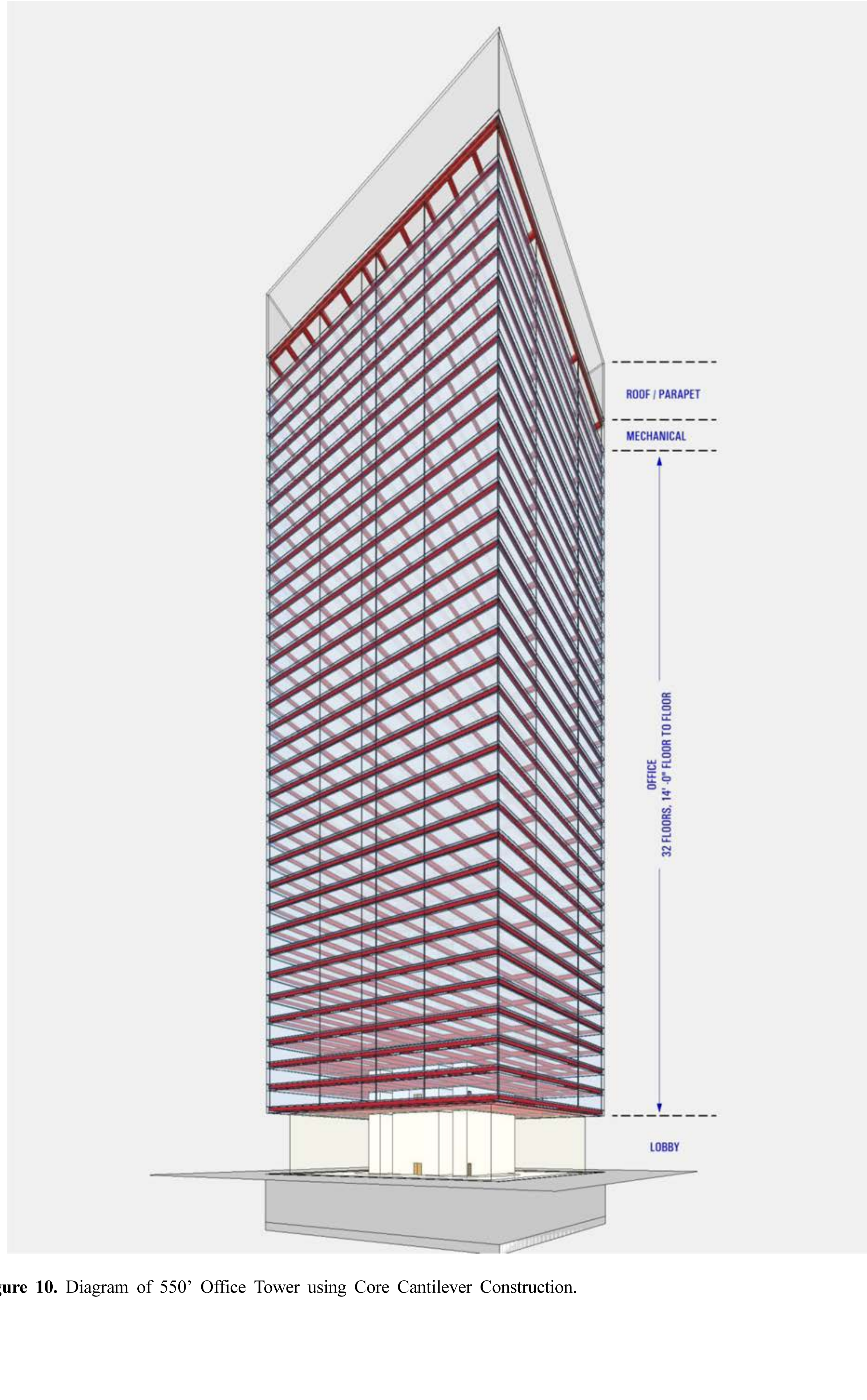


Figure 10. Diagram of 550' Office Tower using Core Cantilever Construction.

