CONCLUSIONS AND RECOMMENDATIONS

Design Summary

Both the composite steel and concrete systems strive to support open office loads and large parking loads in an efficient manner. The composite steel system supports office loads through a 3" composite deck with 3.5" lightweight slab, supported by W10 beams spaced 10'-0" OC spanning the short direction of 30'-0"x20'-0" bays. In the parking structure, a 4" slab on 2" composite deck is supported by W10 beams spaced 5'-0" OC. Girders approach W21 in the office area and W24 in the parking structure. Due to lighter loads, the roof structure is non-composite with slightly larger beams.

The new reinforced concrete design maximizes the efficiency of a two-way slab by changing the column layout to produce a central 30'-0"x30'-0" bay. Though this is a relatively large bay, it produces a column layout conducive to the given parking layout utilizing four less columns than the given system. An 8", 10" and 11" slab is found in the roof, office area and parking deck, respectively. While 3.5" drop panels are primarily used, they are upsized to 4.5" in edge columns in the office structure and to 7" in interior columns in the parking structure to combat shear by moment transfer. Larger columns ranging from 20" square to 20"x30" also combat shear by moment transfer, and they rest on enlarged spread footings.

Evaluation of the Concrete System

Structural Efficiency

Pros

- Smaller 15.5" (office) / 18" (parking) floor section depths
- Resilience to Superimposed Loads
- Simple Connections to Parking Structure
- Limited Lateral Drift
- No complicated fireproofing
- Possibly less excavation from smaller parking deck depth

Cons

- Heavy Structure: Larger Spread Footings
- Large (20x20) Obstructing Columns
- Drop Ceiling Negates Finished Surface
- Floor penetrations may present a problem

Architectural Layout

Pros

- Wider areas around building perimeter for office areas
- Larger Rentable Areas
- Columns disguised by central corridor core
- More parking spaces
- Compatible with precast exterior wall panels

Cons

- Differing rentable areas for first floor offices than originally planned

Constructability

Pros

- Shorter 3 week lead time for rebar
- Concrete may be cheaper in select Northern Virginia areas

Cons

- Longer erection time
- Construction in winter a concern
- Northern Virginia on PCA's "tight cement supply" list
- More expensive according to RS Means 2006

Green Roof

Pros

- Concrete system able to resist larger lateral loads
- Concrete more resistant to water damage from saturated roof

Cons

- Slab sizes in roof under heaviest roof garden similar to slab under parking deck

Evaluation of the Composite Steel System

Structural Efficiency

Pros

- Lightweight system provides for smaller footings
- Smaller W10 columns take up less floor space

Cons

- Larger 27.5" (office) / 30" (parking) floor section depths
- Costly and time consuming moment connections needed for lateral system
- Complicated connections between parking structure and first floor
- Larger drift values
- Floor penetrations and superimposed loads require infill framing

Architectural Layout

Pros

- Columns less obstructive
- Columns can be placed in front of windows

Cons

- Less rentable area and more common area
- Fewer parking spaces

Constructability

Pros

- Less expensive by almost $200,000
- Faster erection time by over 2 weeks

Cons

- Complicated fireproofing required in parking structure and around common areas

Green Roof

Pros

- Under largest green roof system, composite roof structure comparable in size to office floor structure

Cons

- Lateral resistance of the given moment frame system a concern

Final Recommendations

Though concrete appears to be a more logical solution from the viewpoint of structural efficiency, its benefits soon become less convincing once a construction schedule and cost estimate reveal that it costs nearly $200,000 more and takes almost 3 additional weeks to construct. Even in Northern Virginia, where differing cost indexes show that there is a slight bias towards concrete construction, steel would still be the most economical choice. Where floor-to-floor height is not a concern, and where a drop ceiling system are used, concrete is less appropriate from an architectural standpoint.

Most of the complications involved in steel construction are found in the first floor/parking deck structure. Large supporting girders increase excavation depth and are less attractive while complicated fireproofing takes up to an additional three weeks to apply.

Therefore, as suggested by many professionals in the Washington area, the most logical solution would be a hybrid structure, with concrete columns and slab at the first floor and composite steel at the second, third, and fourth floors. By employing a concrete structure on the first floor, the building will benefit from smaller floor section depth and therefore reduced excavation, simplified connections at varying elevations, and a natural fireproofing mechanism. By employing a composite steel system in the office structure, the building will benefit from smaller column sizes, a lighter structure with smaller footings, and less expensive and lengthy construction.

Though the composite steel system would reap structural benefits, the improved architectural layouts depended on a new column layout, with eight interior columns rather than twelve. For a composite steel system resting on the altered layout used throughout the concrete design, brief hand calculations showed that:

- Girders on the critical interior Column Lines 2 and 3, with an expanded 26'-3" tributary width over a 30'-0" length would need to be either a W18x55 or W21x48. This is an increase in size from W18x35 and W21x44 girders with the existing column layout. Infill beams along the 30'-0" length would only need to be upsized to W10x19 spaced 10'-0" OC.
- Critical interior columns with an expanded 788 square foot tributary area would need to be either a W12x96 or W14x90. This is an increase in size from W10x49 in the existing layout; however, given that the concrete columns were over 20x20, larger W14 columns could be a possibility.

Though column sizes do increase dramatically to reflect significantly larger tributary areas, the actual girder and beam layout would not change drastically, and would not translate to significantly greater costs.

Though the green roof does deliver reduced sound and heat transmission through the roof deck, it would require a 10% greater upfront costs and consistent maintenance throughout the life of the building. Considering that this building was built with economy in mind, it would be hard to justify the green roof to the owner. However, when looking beyond initial costs, the addition of a green roof does present greater possibilities in terms of quality of the workspace and therefore overall marketability of the office areas to potential leasers.