EXECUTIVE SUMMARY

The Signal Hill Professional Center is a suburban office building that houses over 68,000 square feet of open office space on four above ground levels in Manassas, Virginia. To increase the number of parking spaces, it takes advantage of its sloping site by excavating into the hillside to accommodate an underground parking area. To maximize this area to nearly 21,300 square feet, this underground space extends beyond the footprint of the building to nearly the limits of the site, and the supporting building structure slopes with the natural terrain.

As designed by Morabito Consultants of Baltimore, the current building structure employs a composite steel system in order to reduce floor section depth and building weight. This system generally uses W10 beams spanning 20'-0" to support a lightweight concrete slab on composite deck, while W21 and W24 girders spanning 30'-0" are sufficient in the office and parking structure, respectively. Due to smaller lateral loads in Northern Virginia, a system of moment frames which transfer shear forces to concrete shear walls in the basement are sufficient in preventing excessive drift.

Though an analysis of the original design revealed that composite steel was an efficient system for the given design conditions, the Signal Hill Professional Center is located outside Washington DC, where concrete design should be commonplace. In the District, strict height restrictions dictate that local structures normally use concrete flat plate systems to reduce floor-to-floor heights through smaller floor section depths. Though this particular building is not limited by height restrictions, and though a drop ceiling would negate any benefits from reduced floor section depth, perhaps the large presence of concrete contractors in the area may make a concrete design more economical.

Therefore, to investigate the possibility of using concrete instead of steel, a concrete system was designed for the Signal Hill Professional Center. This system was then evaluated for structural efficiency, architectural impact, constructability, and effectiveness at integrating green design considerations.

Structural Efficiency. While initially flexure and deflection controlled selection of a two-way concrete floor system, shear around columns from moment transfer came to control in most situations. Further, a new column layout was necessary to create square bays conducive to a two-way slab. The final design features:

- 8" concrete slab with 3.5" drops around all columns in Roof.
- 10" concrete slab with 3.5" and 4.5" drops around columns in Floors 2-4.
- 11" concrete slab with 3.5" and 7" drops around columns in the First Floor/Parking Deck.

Column sizes came to be controlled by shear rather than axial loads; larger column sizes led to larger shear perimeters and therefore larger shear resistance. Though a system of concrete moment frames was sufficient to resist drift, lateral loads increased these unbalanced moments around columns and intensified shear.

Architectural Impact. Since the new structural design relied upon a new column grid, this affected both the central corridor core layout and the positioning of precast panels on the east and west building façade. By re-evaluating the required areas in the

corridor core, three alternative floorplans were created which take advantage of the new column layout. These floorplans, as evaluated by the Building Owners and Managers Association industry standard, increased rentable areas, which could increase annual owner rental income by as much as $17,750.

Due to the flexible nature of precast panels in the building façade, the elevations can be rearranged to prevent concrete columns from interrupting windows. A further study of façade arrangement produced a variety of possible elevations, which would reinforce the traditional base-shaft-capital office building icon.

Constructability. Including larger footing sizes, an estimate using R.S. Means 2006 revealed that the concrete system would cost about $200,000 more than a composite steel system and would take almost three additional weeks to erect. Upon surveying both structural engineers and construction managers in the Washington DC area, it became readily apparent that steel may be the best solution because:

- Though regional adjustment factors for R.S. Means reveal that concrete is generally cheaper than steel, these factors do not offset the $200,000 cost discrepancy.
- The Portland Cement Association placed Washington DC on the cement "tight supply" list for 2005, which would inhibit the ability of concrete contractors to cut costs for lower bids.
- Wintry conditions during building construction meant that heaters, covers, and protective devices would be necessary for concrete construction, which would increase cost and erection time.

Installation of a Green Roof. Using standard roof garden assemblies from Roofscapes, a green roof company in Philadelphia, roof gardens ranging from lightweight systems featuring sedum plants to extensive systems featuring turf and trees were assessed for possible improvements to the building; results show that:

- Structurally, the lighter systems would not drastically increase supporting gravity systems in both steel and concrete. The heavier systems would increase the roof structure to sizes beyond those in the office floors; further, larger loads at the roof diaphragm would produce larger seismic loads. Therefore, lateral systems would need to increase, primarily in the steel system.
- Aesthetically, a roof garden would produce a livable outdoor space in a setting where busy roads and large box stores overshadow pedestrianism. This increased livability comes at the expense of a 10% increase in initial cost and roughly $1,000 per year to maintain.

Per the recommendation of many professionals in the Washington area, the most efficient final design may be a hybrid structure, using concrete columns and slabs in the first floor, and composite steel in the office areas above. Benefits would include increased lateral resistance for the steel system, which would make a green roof possible, and a natural fire stop between the parking area and offices above. Given that steel was determined to be more economical for Manassas, these benefits would not come at the expense of dramatically increased cost or construction duration. To enjoy the benefits of the new column layout with a reduced number of columns, member sizes would increase accordingly within reason.