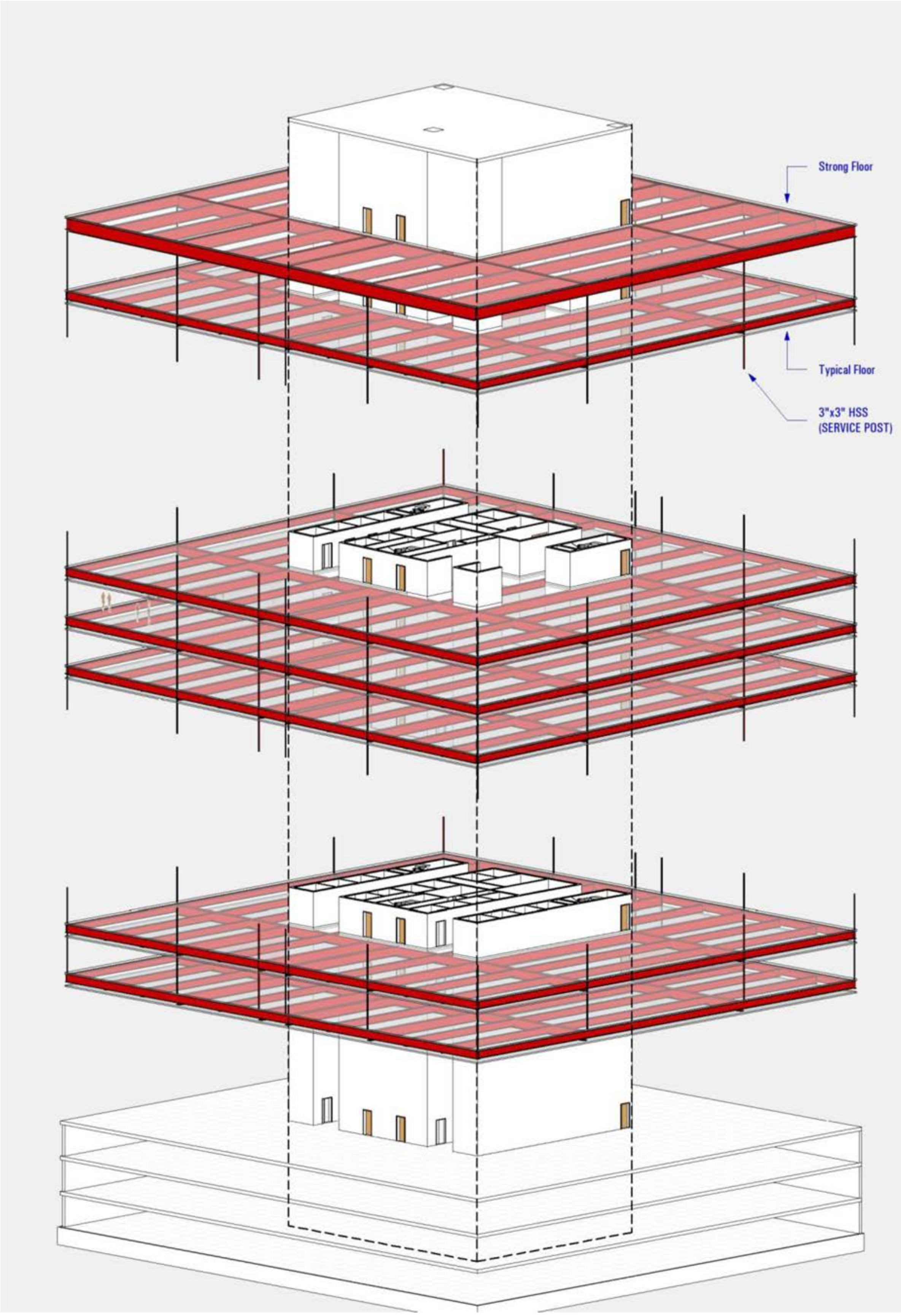


Figure 11. Upper Level Public Space, Confidential Design Scheme.

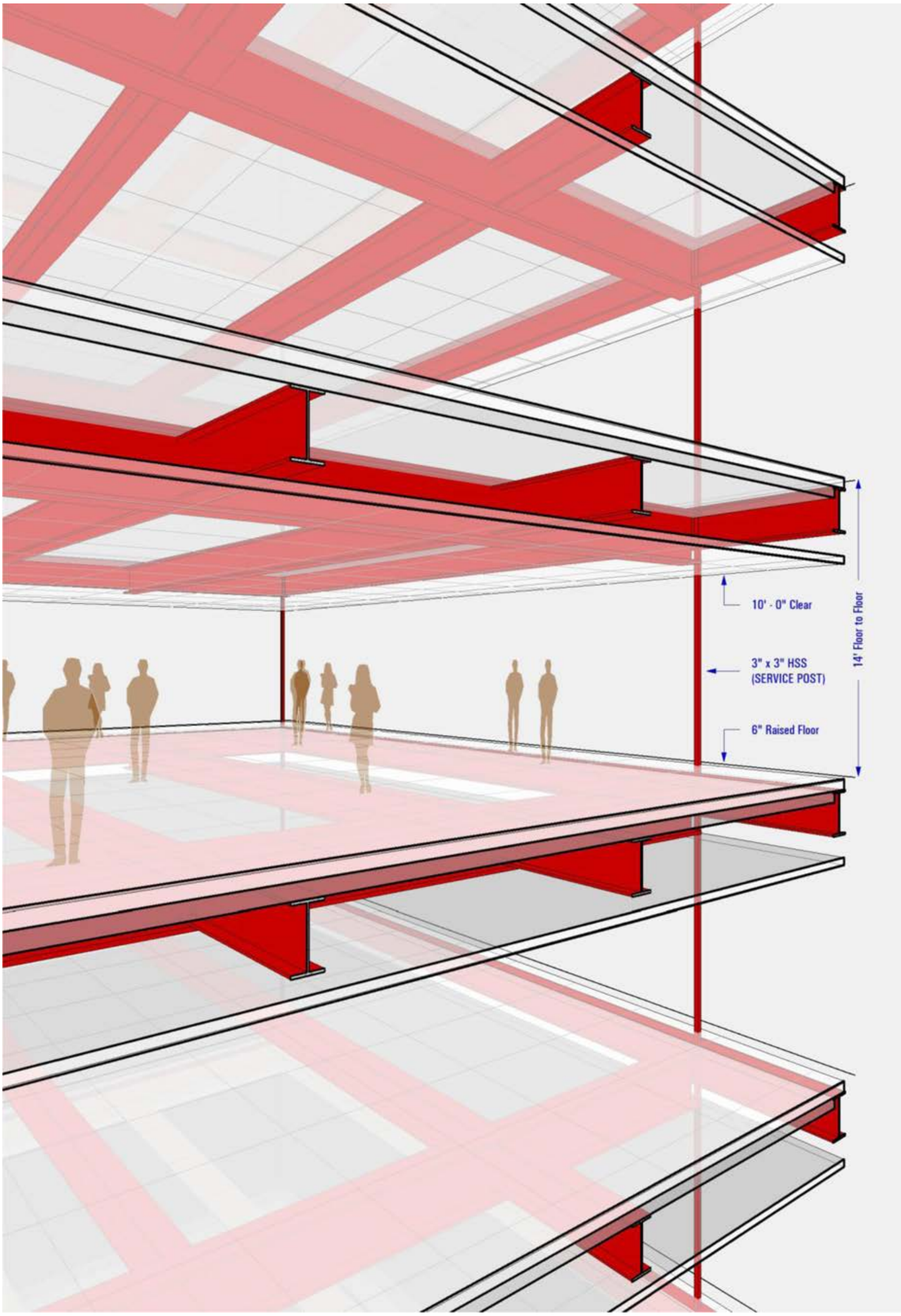


Figure 12. Diagram of Typial Office Floor Structure.

required as one floor per week will be hoisted to its final elevation.

3.2.1. Design Challenges

From a procedural standpoint, the major challenges when considering a non-traditional construction technique such as Core Cantilever construction are: consensus building, coordination, and documentation. The Building Information Model Execution Plan is of significant importance given that the construction sequence relies on "just in time delivery;" the Architectural, Engineering, Construction, and Client teams must be fully coordinated at the time of procurement and construction. The documentation process is fully reliant on a complete Building Information Model deliverable with a Level of Development 400 (e.g., BIM LOD 400). Effectively all details and assemblies must be 3D modeled and sufficiently detailed to allow for coordination, procurement, fabrication, assembly, and installation. Any late stage changes to the documentation is particularly problematic as the construction schedule only allows for a sequential one (1) week schedule per floor once the concrete cores are topped out and cured.

4. The Project

The team selected a generic Midtown Manhattan site for this case-study. The lot is sized 75 feet (22,860 mm) by 100 feet (30,480 mm), with the short side facing the street. The project must have a 20 foot (6,096 mm) rear yard setback and maintain the 80 foot (24,384 mm) street wall. Although the site contains a fixed FAR for allowable project area, the height is not restricted. The project program is an amenity-rich 175 key boutique hotel. The ground floor requires a grand lobby and signature restaurant. Hotel guest rooms must have at least 8 foot (2,438 mm) clear height, and take advantage of views afforded by a high-rise building typology.

4.1. Conventional Construction, Solution 01

To begin the study, the team from LIFT Group analyzed a conventional cast-in-place flat slab concrete structure on the project site. The building structure was laid out on a 20 foot (6,096 mm) by 15 foot (4,572 mm) grid, and composed of shear walls and columns. Cast-in-place cores were added to the structural system to allow for vertical transportation and egress stairs. The building cores are located to the back of the site to free up as much floor area as possible toward the boundary at the street.

The result is a fairly restrictive floor plan with shear walls located at the corners. It is assumed that the primary views are possible from the front and back facades only. Due to the location of the structural grids, a mid-tower amenity may not be possible without the addition of structural transfers. The resulting lobby and restaurant have significant constraints as the columns serve to define both spaces. The estimated construction timeframe is 24 months from excavation to grand opening.

After analysis and preliminary layout test fits, we find that corner rooms are bracketed by shear walls, reducing views. In addition, the column grid causes a reduction in the useable area of the guest rooms. The constraints inherent to a traditional cast-in-place structural system have reduced the economic viability of the project.

4.2. Core Cantilever Construction, Solution 02

Based on our initial study of the cast-in-place concrete solution, it is clear that an alternate approach is warranted to allow for a successful project on this site. Working in collaboration, PCPA developed an alternate plan diagram that takes advantage of the LIFT Group's patented Core Cantilever structural system. The building cores are centrally located; however, they are justified to the boundary at the adjacent properties. The guiding principal behind the structural system is to suspend the floors in cantilever from core elements without any interim vertical support elements. The floors are structured using interlocking and threaded steel wide-flange beams, a steel deck and lightweight concrete slab span between the beams. The steel frame and composite slab are rigid enough to support the building storey without any columnar or traditional shear wall support elements. The resulting floor plate yields a fully unobstructed open plan that maximizes usable area.

The projected schedule for this 365 foot (111,252 mm) case study project is 12 months from excavation to grand opening. The slip form of the core ascends 1 foot (305 mm) per hour, completing 1 floor level of 10 foot 4 inches (2,667 mm) per day. Although it is possible to continue the form's ascension on a 24 hour cycle, many local noise ordinances prohibit it. For this project, the cores for a building height of 365 feet (111,252 mm) are completed in 36 days.

This 30-storey boutique hotel project, in principle, is column and partition free, allowing for layout flexibility and increased usable square area. The useable area for the project has increased by at least 3% by removing the columns and shear walls. Amenity floors take full advantage of the unobstructed layout as they are not required to have partitions that create demising lines between hotel guest rooms. The floors with hotel guest rooms are now afforded open corners with views on two sides, as the only partitions needed are for privacy and unit demises.

5. Conclusion

In summary, there is a unique benefit to core cantilever construction for constrained or "tight" site projects. This structural system can provide fully open plan possibilities with increased useable square area typically lost to vertical structure. In addition, municipalities that count the square area from vertical structural members (columns and shear walls) in the projects Allowable Area calculation, stand to see the greatest benefit. The core cantilever system not only increases valuable useable area, it also increases planning flexibility and lease depth opportunities. Speed of construction is also reduced in the core cantilever system, thus reducing ownerships' financial exposure and providing a quicker delivery to market.

Although a valid technique for small urban in-fill projects, programs that do not have cellular demising requirements are the most suited to this new construction technique. This case study focused on a restricted or "tight" site in-fill projects, but a similar technique can be used for large projects with more land area. In principal, the core cantilever sketch that we have shown can be replicated in quadrants or consolidated to the center to create a much larger open floor plan better suited to contemporary office usages.

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